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CONSTRUCTION OF THE CENTRAL SPENT FUEL STORAGE FACILITY FOR THE VVER NUCLEAR POWER PLANTS OF UKRAINE

PROJECT

VOL. 12.1

Environmental Impact Assessment

PART 1
Materials:

Edition 1

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Designation	Title	Note
571402.201.012-OBOC01-C	Volume Contents	P. 2
571402.201-SP	Project Scope	P. 3
571402.201.012-OBOC01-ВУ	Participants of the Project	P. 6
571402.201.012-OBOC01	Environmental Impact Assessment. Part 1. EIA Materials	P. 7

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571402.201.012-OBOC01-C

Volume Contents

Project		No. of S
Item		1

PAO KIEP

Size A4

Volume No.	Designation	Title	Notes
1.1	571402.201.001-PZ01	Executive Summary	
1.2.1	571402.201.001-PZ02.01	Initial Input Data Book 1	
1.2.2	571402.201.001-PZ02.02	Initial Input Data Book 2	
1.3	571402.201.001-PZ03	Description Of The SNF Management Technology At The NPP Power Units	
2	571402.201.002-GT	The Master Plan And Transport	
3.1	571402.201.003-TH01	Technologies. Part 1. Spent Fuel Handling	
3.2	571402.201.003-TH02	Technologies. Part 2. Waste Management During Operation	
3.3	571402.201.003-TH03	Technologies. Part 3. Auxiliary Systems	
4.1	571402.201.004-AS01	Architectural Planning Solutions. Part 1. Executive Summary. Architectural Solutions	
4.2.1	571402.201.004-AS02.01	Architectural Planning Solutions. Part 2. Executive Summary. Construction Solutions. Book 1. Executive Summary	
4.2.2	571402.201.004-AS02.02	Architectural Planning Solutions. Part 2. Executive Summary. Construction Solutions. Book 2. Calculation Results	
4.3.1	571402.201.004-AS03.01	Architectural Planning Solutions. Part 3. Drawings. Book 1. Architectural Solutions	
4.3.2	571402.201.004-AS03.02	Architectural Planning Solutions. Part 3. Drawings. Book 2. Concrete Structures.	
4.3.3	571402.201.004-AS03.03	Architectural Planning Solutions. Part 3. Drawings. Book 3. Metal Structures.	
5.1	571402.201.005-ETR01	Electrical Part. Part 1. Executive Summary	
5.2	571402.201.005-ETR02	Electrical Part. Part 2. Drawings.	
6	571402.201.006-SKU	Control and Monitoring Systems	
7	571402.201.007-OV	Heating, Ventilation, Air Conditioning	
8	571402.201.008-VK	Water Supply And Sanitation	

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571402.201-SP

Project Scope

Project		No. of S
Item	1	2

PAO KIEP

Volume No.	Designation	Title	Notes
9	571402.201.009-PB	Fire Protection Measures	
10.1	571402.201.010-GO01	Engineering And Technical Measures Of Civil Protection (Civil Defense). Part 1. Executive Summary	
10.2	571402.201.010-GO02	Engineering And Technical Measures Of Civil Protection (Civil Defense). Part 2. Civil Protection Structures (Civil Defense)	
11	571402.201.011-POS	Construction Arrangement	
12.1	571402.201.012-OVOS01	Environmental impact assessment. Part 1. EIA Materials	
12.2	571402.201.012-OVOS02	Environmental impact assessment. Part 2. Annexes	
13	571402.201.013-OCCZ	Sanitary Code Conformance Report	
14	571402.201.014-CFZ	Physical Security System	Classified
15.1.1	571402.201.015-SD01.01	Estimate Documents. Part 1. Consolidated Budget Calculation And Object Estimates. Book 1	
15.1.2	571402.201.015-SD01.02	Estimate Documents. Part 1. Consolidated Budget Calculation And Object Estimates. Book 2. Total Resource Statements	
15.2.1.1	571402.201.015-SD02.01.01	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Part. Part 1	
15.2.1.2	571402.201.015-SD02.01.02	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Part. Part 2	
15.2.1.3	571402.201.015-SD02.01.03	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Part. Part 3. Work Scopes.	
15.2.2	571402.201.015-SD02.02	Estimate Documents. Part 2. Local Calculations. Book 2. Heating, Ventilation, Air Conditioning	
15.2.3	571402.201.015-SD02.03	Estimate Documents. Part 2. Local Calculations. Book 3. Water Supply And Sanitation	
15.2.4	571402.201.015-SD02.04	Estimate Documents. Part 2. Local Calculations. Book 4. Technological Part	

Volume No.	Designation	Title	Notes
15.2.5.1	571402.201.015-SD02.05.01	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Part. Part 1	
15.2.5.2	571402.201.015-SD02.05.02	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Part. Part 2	
15.2.5.3	571402.201.015-SD02.05.03	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Part. Part 3	
15.2.6	571402.201.015-SD02.06	Estimate Documents. Part 2. Local Calculations. Book 6. Instrumentation And Automation	
16	571402.201.016-PPR	Site Preparation Works	

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Contents

PREFACE 12

ABSTRACT 13

1 BASIS FOR THE EIA 14

1.1 The Information About The Documents That Are The Basis For The Development Of The EIA Materials As Part Of The Investment Program Or Construction Project 14

1.2 The List Of Potential Sources Of Impact Of The Proposed Activity On The Environment, Taking Into Account Its Alternatives 14

1.3 Brief Description Of The Types Of Impact Of The Proposed Activity On The Environment, And The List Defined In “The Statement Of Intent” Or At Other Stages Of EIA 14

1.4 The List Of Environmental, Sanitary-Epidemiological, Fire And Urban Planning Restrictions 15

1.5 Data On The Attitude Of Public And Other Stakeholders To The Proposed Activity And Related Issues That Need To Be Addressed 16

1.6 The List Of Normative And Methodological Documents Used 16

1.7 Description Of The Environmental Indicators’ Dynamics Forecasting Techniques And The Substantiation Of The Forecast Periods Used 16

1.8 The Information About The Structural Units Of The Executor And The List Of Subcontractors And Specialists Involved In The EIA 17

1.9 The List And Brief Analysis Of The Previous Approvals And Expert Assessments, Including The Public Examination (If Held) 17

1.10 The List Of Information Sources Used In The Development Of The EIA Materials 17

2 ANNUAL REPORTS OF THE STATE AGENCY OF UKRAINE FOR THE EXCLUSION ZONE MANAGEMENT ON RADIATION SAFETY, OCCUPATIONAL SAFETY AND HEALTH OF WORKERS IN THE EXCLUSION AND COMPULSORY RESETTLEMENT ZONE. PHYSICO-GEOGRAPHICAL CHARACTERISTICS OF THE AREA AND SITE OF THE DESIGN OBJECT 19

2.1 Physical And Geographical Conditions Of The Area 19

2.1.1 The Geographical Location Of The Site 19

2.1.2 The Directional Position And The Distance From The CSFSF To The Nearest Cities And Important Sites 20

2.1.3 The terrain and landscape 22

2.1.4 The Geological Conditions, Seismicity And Neotectonics Of The CSFSF Production Area 23

2.1.5 Soils 25

2.2 Climate Characteristics 28

2.2.1 Air Temperature 28

2.2.2 Wind Direction And Speed 29

2.2.3 Relative And Absolute Air Humidity 30

2.2.4 Precipitation 31

2.2.5 Snow Cover 31

2.2.6 Thunderstorms, Hail 31

2.2.7 Icy Conditions 31

2.2.8 Flood And Rain Floods 31

2.2.9 Fog 32

2.2.10 The Stability Of The Atmosphere 32
2.2.11 Squalls 32
2.2.12 Tornadoes 33
2.3 The Sites Of Natural Reserve Fund (NRF) 34
2.4 General Description Of The Flora And Fauna 36
2.4.1 Floral Complexes 36
2.4.2 Faunal Complexes 38
2.5 The Characteristics Of Distribution Of All Adverse Factors In The Zone Of Influence Of The Proposed Activity 39
2.5.1 Accidental Pollution Of The Surrounding Areas 39
2.5.2 Dangerous Phenomena Of Natural Origin 50
2.5.3 Dangerous Phenomena Of Technogenic Origin 51

3 GENERAL DESCRIPTION OF THE DESIGNED FACILITY 52
3.1 General Description of the Planned Activity and Its Alternatives 52
3.2 Conformity of the Planned Activity to City Development Documents 52
3.3 Positive Environmental, Sanitary/Epidemiological, Social, and Economic Aspects of the Implementation of Planned Activity 53
3.4 Brief Description of the Planned Activity 53
3.4.1 Core Function 53
3.4.2 Brief Process Description 54
3.4.3 Buildings and Structures on the CSFSF Site 55
3.4.4 CSFSF Operation Description 55
3.4.5 Description of Main CSFSF Buildings 63
3.4.6 Water Supply and Wastewater Disposal Systems 68
3.5 Process Waste and Opportunity for Their Reuse, Recycling, Decontamination or Safe Disposal 72
3.6 Assessment of the Potential of the Emergence and Development of Accidents 73
3.7 List and Descriptions of Potential Sources of Environmental Impact 80

4 ESTIMATED IMPACT OF THE PLANNED ACTIVITY ON THE NATURAL ENVIRONMENT 81
4.1 Climate and Microclimate 81
4.2 Air Environment 81
4.2.1 Radiation Impact of the CSFSF on Air Environment 81
4.2.2 Impact of Contaminant Emissions from the CSFSF on Air Environment 91
4.2.3 Total Volume of Emissions during the Operation 106
4.2.4 Conclusions on the Impact of CSFSF's Contaminant Emissions on Air during Operation 110
4.2.5 Noise Pollution of Air during Construction 111
4.2.6 Impact of Electric and Electromagnetic Fields on Air Environment 137
4.3 Geological Environment 140
4.3.1 Radiation Impact on Geological Environment 140
4.3.2 Non-radiation Impact on Geological Environment 140
4.4 Water Environment 140
4.4.1 Radiation Impact on Water Environment 140
4.4.2 Non-radiation Impact on Aquatic Environment 142
4.5 Soils 142
4.5.1 Radiation Impact on Soil 142

4.5.2 Non-radiation Impact on Soil 148
4.6 Flora and Fauna, Protected Sites 148
4.6.1 Radiation Impact on Flora and Fauna, Protected Sites 148
4.6.2 Non-radiation Impact on Flora and Fauna, Protected Sites 149
4.7 Assessment of the Waste Impact During Operation 151
4.7.1 Radioactive Waste (RW) 151
4.7.2 Non-radioactive Waste 151

5 ESTIMATED SOCIAL IMPACT OF THE PROJECTED ACTIVITY 152
5.1 Characteristics Of The Social Environment 152
5.2 The Radiation Impact On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone 153
5.2.1 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone 153
5.2.2 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone With Maximum Consequences 154
5.2.3 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone In Case Of Accident Beyond The Design Basis 155
5.3 The Radiation Impact On The Social Environment Outside The Exclusion And Compulsory Resettlement Zone 157
5.4 Estimated Social Consequences Of Non-radiation Impact On The Air 157
5.5 Social Impact Assessment Related To Noise Exposure 157
5.6 The Assessment Of The Social Impact Of The Electric And Electromagnetic Fields 158
5.7 Assessment Of Social Consequences Related To The Impact On Water Bodies 158
5.8 Assessment Of Social Consequences Related To The Impact On Soils 158
5.9 Assessment Of Social Consequences Related To The Impact On Flora, Fauna, And Reserved Sites 158

6 OPERATION OF THE FACILITIES, IN TERMS OF IMPACT ON FLORA, FAUNA, AND RESERVED SITES, IS ACCEPTABLE.ESTIMATED IMPACT OF THE PROJECTED ACTIVITY ON THE MAN-MADE ENVIRONMENT 159

7 COMPREHENSIVE MEASURES TO ENSURING THE COMPLIANT ENVIRONMENT AND ITS SAFETY 162
7.1 Resource-Saving Activities 162
7.2 Protective Measures 162
7.3 Rehabilitation Measures 163
7.4 Compensatory Measures 163
7.5 Security Measures 163
7.5.1 Security Features Of The Instrumentation And Control System 163
7.5.2 Control And Monitoring Systems Of The Transport And Technological Equipment 164
7.5.3 The Fissile Materials Control And Accounting System 165
7.5.4 Storage Process Monitoring System 165
7.5.5 Radiation Monitoring System 166
7.5.6 Radioactive Drain Monitoring And Control 167
7.5.7 Shower Water Monitoring And Control 167
7.5.8 Heating, Ventilation And Air Conditioning Control and Monitoring Systems 169
7.5.9 Pressurised Air Monitoring And Control System 169
7.5.10 Fire Safety Monitoring And Control System 169

7.5.11 The System Of Monitoring Wells 169
7.5.12 Automated Threat/Emergency Early Detection And Warning System 170
7.6 Summary Of The Monitoring And Post-Project Analysis Programmes 170
7.7 Estimated Environmental Impact Of The Projected Activity 176
7.7.1 Radiation Contamination Risk Assessment 176
7.7.2 Assessment Of The Human Health Risk From Air Pollution By Chemicals 177
7.8 Identification Of The Potentially Dangerous Object 182
7.9 The List And Description Of The Residual Impacts 183

8 EVALUATION OF ENVIRONMENTAL IMPACT DURING CONSTRUCTION 186
8.1 Impact Sources 186
8.2 Radiation Impact During Construction 186
8.2.1 Air Pollution 186
8.2.2 Contamination Of The Soil Surface 187
8.2.3 Additional Exposure Of The Personnel And The Population 187
8.3 Non-radiation Impact During Construction 188
8.3.1 Assessment Of The Impact Of Contaminant Emissions During Operation Of The Construction Equipment 188
8.3.2 Evaluation Of The Impact Of Polluting Substances Emissions During Welding 190
8.3.3 Assessment Of The Impact Of Emissions During Earthworks 191
8.3.4 The Total Volume Of Emissions During Construction Works 194
8.3.5 Estimated Concentration Of Contaminants In The Lowest Atmospheric Layer During Construction 195
8.3.6 Noise Air Pollution During Construction 199
8.4 Assessment Of The Waste Impact In The Course Of Construction Activities 201

9 LIST OF GAPS AND UNCERTAINTIES 203

10 ASSESSMENT OF IMPACT OF CONSTRUCTION, OPERATION AND ACCIDENTS AT THE CSFSF ON THE TERRITORY OF THE NEIGHBORING STATES 207
10.1 General Provisions 207
10.2 Impact Characteristics 207
10.3 Justification Of The Estimation Methods And Software Used 207
10.4 Source Data 207
10.5 Assessment Of The Impact During Construction 208
10.5.1 Air Pollution 208
10.5.2 Contamination Of The Soil Surface 208
10.5.3 Additional Exposure Of The Personnel And The Population 208
10.6 Assessment Of The Impact During Operation 209
10.6.1 Assessment Of The Impact During Normal Operation Of The CSFSF 209
10.6.2 Assessment Of Impact During The Design Basis Accident With The Maximum Consequences 209
10.6.3 Assessment Of Impact During The Beyond Design Basis Accident 209
10.7 Conclusions On The Transboundary Impact Of The CSFSF 210

11 STATEMENT ON THE ENVIRONMENTAL IMPACT OF ACTIVITIES 211
11.1 Data On The Planned Activities, Goals And Ways Of Their Implementation 211
11.2 Significant Factors, Which Affect Or May Affect The State Of The Environment, Taking Into Account The Possibility Of Environmental Emergencies 212

11.3 Quantitative And Qualitative Indicators For Assessing The Environmental Risk Levels And Safety Of The Planned Activity For The Life Of The Population, As Well As Measures To Ensure Implementation Of This Activity In Accordance With The Environmental Standards And Regulations 212
11.4 List Of Residual Impacts 213
11.5 Adopted Measures To Inform The Public About The Planned Activity, Purpose And Ways Of Its Realization 214

Glossary 215

Abbreviations and Acronyms 218

Regulatory Documents and Bibliographic References 219

PREFACE

The Central Spent Fuel Storage Facility (CSFSF) is a nuclear facility of national importance. The decision on construction and location of CSFSF was adopted by the Law of Ukraine “On The Management Of Spent Fuel: Location, Design And Construction Of The Centralized Storage Facility For Spent Fuel Of The Domestic VVER Nuclear Power Plants” following Investment Feasibility Study approved by the Resolution of the Cabinet of Ministers of Ukraine № 131-p of 04.02.2009. Main results of the study:

- CSFSF is to be located on the site between the villages of Staraya Krasnitsa, Buryakovka, Chistogalovka and Stechanka in Kyiv province within the exclusion zone with radioactive contamination after the Chernobyl disaster;
- the storage of spent nuclear fuel technology to be used is surface “dry” storage with double-barrier insulation system;
- CSFSF lifetime — 100 years;
- CSFSF capacity — 16529 SFAs, including: 12010 pcs of VVER-1000 SFAs and 4519 pcs of VVER-400;

The CSFSF is based on the technology by Holtec International Technology (hereinafter — Holtec). Main elements of the technology:

- MPC — multi-purpose cask;
- HI-STAR 190 UA (hereinafter —HI-STAR) — transportation cask;
- HI-STORM 190 UA (hereinafter — HI-STORM) — storage cask;
- HI-TRAC 190 UA (hereinafter — HI-TRAC) — transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT);
- car transporter for the HI-STAR.

The project provides for the reception of HI-STARs with an MPCs, concrete-casting of the HI-STORMs’ shells, transfer of the MPCs from the HI-STARs to HI-STORMs, and the storage of the HI-STORMs, filled with spent nuclear fuel on the territory of the CSFSF.

The description of the SNF management technology at the power units, submitted by the technology providers, is set out in Volume 1.3. The binding of the technology to a specific nuclear power unit will be made under the projects of modification in accordance with the current legislation in the field of nuclear energy.

This project of the CSFSF (Version 1) is developed on the basis of the approved Feasibility Study, Design Brief, Planning Requirements and limitations under Agreement № 571402 of 03.10.2014 between State Enterprise “National Nuclear Energy Generating Company “Energoatom” and Public Joint Stock Company “Kyiv Research and Design Institute “Energoproject””.

This project of the CSFSF (Version 1) is developed on the basis of the approved Feasibility Study, Design Brief, Planning Requirements and limitations under Agreement № 571402 of 03.10.2014 between State Enterprise “National Nuclear Energy Generating Company “Energoatom” and Public Joint Stock Company “Kyiv Research and Design Institute “Energoproject””.

ABSTRACT

The state policy of Ukraine, as provided for in the Constitution of Ukraine, [1] is aimed to ensure the environmental safety and maintenance of the ecological balance on the territory of Ukraine.

For this purpose, Ukraine carries out, on its territory, ecological policy aimed at maintaining safe environment for the living and inanimate nature, protection of life and health of the population from the negative effects caused by the environmental pollution, to achieve a harmonious interaction between the society and the nature, protection, rational use and restoration of the natural resources [1, 3].

According to the acting requirements (Art. 51 of the Law of Ukraine “On Environmental Protection” [3]), economic and other activities should be supported by the materials of evaluation of their impact on the environment and human health.

The implementation of the EIA section as part of the project is required by DBN A.2.2-3:2014 [11].

The presented section of the EIA is based on the requirements of DBN A.2.2-1-2003 [10], the Ukrainian environmental and sanitary legislation [12-20], as well as on some specific conditions of the design object in the exclusion zone, and the unconditional (obligatory) resettlement — the exclusion and compulsory resettlement zone [21].

The presented section of the EIA is based on the EIA approved by the CMU [22, 23] as part of the CSFSF investment feasibility study [24], with regard for the requirements of the normative-legal acts in the field of environmental protection, which entered into force after the adoption (26.08.2008) of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study [25].

The EIA materials are prepared in full, because the planned activities belong to the list of activities and objects that represent an increased environmental hazard, according to Resolution № 808 of Cabinet of Ministers of 8.28.2013 [20].

Since the planned activities belong to the list of activities with possible impact on the territory of neighboring states, the EIA is carried out with regard to the requirements of the environmental impact assessment of the Convention on Environmental Impact Assessment in Transboundary Context [26] ratified by Ukraine on 19 March 1999 [27].

1 BASIS FOR THE EIA

1.1 The Information About The Documents That Are The Basis For The Development Of The EIA Materials As Part Of The Investment Program Or Construction Project

The development of the EIA materials as part of the project "Construction Of The Central Spent Fuel Storage Facility" is based on the following documents:

- Contract № 571402 for the development of design “Construction Of The Central Spent Fuel Storage Facility” between Public Joint Stock Company “Kyiv Research and Design Institute “Energoproject” and PC Atomproectenginiring;
- Design Brief:
- Terms of Reference for the development of the EIA (Appendix Б, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes).

1.2 The List Of Potential Sources Of Impact Of The Proposed Activity On The Environment, Taking Into Account Its Alternatives

During the construction works, the sources of environmental impact will include the construction machinery, vehicles, electric welding and painting works.

This involves slight pollution of air with dust, fuel combustion products, solvents, paints and varnishes. In addition, during construction, the waste is produced.

The negative effects of these sources are temporary and limited by the construction time.

The source of permanent negative impact of the operation is the CSFSF radiation exposure, the air pollution from the combustion products of motor and railway transport, the emissions from the concrete plant, the noise pollution from the CSFSF infrastructure equipment. In addition, during operation, the waste is produced.

The quantitative assessment of the environmental impact during construction and operation of the CSFSF is presented in the relevant sections of this volume.

1.3 Brief Description Of The Types Of Impact Of The Proposed Activity On The Environment, And The List Defined In “The Statement Of Intent” Or At Other Stages Of EIA

The characteristic of the environmental impacts are set out in “The Statement of Intent” (Appendix B, Volume 12.2. Assessment Of Impact On The Environment. Part 2. Annexes), namely:

- the impact on the climate and microclimate — no impact;
- the impact on the geological environment — the impact is not expected;
- the impact on the air environment:
  - during construction — slight dust generation, radiation exposure below the established admissible level in the exclusion areas;
  - during operation — radiation exposure well below the limits established by the acting norms;
- impact of the water environment — slight dust generation, radiation exposure below the established admissible level;
- impact on the soils:
  - during construction — the fertile soils, if any, will be removed from the construction site; in addition, a positive point about the exclusion zone: the rehabilitation of the radiation-contaminated areas required for construction and operation;
  - during operation — radiation exposure, which will have no significant effect on the current radiation situation in the environment;

- the impact on the flora and fauna, protected sites — no significant adverse impact;
- the impact on the surrounding social environment — radiation exposure well below the limits established by DGN 6.6.1-6.5.001-98 (NRBU-97) [14];
- the impact on the man-made environment — radiation exposure within normal levels for the personnel of the neighboring facilities in the buffer zone.

1.4 The List Of Environmental, Sanitary-Epidemiological, Fire And Urban Planning Restrictions

The ecological and sanitary-epidemiological restrictions applied to the construction and operation of the CSFSF are aimed at the implementation of the proposed activity and operation without deterioration of the existing environmental performance around the CSFSF, taking into account the compliance with the limits of radiation-hygienic parameters established by DGN 6.6.1-6.5.001-98 [14] and DGN 6.6.1-6.5.061-2000 [15].

Also, the environmental and sanitary-epidemiological limits are determined by the presence of control limits, threshold levels and levels of action as to the radioactive contamination of the sites for the exclusion and compulsory resettlement zone [19].

Moreover, the environmental and sanitary-epidemiological limits are determined by the presence of the sanitary protection zone around the designed site, according to DSP-173-96 [28].

The sizes of the sanitary protection zone and the control zone are defined in the CSFSF investment feasibility study [24]:

- the sanitary protection zone — within 100 m from the border of the site, taking into account the geometry of the CSFSF site;
- the CSFSF control zone — within 600 m from the storage site.

As part of the fire safety design for object, the following restrictions are established:

- the buildings and structures are located on the site of the enterprise with regard for the minimum required distances (fire breaks) between them, as established by SNIP II-89-80* [29].
- the limitations concerning the fire resistance of the buildings and structures (degree of fire resistance) stipulated by the fire resistance classes of the building structures established by DBN V.1.1-7-2002 [30].
- the number of storeys and the floor areas of buildings within the fire compartments are limited by the requirements of SNIP 2.09.02-85 [31], SNIP 2.11.01-85 [32], DBN V.2.2-28:2010 [33].
- the restrictions as to the equipment of the enterprise territory, the buildings and structures, the systems, indoor and outdoor fire water supply, fire-protection systems (fire alarm, automatic fire suppression, fire warning and evacuation, smoke detection, centralized fire monitoring, lightning protection), as well as the implementation of the measures in fire protection of the engineering systems not related to the fire-protection system (heating and ventilation systems, electrical systems, emergency lighting systems, etc.) are set by DBN V.2.5-56:2014 [34], DBN V.2.5-64:2012 [35], DBN V.2.5-67:2013 [36], DBN V.2.5-74:2013 [37], DBN V.2.5-28:2006 [38], DSTU B V.2.5-38:2008 [39], NPAOP 40.1-1.32-01 [40], PUE [41] and others.
- during operation of the enterprise, the restrictions are applied in terms of performance of a set of organizational and technical measures to ensure fire safety conditions and in accordance with the requirements of NAPB A.01.001-2014 [42].

The planning requirements and restrictions are set out in Annex Г, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

1.5 Data On The Attitude Of Public And Other Stakeholders To The Proposed Activity And Related Issues That Need To Be Addressed

For the purpose of informing the public about the proposed activity, taking into account the requirements of the Convention “On Access To The Information, Public Participation In Decision-Making And Access To Justice In The Environmental Matters” [43] ratified by Ukraine on July 6, 1999 [44], the following events will be held at the feasibility study stage:

- publication of the Statement of Intent (25.01.2007);
- holding a public consultation process on the construction of the central storage facility for nuclear fuel from the VVER nuclear power plants of Ukraine (after 06.02.2008);
- a round table in Slavutych on the construction of the CSFSF (28.02.2008);
- a round table in Ivankov on the construction of the CSFSF (01.03.2008);
- public hearings on the proposed activity in Slavutych, Kyiv region (22.03.2008);
- publication of the Environmental Impact Statement (07.03.2007).

The recommendations of public hearings on the placement of the CSFSF for the VVER nuclear power plants in Ukraine and its impact on the environment, held in Slavutych, Kyiv region, on 22 March 2008, are listed in Annex Д, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Following the principles of the environmental policy of National Nuclear Energy Generating Company “Energoatom” and in accordance with the requirements of the legislation of Ukraine, the information on the proposed activity is kept up to date on the website of the National Nuclear Energy Generating Company “Energoatom”. The links to the materials on the public relations under the CSFSF project are posted on the official website of the National Nuclear Energy Generating Company “Energoatom” as shown in Table 1.1.

Table 1.1 **Links To The Materials On Public Relations Under The CSFSF Project**

Title	Electronic address (URL) of the remote resource
Media about CSFSF	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/media/
Materials for the public	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/press/
Official documents	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/official/

For the purpose of informing the public about the proposed activity, the Project stage involves the following activities:

- publication of the Environmental Impact Statement;
- information update on the website of National Nuclear Energy Generating Company “Energoatom”.

1.6 The List Of Normative And Methodological Documents Used

The specific normative and methodological documents used during the preparation of the EIA materials are indicated in the text as references and are listed in List Of Reference And Normative Documents.

1.7 Description Of The Environmental Indicators’ Dynamics Forecasting Techniques And The Substantiation Of The Forecast Periods Used

The predictive assessment of the dynamics of the environmental indicators is based on the assessment of the impact over the full scope of works performed on the CSFSF site.

The assessment of the radiation factors is based on the radioactive decay of the radionuclides contained in the environmental pollution, as well as additional pollution from the planned activities.

Where there is no reliable baseline data necessary to carry out the environmental impact assessment of the planned activity, the conservative approach is used.

1.8 The Information About The Structural Units Of The Executor And The List Of Subcontractors And Specialists Involved In The EIA

The EIA materials as part of the project “Construction of Central Spent Fuel Storage Facility for the VVER nuclear power plants of Ukraine” were prepared by the subdivisions of Public Joint Stock Company Kyiv Research and Design Institute “Energoproject”:

- Production and Technical Department — Department No. 202;
- Main Technology Division of NPP — Department No. 203;
- Main Technology Division of TPP — Department No. 204;
- Radioactive Waste Handing And Water Treatment — Department No. 205;
- Electrical Engineering Department — Department No. 207;
- Department Of Automated Control Systems — Department No. 209;
- Department Of Reinforced Concrete Structures And Design — Department No. 211;
- Architectural Department For Industrial And Civil Engineering — Department No. 214;
- Heating and Ventilation Systems — Department No. 215;
- Water Supply Department — Department No. 216.

The subcontractors who participated in the development of the EIA materials:

- The State Enterprise Kyiv Institute Of Engineering Survey and Research “Energoprojekt” — SE KIESR EP;
- The Research Institute “Ukrainian Scientific Research Institute of Ecological Problems” — UKRNIIEP;
- The Institute of Nuclear Power Plants Safety of the National Academy of Sciences of Ukraine — IPB AES NANU.

1.9 The List And Brief Analysis Of The Previous Approvals And Expert Assessments, Including The Public Examination (If Held)

In relation to the object of design, the CSFSF investment feasibility study [24] was performed as approved by the State expert appraisal board (conclusion by SE “Ukrderzhbudekspertyza” № 84/54/288 of 26.08.2008 [25]) and Resolution of the Cabinet of Ministers № 131-p of 04.02.2009 [22].

1.10 The List Of Information Sources Used In The Development Of The EIA Materials

The main source of information used in the development of the EIA materials as part of the project "Construction of Central Spent Fuel Storage Facility for the VVER nuclear power plants of Ukraine" is the EIA within the CSFSF investment feasibility study [24].

Also, the data on engineering surveys carried out for the project “Construction of Central Spent Fuel Storage Facility for the VVER nuclear power plants of Ukraine” were used as the source data, namely:

- the scientific research report on the engineering survey: Book 2. Geotechnical Works (19-571402/172-08-735) [45];

- the report on the research project “Evaluation Of Safety Of Construction And Installation Works Under The Project Of Building A Central Spent Fuel Storage Facility for the VVER nuclear power plants of Ukraine” [47].

The initial data for the EIA were also collected from all the available sources that characterize the current state of the environmental components of the CSFSF zone, the monitoring data, the results of technical and other studies of the past years, the cartographic materials and other information.

The data on the initial state of the natural, social and technological components of the environment on the territory of the potential impact of the projected site, as well as the radiological conditions were obtained from the following sources:

- the scientific periodicals, monographs, proceedings of scientific conferences on the exclusion and compulsory resettlement zone;
- the STR reports by scientific institutes of NAS of Ukraine;
- annual reports GSNPP Ecocenter on the results of monitoring of the radiation situation within the territory of exclusion and compulsory resettlement zone;
- the ecological passport of the Kyiv Province;

2 ANNUAL REPORTS OF THE STATE AGENCY OF UKRAINE FOR THE EXCLUSION ZONE MANAGEMENT ON RADIATION SAFETY, OCCUPATIONAL SAFETY AND HEALTH OF WORKERS IN THE EXCLUSION AND COMPULSORY RESETTLEMENT ZONE. PHYSICO-GEOGRAPHICAL CHARACTERISTICS OF THE AREA AND SITE OF THE DESIGN OBJECT

2.1 Physical And Geographical Conditions Of The Area

2.1.1 The Geographical Location Of The Site

The area for the CSFSF is located in Ivankov administrative district of Kyiv province within the exclusion and compulsory resettlement zone.

The map of the site is shown in Figure 2.1.

Figure 2.1. **The Site Location Map**

The CSFSF site is located in the area between the abandoned settlements of Buryakovka, Chistogalovka and Stechanka, and is stretched out in the south-north direction. The bordering sites are:

- “Vector” production facilities — on the east;
- the 110 kV overhead power line — on the west;
- the access road to the "Vector” production facilities — on the west;
- wood located within 1 km from the nuclear waste burial facility “Buryakovka”.

The site is located 12 km south-west from the Chernobyl nuclear power plant.

According to the plan of construction, the CSFSF site is located within the SPZ of the radiation-dangerous object — the facilities for decontamination, transportation, processing and disposal of the radioactive waste from the areas contaminated by the Chernobyl accident — production facilities “Vector”. The plot area is 18.2 hectares. The shortest distance from the CSFSF structures to the structures of “Vector” is 160.00 m.

The schematic map of the master layout plan of the CSFSF is provided in Annex E, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The sizes of the sanitary protection zone and the control zone are defined in the CSFSF investment feasibility study [24]:

- the sanitary protection zone — within 100 m from the border of the site, taking into account the geometry of the CSFSF site;
- the CSFSF control zone — within 600 m from the storage site.

The situational plan (sketch map) of the area for the design facilities as well as the sanitary protection zone (100 m) and the area CSFSF control zone (600 m) are shown in the figure below.

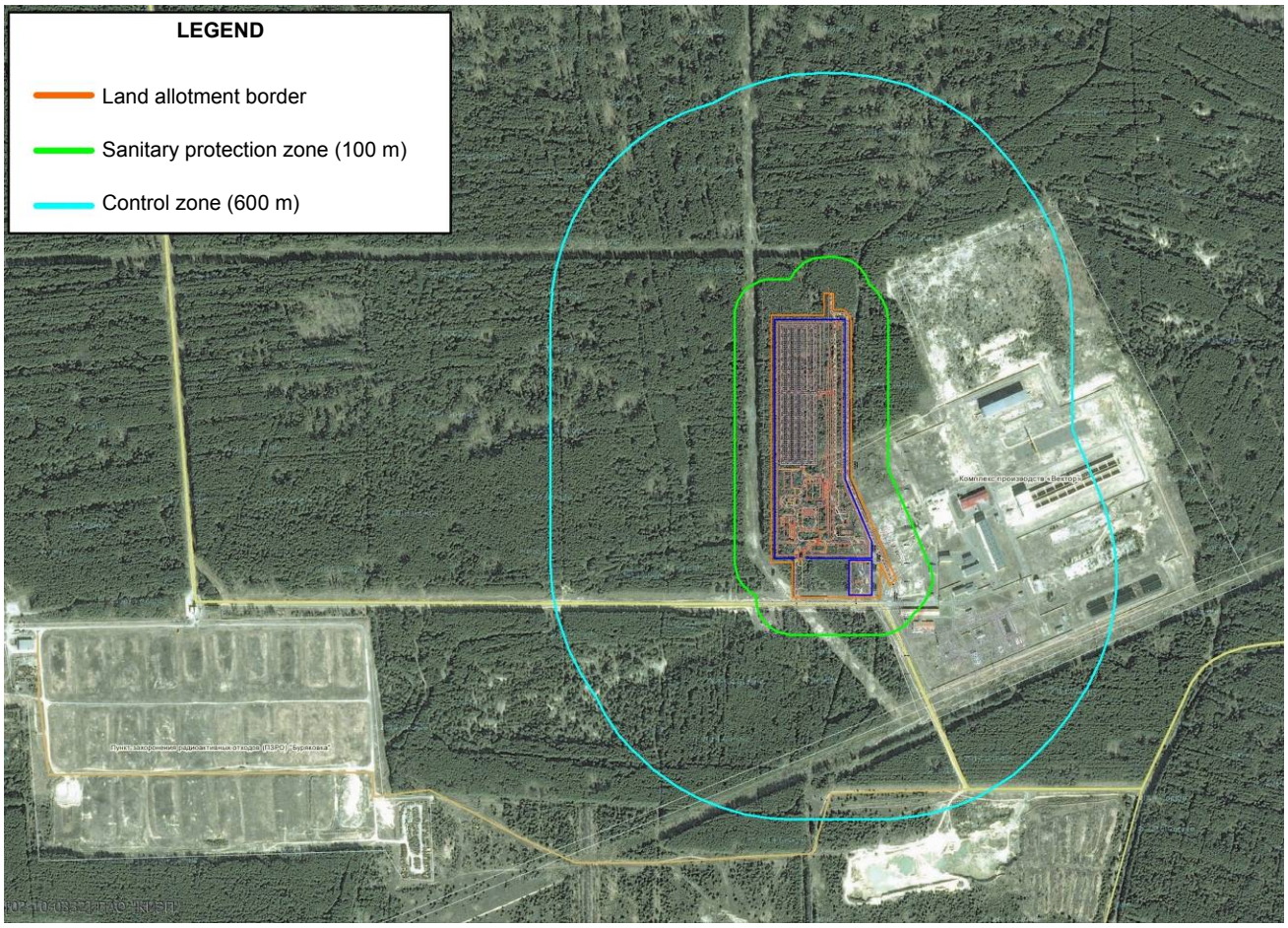


Figure 2.2. **The Situation Plan (Sketch Map) Of The Designe Site**

2.1.2 The Directional Position And The Distance From The CSFSF To The Nearest Cities And Important Sites

The distance and direction from the CSFSF site to the nearby cities and important sites is presented in Table 2.1.

Table 2.1. **The Direction And Distance From The CSFSF To The Nearest Cities And Important Sites**

Site	Direction from the CSFSF	Distance, km
Chernobyl	Southeast	20
Ivankov	South	43
Slavutich	Northeast	58
Chernihov	Northeast	90
Kyiv	South	110
The state border between Ukraine and the Republic of Belarus	Northwest	13
The border of the exclusion and unconditional (obligatory) resettlement zone	North East South South-west West Northwest	13 28 23 12 39 29
The inner boundary of the 10-km special radiation danger zone (the 10-km Chernobyl NPP zone)	South-west	2
“Buryakovka” burial site	South-west	1.1
Chernobyl NPP production site	Northeast	12
“Shelter”	Northeast	12
The Sahan River floodplain	North	9
The Uzh River floodplain	South-west	11
The Pripyat River floodplain	Northeast	12
Kyiv water storage	Southeast	32

2.1.3 The terrain and landscape

The CSFSF site area is thee right-bank watershed the Pripyat River valley and the left-bank watershed of the Uzh River valley, and is characterized by the undulating relief created by the water-glacial accumulation. The distance to the Pripyat River is 8 km, to the river Uzh — 18 km.

The relief of the area around the storage facility is of aeolian nature. The relief is accumulative, undulating, represented by a variety of genetic categories of smaller order. The relief of the area is slightly slopy from north to south and is characterized by altitudes from 142.00 to 139.00 m in the northern part and from 138.50 to 137.00 m in the south.

Territory of the exclusion and compulsory resettlement zone features more landscape diversity, including about 20 different landscapes [48].

The typical landscape forms of the Chistogalovka Chernobyl and Pripyat-Dnepr physiographic regions, as well as their relative areas falling within the exclusion and compulsory resettlement zone, are shown in table 2.2.

Table 2.2. **The Typical Forms Of Landscape Within The Area Of Impact Of The Proposed Activities**

Typical Landscape Form	Typical Soils	Typical Vegetation	Area, %
Terminal moraine ridges	Sod-podzolic silty sands	Pine-oak forests	10
Steepe (8-12°) convex-concave deluvial slopes	Sod-podzolic silty sands	Hornbeam-oak forests	4
Low flat floodplains	Alluvial sod or turf-covered sand and sod	Swamp willow	12
Flat and hilly floodplain sandy terraces	Sod-podzolic sands	Dry-grass pine forests	14
Flat floodplain terraces formed by lowland peat	Peat-bogs	Alder and willow swamp grass	12
Reclaimed deposits	-	-	14
Dry deposits	-	-	28
Other	-	-	6
TOTAL			**100**

2.1.4 The Geological Conditions, Seismicity And Neotectonics Of The CSFSF Production Area

2.1.4.1 Geological Conditions

The geological structure of the area of influence of the planned activities is composed of the Precambrian crystalline formations (the Proterozoic group) and the sediment deposits (the Palaeozoic, Mesozoic and Cenozoic groups).

In terms of geomorphology, the CSFSF site is located in the north-eastern part of the Kyiv moraine outwash plains (Kyiv Polissya) being the part of the Polesie lowlands, which belong to the stratum-plains.

The absolute altitudes of the construction site are 136.98 to 140.78 m.

The geological structure to the depth of 42.0 m is formed by the Middle Pleistocene deposits (fgRII) of fluvioglacial, lacustrine, fluvioglacial and moraine origin. In general, these rocks are of the glacial complex of the Dnieper glaciation. The fluvioglacial deposits are sandy-clay soils. The sands are light gray, yellowish-gray to brown, small- and medium-grain, with layers of dust-like sands. In the thick sands at different depths, there are fixed lenses of clay soils. The clay soils are presented by yellowish brown sandy loam and loam. They occur as lenses and layers generally 2 to 6 m thick. The drilled depth is 41.8 m. On the surface, the fluvioglacial sediments are covered by a layer of soil and vegetation. Near “Vector” facilities, greeted bulk soils wit the depth of 0.5 to 1.9 m occur. The deposits of the Kyiv stratum of the Eocene (R2kv) lie at the depth of 40.0 m, the absolute altitudes of the top range from 99 to 110 m; there are marls, bluish-green and mica clays. The deposits are found everywhere, but washed out (with gaps) in some areas. The features of the geological and hydro-geological conditions of the CSFSF construction site are determined by its affinity to the watershed plateau between the valleys of the rivers Pripyat and Uzh.

2.1.4.2 Hydro-geological Conditions

The hydro-geological conditions of the CSFSF site are determined by the characteristics of aquifers and the locally developed poorly permeable sediments in the following stratigraphic sequence:

- the aquifer system of the Quaternary deposits;
- the poorly permeable deposits of the Kyiv Eocene stratum (the marl stratum);
- the aquifer system of the Eocene sediments;
- the poorly permeable deposits of marl-chalk in the upper part of the Upper Cretaceous;
- the aquifer system of the mid-Cretaceous sediments.

Because of certain permeability and uneven spread of the poorly permeable sediments, all the listed aquifers are interconnected and form a single hydraulic system.

With the explored depth (42 m) the dominating is the Quaternary aquifer system. The water of the Quaternary deposits aquifer complex is located in the Mid-Pleistocene glaciofluvial sediments. The aquifer system is unconfined. In terms of salt composition, the water is mainly hydrocarbonate calcium, non-corrosive to concrete. In terms of protection from the surface radioactive chemical pollution, the Quaternary aquifer is vulnerable. The depth of the groundwater layer varies from 12.2 to 19.2 m. The absolute altitudes range from 120.45 to 126.95 m. In the area of “Vector”, the registered water type is the vadose water at the depth of 3.6 to 3.7 m, which corresponds to the absolute altitude of 133.45 to 133.51 m. The hydrogeological situation on the CSFSF site is stable, there were no significant fluctuations of the water level during the survey (winter-spring) [45]. The rock permeability (filtration factor) in the area of the CSFSF is shown in Table 2.3.

Table 2.3. **The Rock Permeability (Filtration Factor) In The Area Of The CSFSF**

Soil	Filtration Factor, m/day
Silty sand in the aerated zone	1.75
Silty sand in the saturation zone	3.5
Chalky-sand in the aerated zone	3.0
Chalky-sand in the saturation zone	4.0
Medium-grain sand	15
Fluvioglacial loam	0.1
Fluvioglacial sandy loam	1.0

Temporary water table of the vadose water may form in the thick deposits on top of the impermeable layers of clay soils. The water confining stratum was not found within the drilling depth. The top of the poorly permeable sediments is located at the depth of more than 40.0 m in the watershed area. The poorly permeable sediments of the Kyiv stratum (the marl stratum) are of regional distribution, they separate the Quaternary deposits aquifer from the pressure-unconfined aquifer system of the Eocene (the Buchaksko-Kanevsky) deposits. In the course of study [45], based on the results of laboratory tests of soils and the geophysical studies in the wells (radioisotope logging), the main indicators of the physical and mechanical properties of soils were determined. The engineering-geological elements CSFSF site are set out in Table 2.4.

Table 2.4. **Geotechnical Elements Of The CSFSF Site**

EGE	Properties Of The Engineering-Geological Elements (EGE)	Geological Index
1	Soil and vegetation layer	eH
1a	Bulk layer — fine sand	tH
2	The sand is fine, dense, of heterogeneous granulometric composition, with the water saturation from poor to rich	fgP_{II}
3	The sand is pulverescent, dense, of heterogeneous granulometric composition, with the water saturation from poor to rich	
4	The sandy loam is pulverescent, above the GWL — solid, below the GWL — plastic	
5	The loam is light and pulverescent, stiff and plastic	
6	The sand is medium-grained, of homogenous granulometric composition, dense, with the water saturation from poor to rich	

2.1.4.3 The Seismicity And Neotectonics Of The CSFSF Production Area

Currently, the CSFSF construction site is outside the area of the latest faults. According to DBN V.1.1-12:2014 [50], the seismicity of the area on the MSK-64 scale is set out below (Annex B to the DBN):

- the map fragment OCP-2004-A — 5 points with the seismic gap of 500 years (the seismic intensity exceedance probability for 50 years — 10 %);
- the map fragment OCP-2004-B — 5 points with the seismic gap of 1000 years (the seismic intensity exceedance probability for 50 years — 5 %);

- the map fragment OCP-2004-C — 6 points with the seismic gap of 5000 years (the seismic intensity exceedance probability for 50 years — 1 %).

The East-European platform, to which the CSFSF industrial site belongs, is considered of weak seismic activity.

The strong Romanian (Carpathian) earthquakes are centered in the Carpathian Arc zone (The Vrancea zone) at the depth of 120-160 km. They are deep-focus subcrustal earthquakes of 9-10 points in the epicenter. The seismic waves from these earthquakes are detected on the territory of Ukraine.

For the area of the CSFSF industrial site, the maximum background seismicity impact for average soil conditions is assumed in accordance with the Letter of Construction Committee of Ukraine [51]:

- for the design earthquake (DBE) ..... 5 points;
- for the maximum design earthquake (MDE) ..... 6 points.
- The likelihood of MDE is 10^{-4}, PBE — 10^{-2}.

2.1.5 Soils

The soil cover under the potential impact of the projected area of activity is characterized by a mosaic, microcomplex and contrast deposition patter, which is explained by the variety and abrupt changes of the soil formation factors. These include a wide range of soil-forming rocks of different particle size and mineralogical composition, a complex meso- and micro-relief being the cause of sharply differing moisture conditions, expressly humid climate and diverse vegetation [52].

The parent rocks are the Quaternary deposits — the super-moraine water-glacial sands and the ancient and modern alluvium. In the floodplains and terraces there are deposits of biogenic origin, represented mostly by low-lying peat bogs of various thickness.

The soil cover of the exclusion and compulsory resettlement zone is very diverse and complex. There are 14 most common soil types [53].

The degree of complexity of the soil cover is determined not only by the typological variety of soils, but also by their combinations, size and contours. In this respect, the soil cover of the physiographic areas of the European woodlands, including the territory of the exclusion and compulsory resettlement zone, belongs to one of the most complex in the world.

The characteristic feature of the CSFSF construction site is the combined floodplain (pine forest) river terraces, which form aligned interfluves wit the most common soils extending dozens kilometers.

The distribution of the genetic soil types in the exclusion and compulsory resettlement zone is shown in Table 2.5.

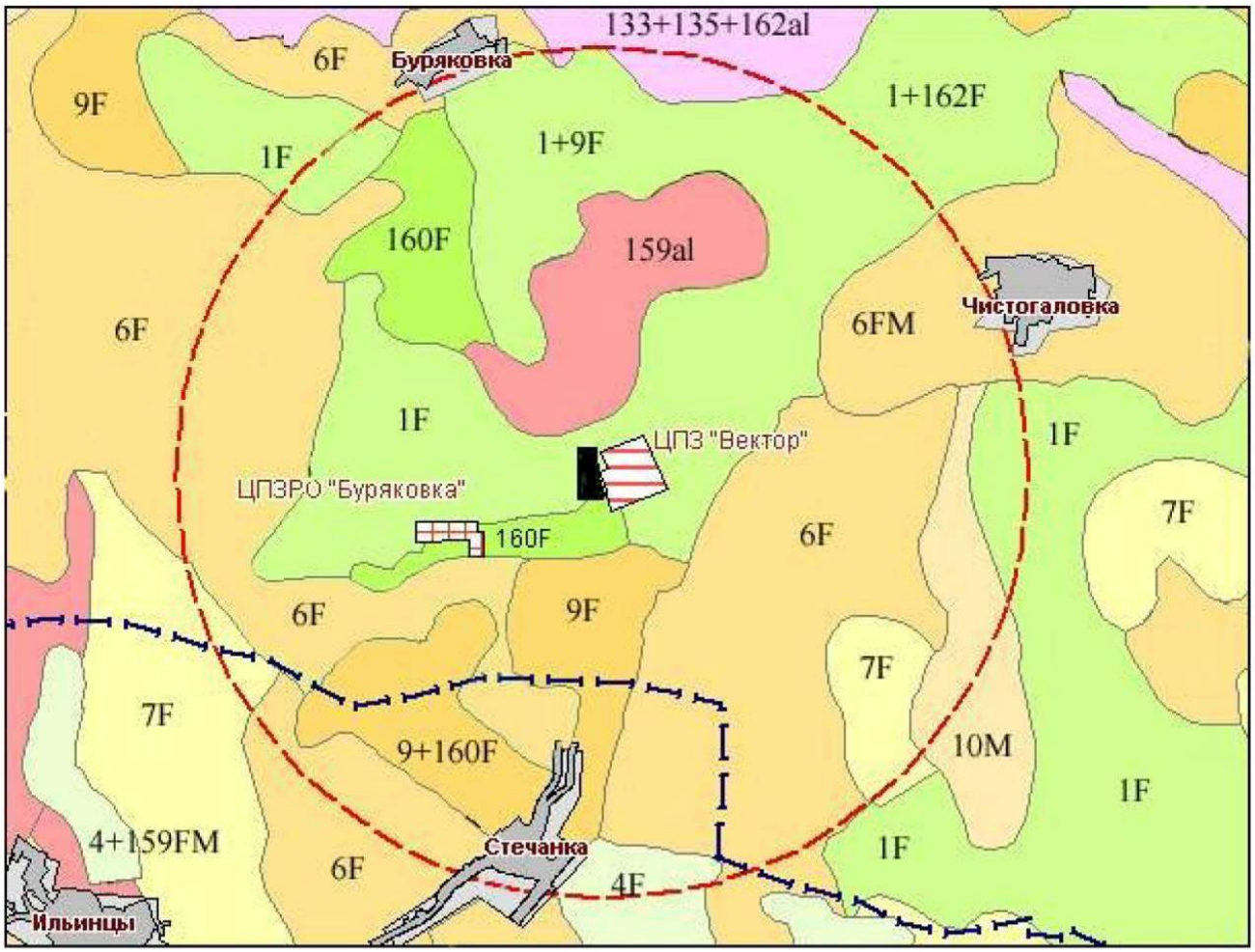
Table 2.5. **Distribution Of The Genetic Soil Types In The Exclusion And Compulsory Resettlement Zone**

Soil Groups By Contours	Contour Area, %
Poorly turfy and poorly humous sands	1.9
Soddy, cryptopodzolic and poorly podzolic sandy and clayey-sandy gleic and non-gleic soils in combination with sod gley loamy soils	4.7
Soddy, poorly and medium-podzolic sandy and clayey-sandy soils	12.7
Sod-podzolic loamy soils	3.0
Soddy, cryptopodzolic sandy and clayey-sandy gleic soils in combination with sod gley sandy, clayey-sandy and loamy soils	31.7

Soil Groups By Contours	Contour Area, %
Soddy, poorly podzolic gleic sandy and clayey-sandy soils in combination with the sod mid- and heavily podzolic gleic loamy-sand and sod gleic loamy-sand soils	10.0
Soddy, poorly podzolic gleyey loamy-sand soils in combination with the sod mid- and heavily podzolic gleic loamy-sand soils	2.5
Soddy, mid- and heavily gleic loamy-sand soils in combination with the sod gleyey loamy-sand soils	5.5
Sod podzolized soils and their differences	0.1
Soddy, gleic sandy and clayey-sandy soils in combination with sod cryptopodzolic sandy and clayey-sandy gleyey and bog soils	8.3
Soddy, gleic loam-sandy and loamy soils in combination with sod gleyey sandy and clayey-sandy and bog soils	10.0
Bog soils in combination with peat-bog soils	5.7
Peaty and peat-bog soils	1.1
Lowland peatland	2.8
Total	**100.0**

The soil cover on the CSFSF site is shown in Figure 2.3.

The major genetic soil type is sod-podzolic. This includes the crypto-sod, poorly and mid-dzolic sandy, clayey-sandy gleic and non-gleic soils typically occurring in conjunction with the sod gleic sandy and clayey-sandy soils. Another most common genetic type of soils is sod soils. This type of soil is characterized by microcomplex bedding. They are usually found in combination with the sod-podzolic soils. Large massifs of sod soils occur in the central parts and the riverbed parts of the floodplains as well as in other periodically strongly moisturised lowlands. All of them are more or less gleic. In terms of particle size distribution, the sod soils do not differ from the sod-podzolic soils. However, the high moisture content and a relatively high amount of plant residue contribute to greater accumulation of humus, which puts these soils among the most fertile soils of the exclusion and compulsory resettlement zone.



LEGEND

■ - CSFSF construction site
160 - Soil Type Code
1+162F - Soil Complex

Soil-forming Rocks
al - Alluvial deposits
F - Fluvioglacial deposits
FM - fluvioglacial deposits with underlying moraine (<1 м)

Soils
1 - Soddy, cryptopodzolic sandy (forest sands)
4 - Soddy-podzolic loamy sands
6 - Soddy, poorly podzolic, gley, sandy and clayey-sandy
7 - Soddy, poorly podzolic, gleyey, loamy-sandy
9 - Soddy, poorly podzolic, gleyey, sandy and clayey-sandy
10 - Soddy, poorly podzolic, gleyey, sandy and clayey-sandy
133 - Bog
135 - Peat-bog
159 - Soddy, gleic sandy and clayey-sandy
160 - low-humus and poorly soddy sands
162 - Soddy, gleic, loam-sandy

Figure 2.3. **The Schematic Map Of The Soil Cover Within 5 Km Around The CSFSF Site**

There are also bog soils in combination with the peat-bog soils and fen peatlands. They are formed in relatively deep depressions on the floodplain terraces of the rivers in conditions of constant excessive moisture under the marsh vegetation, which leads to the accumulation of peat. The bog soils are especially widespread in the northern part of the exclusion and compulsory resettlement zone, forming large massifs there. In the southern part of the zone, the peat soils and peat fens occur more often.

Like on the entire territory of the exclusion and compulsory resettlement zone, the largest area is occupied by the sod-cryptopodzolic sandy, clayey-sandy gleyey and non-gleyey soils. These soils were formed on the ancient alluvial sandy noncalcic deposits, which explains the low fine-grain content.

The solid phase of the sandy and clayey-sandy soils is almost monomineral (95 %) containing chemically inert quartz (SiO_2). These specific characteristics determine their negative ecological properties — the high water permeability at low sorption capacity (3.4–3.8 mEq/100 g), the low potential fertility because of poor content of humus and nutrients, the poor water capacity and high acidity (pH_{KCL} — 4.6–4.9). Thus, these soils have the least ability to accumulate the technogenic radioactive contamination.

2.2 Climate Characteristics

The territory under potential impact of the projected activity is open to the inflow of the air masses formed over the Atlantic and Arctic, the Mediterranean and the Black seas. It is also influenced by the continental air from the Eurasian plains.

According to the climatic zoning, the CSFSF site is located in the Climatic Region I, according to DSTU-NB V.1.1-27:2010 [54]. The climate of the zone of influence of planned activity is moderate continental with mild winters and warm, humid summers. This area is characterized by positive moisture balance. Most of the precipitation (70 %) occurs in the warmer months. The transitional seasons (spring and autumn) are lengthy. This is due to the arrival of the warm sea air, which is accompanied by considerable cloudiness and precipitation preventing the air warming in spring and cooling in autumn. The transition to the cold period is related to the invasion of the cold arctic air, which leads to a sharp and substantial cooling — the first frosts and snow. The frequency and intensity of these invasions gradually increase and reach the maximum in winter.

To characterize the climatic conditions of the area of influence of the projected activity, the long-term observation data of hydrometeorological station “Chernobyl” have been used as supplied by the Central Geophysical Observatory CGO (Annex Ж, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes).

2.2.1 Air Temperature

The major parameters that characterize the temperature regime of the surface layer of the atmosphere in the vicinity of the zone of influence of the projected activities, are shown in Table 2.6.

The average monthly temperature in the vicinity of the CSFSF site is shown in Table 2.7.

Table 2.6. **The Basic Air Temperature Parameters In The Vicinity Of The Zone Of Influence Of The Projected Activities**

Parameter	Temperature, °C
Annual mean	6.7
Absolute maximum (July)	39.0
Absolute minimum (January)	Minus 35.0
Average monthly maximum of the hottest month (July)	24.2
Average monthly minimum of the coldest month (January)	Minus 6.1

Table 2.7. **The Average Monthly Temperature In The Vicinity Of The CSFSF Site**

Month	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Temperature, °C	Minus 6.7	Minus 5.0	Minus 0.13	7.5	14.3	17.7	19.1	18.2	13.1	7.2	1.7	Minus 2.7

The design temperature for the coldest five days is minus 22 °C. The warmest month of the year, according to the observations of Hydrometeorological Station “Chernobyl”, is July — the average temperature is +19.1 °C. With the probability of 1 % the maximum air temperature in the area of the proposed activity can reach +40,0 °C and above.

The maximum temperatures lead to droughts, which may be accompanied by forest fires.

2.2.2 Wind Direction And Speed

The area around the CSFSF site is open for the inflow of the air masses formed in the Atlantic and Arctic, and the Mediterranean and the Black seas. This area is also influenced by the continental air from the Eurasian plains.

During the year, the prevailing wind direction near and around the CSFSF site is west, northwest and southwest. In summer, the prevailing wind direction is west-north-west for 17.2% of the time. In winter, the prevailing wind direction is west-southwest (for 16.9-17.3 % of the time).

The wind directions chart for the CSFSF site (windrose and anti-windrose) is shown in Figure 2.4.

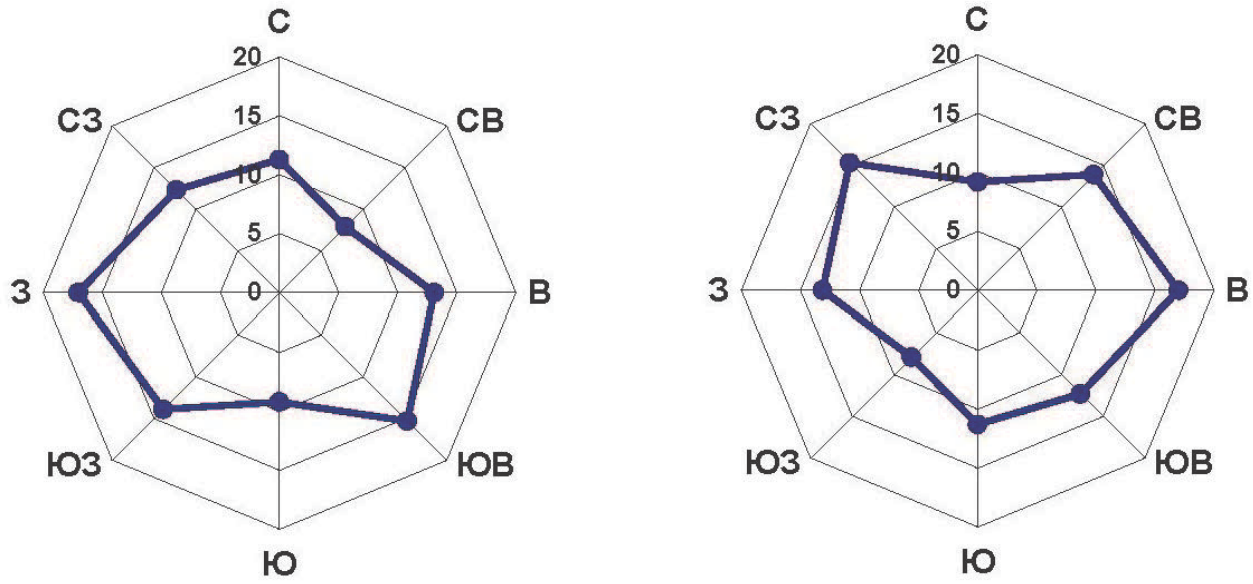


Figure 2.4. **Chart of Wind Direction Recurrence (%)**
For The CSFSF Site (Windrose And Anti-Windrose)

In most cases (50–60 %), the observed wind speed is 2.1 m/s. Calm weather is not typical for the region. In winter, it recurrence amounts to less than 1 %. In summer, it rises up to 3 % or more. In winter, the recurrence of wind speed of 10 m/s or more is 5 %, while, in summer, it is 1.2 %.

The recorded maximum wind speed is 25 m/s both in winter and in summer.

Storm winds (15 m/s and more) are not frequent in the vicinity of Chernobyl. During the cold period, their last for 1-2 days in the period. During the warm period, the average persistence is 1 day in the period. However, in some years, the wind speed can reach or exceed 15 m/s staying for 10 days during the period.

The wind speed of 18 m/s might occur once a year, the speed of 21 m/s — once every five years, 22 m/s — once in 10 years, and 24 m/s — once in 20 years.

The calculated maximum wind speeds and the probability values are as follows:

- 0.01 %..... 47.3 m/s;
- 0.1 %..... 40.4 m/s;
- 1.0 %..... 32.0 m/s;
- 2.0 %..... 25.0 m/s;

2.2.3 Relative And Absolute Air Humidity

The absolute humidity changes as the air temperature changes:

- the annual average relative air humidity is 77 %;
- the water-vapor partial pressure is 0.86 kPa.

In winter, the average monthly relative air humidity reaches its peak, while the average seasonal value is 86 %.

As the temperature increases, the relative air humidity drops from 80 % in March to 64 % in May. In April, the humidity starts to get summer features. The average seasonal humidity is 72 %. In summer, the relative humidity gradually grows as the storm activity and precipitation increase.

In autumn, the relative humidity significantly increases from 74 % in September to 81 % in October, and 88 % in November. In general, the relative humidity is 81 % in autumn.

On the CSFSF site, there are 122 humid days per year (the relative humidity of 80 % or more) and 19 dry days (moisture content of 30 % or lower).

2.2.4 Precipitation

In terms of precipitation, the CSFSF site is located in the zone of sufficient moisture. The annual precipitation pattern is characteristic for the continental areas.

The precipitation occur mainly (70–75 %) in the warm season. The average annual amount of precipitation exceeds the evaporation. The annual precipitation layer in the multi-year cycle varies from 301 to 829 mm.

The average monthly rainfall varies from 26 mm in February to 78 mm in July. The maximum daily precipitation is 190 mm. The maximum precipitation with the probability of 10^{-4} in a 20-minute period can reach 72 mm.

On average, 150 days in a year, the precipitation does not exceed 0.1 mm (water).

2.2.5 Snow Cover

The characteristic snow load (the average snow load component that may be exceeded 1 time in 50 years) is 1600 Pa.

The winter is characterized by frequent thaws and unstable snow cover. The stable snow cover is formed about a month after the first snowfall. The stable snow cover is not achieved in about 7-10 % of winters. The average date of snow cover occurrence is the 20th of November. On average, the snow stays till mid-March. The number of days with snow cover is 90–102. In winter, the thickness of snow cover varies. The snow depth on the open areas reaches 8 cm on the average. The average maximum height for winter is 17 cm, the absolute maximum is 41 cm. The snow cover of 75 cm occurs once every 100 years. In 7 % of winters, the snow cover is absent. The maximum layer of snow accumulated in one snowfall is 20 cm.

2.2.6 Thunderstorms, Hail

Thunderstorms occur mainly during the period from April to September and, very rarely, in March and October (up to 2 times in 10 years).

The average number of stormy days a year is 29, the maximum is 45.

In the area of the CSFSF site, hail may occur from April to October. In June, the hail occurs every other year; in July and August — once in 5 years. During the year, the average is 2 days with hail. 20 % of the years is hail free. In some years, there may be 3 days with hail, and 9 days in the whole year.

Hail falls unevenly, as a rule, on small areas.

2.2.7 Icy Conditions

The CSFSF site belongs to the area with moderate icing conditions. Icing occurs throughout the cold season (October to April). In the early autumn and late spring, icing is very rare — once every 5–10 years.

In terms of icy conditions, the area under consideration belongs to the Area II.

The ice thickness recurrence 10 m above the ground reaches 5 mm once in 5 years, at the height of 200 m it is 35 mm.

2.2.8 Flood And Rain Floods

Over the past 100 years, the spring floods with water flow rate exceeding 4000 m^3/s occurred in 1932, 1941, 1958, 1970 and 1979. The highest flood in the post-accident period was recorded in 1999.

Rain floods usually less intense, than the spring floods. The average recurrence 1 to 2 times per year, and the duration is much less than that of the spring floods.

2.2.9 Fog

In autumn and winter, there are 5 to 9 days with fog per month. In summer, fog is rare. The average duration of fog throughout the year is more than 291 hours. The duration of fog in winter ranges from 30 to 69 hours, in summer — 2 to 5 hours. The average duration of fog during a day is 6 hours (on foggy days).

2.2.10 The Stability Of The Atmosphere

The data on the atmospheric inversion obtained from Meteorological Station “Kyiv”, where the measurements are taken twice a day (day and night) using radiosondes.

Most of the surface inversions occur during the night (especially during the warm period of the year), in the afternoon they, are less frequent, than at night.

The surface inversions recurrence during the year (as a percentage of the number of radiosonde launches in the current month and period) is 47 at night and 3 duing the day.

The average annual capacity of the night surface inversion (thickness) is 0.38 km, the daytime surface inversions is 0.65 km.

The average annual rate of surface inversions (the temperature difference between the lower and the upper limits) is 2.4 degrees at night, and 3.6 degrees during the day.

During the day and at night, there is no significant difference in the recurrence of the relief inversions, but it is the greatest. Most significant recurrence of the relief inversion occurs during the cold season.

The relief inversions recurrence during the year (as a percentage of the number of radiosonde launches in the current month and period) is 40 at night and 46 at noon.

The annual average daily rate of the relief inversions is 0.36 km (2.2 degrees).

2.2.11 Squalls

In the area of the CSFSF site, squalls occur mainly during the warm period of the year, when there are strong convection flows and large temperature contrasts. The frequency of squalls over the major part of Ukraine is insignificant, just one day per year. The occurrence of winds up to 25 m/s in Kyiv province is once in three years. The average number of days with the wind speed of 25 m/s and higher, are set out in Table 2.8

Table 2.8. **The Average Number Of Days With The Wind Speed Of 25 m/s And Higher**

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Kyiv, Chernobyl	0.1	0.1	-	0.05	0.1	0.05	0.02	0.05	-	0.1	0.1	0.02	0.7

Squalls are characterized by sharp short-term strengthening of the wind speed and unexpected changes in its direction. On the territory of Kyiv and Chernihiv regions, the squalls occur once in 3–5 years. The data on the average number of squalls and their recurrence are shown in Table 2.9.

Table 2.9. **Squall Days Recurrence**

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	N	%

Kyiv Province	-	-	1	1	1	3	4	7	-	-	-	-	17	0.05	36.4

The duration of heavy squalls is insignificant. Usually (in 69 % of cases), they last for no more than one hour. During squalls, the wind speed is often about 21-35 m/s. The squally winds are usually accompanied by pouring rains and thunderstorms; hail is rare. During squalls, the atmospheric pressure fluctuates (it is low before the squall, and rises after it). The air temperature during the squalls sharply falls, and then slightly increases (the temperature difference is often more that 10 °C).

2.2.12 Tornadoes

In Ukraine, a tornado is a rare natural phenomenon.

Tornadoes are usually associated with the instability of warm air masses near the cold front as well as the presence of powerful cumulonimbus. Tornadoes may occur over any surface. Most often their intensity is of the Class 1. However, more intense tornadoes of Class 3 are also possible. The tornado loads are established by Main Normative Requirements And Estimates Of The Tornadoes For The Are Of Chernobyl NPP (approved by Order No. 64 of DerzhBud of Ukraine of 21.10.2002). The probability of exceeding the estimated tornado class for the objects, located on the industrial site of Chernobyl NPP should be assumed as $P=1x10^{-6}$ (for the newly designed objects) or $P=1\times10^{-5}$ (for the objects under operation and reconstruction). The design tornado characteristics are set out in Table 2.10.

Table 2.10. **Design Characteristics Of Tornadoes**

Design Characteristics Of Tornadoes	Value
Design tornado probability class, k_p	1.5
Exceedance probability (event/year)	1×10^{-5}
Maximum rotational speed of the funnel, V_p, m/s	50
The speed of progressive motion, U_p, m/s	12.6
The pressure difference between the center and the periphery of the tornado funnel, ΔP_p (hPa)	31.0
The length of the tornado path, L_p (km)	5.0
The width of the tornado path, W_p (km)	0.05

According to the standard calculations [55] presented in “The Design Study Of The Building Structures”, 30-406.218.002.RK02 [56] and “The Consolidated Report On The Survey Of Structures, Systems And Components”, 30-406.211.002.OT00 [57] the tornado is not considered a threat to the CSFSF site’s safety.

2.3 The Sites Of Natural Reserve Fund (NRF)

Due to the wealth of flora and fauna in the exclusion and compulsory resettlement zone, on the territory of which it is planned to build the CSFSF, and its role in the maintenance of the Pan-European biocenotic, species and population relationships and flows, 11 natural reserve fund (NRF) sites were established long before the even before the Chernobyl disaster [58, 59].

In addition, in 2007, the zoological reserve of national importance “Chernobyl Special” with the area of 48,870 hectares was declared an NRF territory [60].

The territory of “Chernobyl Special” Reserve was announced wildlife preserve for the purpose of observation and regeneration of the natural complexes under the conditions of reduced industrial load, because these lands were withdrawn from economic use, dissociated from the surrounding areas, and classified as radiation-dangerous. The preserve is located in the zone of mixed forests characterized by rich and unique vegetation. There are 19 species of plants listed in the “Red Book of Ukraine.” The vertebrate fauna is very diverse, which is primarily the result of the protected regime established after the Chernobyl NPP accident in 1986. There are 38 animal species listed in the “Red Book of Ukraine.”

The list of the Ukraine’s NRF sites located on the territory of the exclusion and compulsory resettlement zone and their distances from the CSFSF site are shown in Table 2.11; the location is represented in Figure 2.5.

Table 2.11. **The List Of The NRF Sites On The Territory Of The Exclusion And Compulsory Resettlement Zone And The Distances From The CSFSF Site**

NRF Site No.	Title	Area, ha	Distance from CSFSF km
1	Republic Preserve “Ulyinsky” (hydrological reserve)	2000	~22.65
2	Centuries-old Oak Stands (botanical reserve) (local importance)	12	~20.22
3	The Prof. D. I. Tovstolesa Alder Stands (botanical reserve), partially destroyed (local importance)	4.8	~8.73
4	The “Gorodishche” Natural Monument (complex) (local importance)	5	~8.15
5	The Scots Pine Site (botanical reserve) (local importance)	5.8	~28.32
6	The Oak Tree (botanical reserve) (local importance)	0.02	~8.73
7	The Oak Stands (botanical reserve), partially destroyed (local importance)	11	~21.14
8	The Age-old Pine Tree (botanical reserve), extinct (local importance)	2.1	~8.15
9	The Centuries-old Oak Stands (botanical reserve) (local importance)	14.6	~16.05
10	“Zagoriye” Site (botanical reserve) (local importance)	110	~20.93
11	The Black Alder Stands in the Pripyat Floodplain (botanical reserve) (local importance)	14.3	~13.94
12	National Zoological Reserve “Chernobyl Special”	48870.0	~22.00

Legend

1	Republic Preserve “Ulyinsky” (hydrological reserve)
2	Centuries-old Oak Stands (botanical reserve)
3	The Prof. D. I. Tovstolesa Alder Stands (botanical reserve)
4	The “Gorodishche” Natural Monument (complex)
5	The Scots Pine Site (botanical reserve)
6	The Oak Tree (botanical reserve)
7	The Oak Stands (botanical reserve)
8	The Centuries-old Pine Trees
9	The Centuries-old Oaks
10	“Zagoriye” Site
11	The Black Alder Stands in the Pripyat Floodplain
12	National Zoological Reserve “Chernobyl Special”

Figure 2.5. **The NRF sites Layout On The Territory Of The Exclusion And Compulsory Resettlement Zone**

In connection with the increasing richness and diversity of flora and fauna, as well as the special status of the exclusion and compulsory resettlement zone, the scientific community of Ukraine proposes to grant the status of NRF to a significant number of sites with the total area of 13,640 ha [61-63].

Now, the exact number of protected plant and animal species on the territory of the exclusion and compulsory resettlement zone is not known. According to recent data, there have been found 22 plant species listed in the “Red Book of Ukraine” and 16 rare plant species [61-66].

On April 26, 2016, the President of Ukraine signed a decree on the establishment of Chernobyl Radiation-Ecological Biosphere Reserve with the area of 227 thousand hectares on the territory of

Ivankiv and Polesie Districts of Kyiv Province. The decree will come into force from the date of entry into force of the law governing the allocation of land plots of the exclusion and compulsory resettlement zone and the environmental protection regime of the territories and natural reserve fund sites created on the territory of such zones, as well as the cancellation of the requirement of establishing the biosphere reserves solely on the basis of nature reserves and national parks.

According to the decree, the Cabinet Ministers of Ukraine shall, within six months, establish the provisions on the reserve and, within two years, resolve the issue of allocating 226,964.7 hectares of lands and develop the land management plan, and approve the reserve master layout plan.

2.4 General Description Of The Flora And Fauna

2.4.1 Floral Complexes

The area around the CSFSF site is characterized by a set of ecotopes (forest, meadow, swamp) and the parameters of the the corresponding phytocenoses typical for Ukraine's Polissya Ukraine and the exclusion zone.

Since the accident, the forests of the exclusion zone changed greatly due to direct (effect of radiation) and indirect (lack of forest management) factors of the radioactive pollution. The lack of forestry management after the accident caused vast forest mortality due to natural disasters (fire, flooding, mass development of pests and diseases, etc.).

In terms of forest-vegetation zoning and soil-and-climatic conditions of the exclusion zone, the area belongs to the zone of Ukrainian Polissya (Kyiv Polissya subzone). This area covers the Polesie Lowlands of the East European Plain.

Since the cessation of economic activity, the former farmlands in the exclusion zone (especially their vegetation) have experienced significant transformations. In the first years after the accident, the farmlands overgrew with annual weeds. Over the next two-three years, the annual weeds were supplanted by creeping stem grasses (biennial and perennial). Starting from 1994–1995, the changes in the floral composition of grasslands achieved relative stability, which continues to the present. Now, the treeless areas of the Chernobyl zone are predominantly covered with couch-grass, bush grass and others.

In the past decade, the intensive processes of overgrowing of the meadows and fallow lands with woody vegetation was observed in the Chernobyl Exclusion Zone. In is mainly the self-seeding of birch and pine. The scientists believe that due to the natural reforestation more than 40 % of the grasslands in the Chernobyl zone are covered with woody vegetation.

In the places that are completely overgrown with couch-grass, vegetation layer is very dense with 100 % coverage. This produced a sufficiently thick layer of litter (dead plant remains), which prevents the establishment and growth of other plants, especially trees. Under such conditions, in areas with the predominance of couch-grass, the reforestation process is extremely slow.

The species composition of the forests in the exclusion and compulsory resettlement zone is primarily determined by the growth conditions (soil and moisture conditions). The structure of the forest resources in the exclusion zone, if compared to the pre-accident period, is characterized by significant changes explain by the transition of more productive farmlands to the forests.

The spatial distribution of vegetation types in the exclusion and compulsory resettlement zone is shown in Figure 2.6.

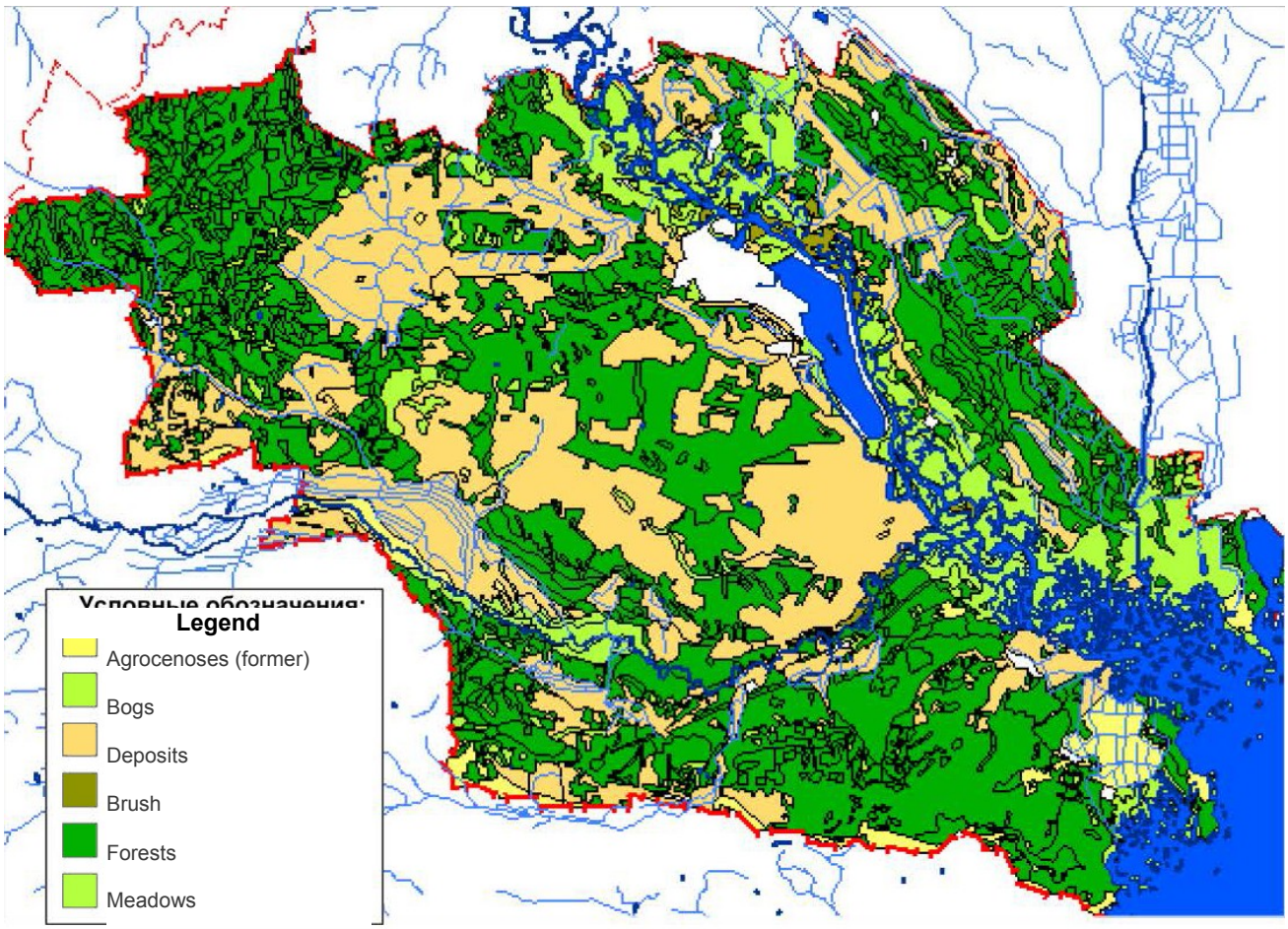


Figure 2.6. **Spatial Distribution Of Vegetation Types In The Exclusion And Compulsory Resettlement Zone**

The structure of lands under potential influence of the projected activities is shown in Table 2.12.

Table 2.12. **The Structure Of Lands Under Potential Influence Of The Projected Activities**

Land Types	Area	
	ha	%
Woodlands (protecting plantations also), including:	98,870	48.5
• Coniferous species	78,700	38.6
• Foliage species	20,170	9.9
Other woodlands (forest nurseries, wood roads, cuttings)	2,170	1.1
Total woodlands	101,040	49.6
Nonforest areas, including:	68,050	33.3
• Burnt woods	7,185	3.5
• Cleared areas	700	0.3
• Deposits	60,170	29.5
Bogs	4,930	2.4
Sands	380	0.2
Water	17,360	8.5
Abandoned settlements, roads and lands	12,280	6.0
TOTAL	**204,040**	**100**

2.4.2 Faunal Complexes

The fauna in the area of potential impact of the projected activities is represented by the faunal complexes characteristic of the forests of the northern part of Kyiv Polesye.

The new stage in the development of natural complexes of the region manifested itself in the form of secondary environmental consequences caused by the Chernobyl disaster. It was due to complete evacuation of the population and significant decline in the economic activity.

As a result of natural processes, the structure of zoological complexes steadily changed towards its original natural state, specific to this natural and geographical area.

Compared to the pre-accident period, the sustained diversity and mosaic vegetation cenoses, as well as the absence of chemical treatment of farmland greatly enriched and stabilized the entomocomplexes, increased the number of rare and pollinating insects (except for the loose, not well maintained plantations of tree monocultures and burnt areas).

To a large extent, the share of synanthropic species (sparrows, city swallows, gray pigeons, rooks, jackdaws, white storks, rats, house mice, stray cats and dogs). Also increased the share of species of trees and shrubs, and forest complexes. In the absence of anthropogenic load, the number of commercial species (hazel grouse, black grouse, beaver, muskrat, deer, wild boar, elk, deer, wolf, fox, raccoon dog) increased. Formerly missing extinct and minority protected species (common crane, black stork, white-tailed eagle, serpent eagle, lynx, otter, badger) began to appear.

Due to the fact that the exclusion zone is located at the crossroads of the historical migration routes of animals, its practically reserve status and the variety of landscape conditions contribute to the preservation of the numbers of migratory species of birds and mammals (brown bat).

The absence of humans and good opportunities for development are the main factors that attract wild animals even to the abandoned villages and most contaminated areas of the Chernobyl zone. The zoocenoses structure of the Chernobyl exclusion zone is gradually changing towards the formation of autochthonous complexes, inherent only to the conditions of this natural and geographical area.

The current state of biocenoses in the exclusion zone suggests their further progressive development. The changes in the species composition of vertebrates will be negligible. Also, significant increase in the number of animals is not expected, as the faunal complexes have reached the level of natural long-term fluctuations and, in the absence of intervention in their natural processes, their development (size and spatial distribution) will be determined by the current state of food supply and the interspecies relationships (ecological niches capacities).

2.5 The Characteristics Of Distribution Of All Adverse Factors In The Zone Of Influence Of The Proposed Activity

The nature and extent of the proposed activity implies the predictive assessment of the existing and potential hazards [67] that may lead to a breach of the normal conditions of the proposed activity.

2.5.1 Accidental Pollution Of The Surrounding Areas

The construction works will be carried out on the territory of the exclusion and compulsory resettlement zone, which is characterized by the radioactive pollution caused by the consequences of the Chernobyl accident in 1986.

In order to improve the radiation safety in accordance with the Order № 940 of the SSE “Chornobyl NPP” of 12.20.2013 [19] the exclusion zone is divided into three radiation-regime zones, namely:

Zone I (the 10-kilometer zone) — the area within a 10-km radius around the Chernobyl Nuclear Power Plant. In this area, the radiation-hazardous works are carried out on the basis of programs agreed with the regulatory authorities in accordance with the requirements of the current normative-legal acts on radiation safety in Ukraine. The strict radiation monitoring procedures are implemented in this zone.

Zone II (the buffer zone) — the territory from the border of the 10-kilometer zone to the outer edge of the exclusion zone (except the city of Chernobyl). In this area, constant radiation monitoring is implemented.

Zone III (the residential zone) — this zone comprises a part of the territory of Chernobyl and the surrounding sites where there are dormitories and administrative building of the State Agency of Ukraine for the Exclusion Zone Management, the public catering facilities and retail outlets, the social, cultural, health-care institutions, and the access roads.

The CSFSF construction site is located in Zone I.

2.5.1.1 Radioactive Pollution Of The Boundary Layer Of The Atmosphere

The radioactive contamination of the boundary layer of the atmosphere around the CSFSF site is considered in the reports and a number of other documents [68-77].

Currently, the highest content of radionuclides in the aerosols of the boundary layer of the atmosphere in the exclusion and compulsory resettlement zone is detected in the nearest 10-kilometer zone around Chernobyl. As a result of natural processes of decomposition and

accumulation, the share of the main dose-forming radionuclides (^{137}Cs and ^{90}Sr) is relatively stable against the dynamics of the content of alpha-emitting nuclides (^{241}Pu and ^{241}Am) (Table 2.13).

Table 2.13. **The Average Relative Activity Of The Radionuclides Of Technological Origin Detected In The Aerosols Within The Nearest 10-kilometer Zone Of Chernobyl in 2011–2014 [68-71]**

Radionuclide	Content,% Of The Total Activity			
	2011	2012	2013	2014
^{137}Cs	72.00	71.00	71.00	71.00
^{90}Sr	21.00	22.00	22.00	22.00
^{238}Pu	0.10	0.10	0.10	0.10
$^{239+240}$Pu	0.21	0.20	0.20	0.20
^{241}Pu	5.92	5.80	5.70	5.60
^{241}Am	0.77	0.90	1.00	1.10

The stabilization of the radiation situation in the exclusion and compulsory resettlement zone is supported by relatively small range of average activity value fluctuations in the boundary layer of the atmosphere in the peripheral areas. On the contrary, in the nearest 10-kilometer zone of Chernobyl Nuclear Power Plant, the pollution of the atmospheric boundary layer a result of intense and episodic anthropogenic activity is characterized by significant fluctuations (Table 2.14).

Table 2.14. **The Volumetric Activity Of ^{137}Cs (Bq/m^3) In The Boundary Layer Of The Atmosphere In The Stationary Monitoring Points In 2013-2014 [70-71]**

Monitoring Point	2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Distance from the CSFSF site — under 10 km						
Chistogalovka	2.9E-06	4.1E-04	8.3E-05	2.5E-06	6.8E-04	1.1E-04
Buryakovka	3.0E-06	4.1E-04	1.0E-04	1.3E-06	6.7E-04	1.2E-04
Distance from the CSFSF site — 10 to 20 km						
VRP-750	6.4E-05	**1.8E-02**	1.1E-03	6.0E-05	4.6E-03	7.4E-04
Oil Terminal	1.4E-05	1.9E-03	4.2E-04	1.6E-05	5.7E-03	4.5E-04
Pripyat	6.0E-06	4.1E-04	1.0E-04	3.9E-06	8.8E-04	1.2E-04
OPS	6.5E-06	8.7E-04	1.3E-04	4.0E-06	6.1E-03	3.7E-04
Zimovyshche	1.3E-06	1.9E-04	4.3E-05	1.1E-06	5.9E-04	5.5E-05
Starosillya	1.5E-06	1.5E-04	3.5E-05	1.7E-06	3.6E-04	3.2E-05
Kopachi	2.8E-06	2.6E-04	5.9E-05	1.3E-06	3.8E-04	5.1E-05
Benevka	3.4E-06	2.0E-04	3.2E-05	1.4E-06	5.2E-04	4.3E-05

Monitoring Point	2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Distance from the CSFSF site — 20 to 30 km						
Mashevo	3.0E-06	3.1E-04	6.0E-05	1.7E-06	5.2E-04	8.3E-05
Chernobyl	1.4E-06	**8.0E-05**	1.7E-05	1.1E-06	**1.1E-04**	1.6E-05
Dytyatky	1.1E-06	3.6E-05	8.4E-06	1.0E-06	5.6E-05	8.4E-06
Note. The values exceeding the reference levels for the territory under consideration are in bold [19]						

The analysis of the observed data for 2013–2014 shows that there were two cases of exceeding the current reference levels (RL) of air pollution with ^{137}Cs in Chernobyl (the residential zone) causes by a combination of intense anthropogenic emission and adverse weather conditions (absence of rain, strong wind of constant direction).

The cases of exceeding of the RLs in Chernobyl were observed in the previous years also. Thus, in 2012, Automated Radiation Monitoring System “Chernobyl” registered two cases of exceeding the RLs of air pollution with ^{137}Cs by factors of 2.0 and 2.3, and ^{90}Sr — by a factor of 1.5 [73]. It should be noted that one of the possible causes of systematic excess of the RLs in the residential area (Chernobyl) is the relatively low RLs set for the area, which do not take into account the real dynamics of the radiation situation.

Depending on the nature of technological activity and the distance from the source of radioactive aerosols emission, as well as the wind direction and speed, the intensity of the radioactive fallout on the territory of the exclusion and compulsory resettlement zone varies considerably. The analysis of the data indicates that the most intense precipitation was observed in 2013, and the source was within the industrial site of SSE “Chornobyl NPP” (Table 2.15).

Table 2.15. **The Intensity Of The Atmospheric Fallout Of ^{137}Cs In The Stationary Monitoring Points In 2013 And 2014, Bq/(m²·d) [70-71]**

Monitoring Point	2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Distance from the CSFSF site — under 10 km						
Chistogalovka	0.04	1.50	0.26	0.04	0.79	0.20
Buryakovka	0.03	1.90	0.27	0.03	1.00	0.30
Distance from the CSFSF site — 10 to 20 km						
Oil Terminal	0.25	5.90	2.30	0.19	7.30	1.60
OPS	0.03	16.00	1.50	0.01	0.57	0.17
Zimovyshche	0.02	0.68	0.12	0.02	0.61	0.14
Starosillya	0.02	0.41	0.09	0.01	0.22	0.08
Kopachi	0.02	6.50	0.40	0.01	0.79	0.22
Benevka	0.02	0.32	0.11	0.01	0.41	0.12

Monitoring Point	2013			2014		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Distance from the CSFSF site — 20 to 30 km						
Mashevo	0.02	0.89	0.20	0.01	0.57	0.17
Chernobyl	0.03	0.18	0.07	0.03	0.80	0.34
Dytyatky	0.01	0.09	0.04	0.01	0.09	0.04

The CSFSF site is characterized by the same laws of emergence and distribution of the air pollution as the territory of the exclusion and compulsory resettlement zone.

The specificity of the CSFSF site is the high percentage of forestry area (especially in the north and east) and the developed mesorelief that prevent air pollution by dust transfer when strong winds occur. Therefore, the crucial role in the formation of high content of radioactive aerosols in the air around the CSFSF site belongs to the technogenic factors — the radioactive waste processing activities, the vehicles' traffic, etc.

According to the research [47] conducted on the CSFSF site, the following concentrations of long-lived radionuclides of the Chernobyl origin (^{137}Cs, $^{90}Sr+^{90}Y$) were detected in the bordering air layer:

- Measurements of 28.10.2014 ..... $2{,}3\times10^{-5}\pm5{,}3\times10^{-6}$ Bq/m³;
- Measurements of 04.11.2014 ..... $4{,}5\times10^{-5}\pm1{,}2\times10^{-5}$ Bq/m³.

2.5.1.2 Radioactive Contamination Of The Surface Waters

As a result of the Chernobyl disaster and the accident fallouts all the water bodies within the 10-kilometer zone of the SSE "Chornobyl NPP" were contaminated and keep being contaminated.

Currently, the water bodies (rivers, streams, lakes, ponds, backwaters, canals and waterways) play the leading role in the redistribution of the radionuclides in the environment within the exclusion and compulsory resettlement zone. The radioactive substances soluble in the melt, rain and flood waters migrate via the runoff into the groundwater and streams, and flow into the into rivers and lakes from the surface. The main contribution to the formation of the radioactive contamination of the surface waters is made by ^{137}Cs and ^{90}Sr. Since 1988, the concentration of ^{90}Sr in the river water is constantly increasing, and amounted to 60-75 % of their total activity in the recent years [75]. The dynamics of ^{90}Sr washout by the major watercourses in the exclusion and compulsory resettlement zone is shown in the Table 2.16.

Table 2.16. **The Dynamics Of ^{90}Sr Washout By The Major Watercourses And Other Sources In The Exclusion And Compulsory Resettlement Zone In 1998–2002 [75]**

Site	Washout of ^{90}Sr, (n 10^{12}) Bq				
	1998	1999	2000	2001	2002
Pripyat River (point of entrance to the 30-kilometer zone)	2.58	3.21	1.71	1.29	0.51
Sahan River	0.06	0.04	0.02	0.05	0.01
Runoff from the left-bank polder	1.50	1.39	0.35	0.57	0.17
Cooling pond infiltration flow	0.17	0.10	0.09	0.10	0.07
Glinitsa River	0.24	0.28	0.21	0.21	0.15
ChNPP cooling pond infiltration	0.40	0.40	0.40	0.40	0.40
Infiltration fro the backwaters, inflow with the groundwaters and from the floodplain	1.42	4.78	0.58	0.52	0.34
Pripyat River, Chernobyl	6.37	10.2	3.36	3.14	1.65
Inflow of ^{90}Sr into Pripyat River within the 30-kilometer zone, (n 10^{12}) Bq/input from the 30-kilometer zone, %	3.79/59	7.0/69	1.65/49	1.85/59	1.14/69
Uzh River	0.49	0.27	0.14	0.20	0.04
Braginka River	0.51	0.28	0.13	0.22	0.08
The total outflow to the Kyiv Reservoir: Pripyat River, Uzh river, Braginka River	7.37	10.80	3.63	3.56	1.77

The water bodies in the exclusion zone are not used for domestic purposes. However, they are located within the areas occupied by the personnel of the exclusion zone and, therefore, are under continuous health, chemical and biological monitoring. The concentration of ^{137}Cs and ^{90}Sr in the water streams and pools of the exclusion and compulsory resettlement zone are shown in Table 2.17.

In the south-western sector of the distant 10-30-kilometer zone of the CSFSF site, the biggest watercourse is the River Uzh and its tributaries — the rivers Ilya and Veresnya.

The CSFSF site is located near the elevated watershed plateau of River Pripyat and its tributaries — the rivers Sahan and Uzh. Actually, within the 10-kilometer zone around the site, there are no large watercourses with floodplains where the washout of radionuclides during flood is possible (Table 2.17).

Due to the combination of the landscape features that determine the substances runoff, the greatest hazard in the 10-kilometer zone is the surface runoff from the CSFSF site. However, the absence of sudden changes in the terrain elevation, the dominance of sands in the soil cover and the high percentage of forest areas significantly impair the development of the surface runoff. Therefore, the main form of radionuclide migration in the area is the runoff and wind erosion, which are possible in the sparcely occupied southern sector of the 10-kilometer zone of the CSFSF site. In addition, the 10-kilometer zone around the site is bordered with marshes on the south-western and north-western sides, where the boundary zones are the accumulative areas of local landscapes and the biogeochemical barriers to further migration of radionuclides.

Table 2.17. **Concentration Of ^{137}Cs And ^{90}Sr In The Water Streams And Water Bodies Of The Exclusion And Compulsory Resettlement Zone in 2001 [76]**

Site and Monitoring Point	^{137}Cs, kBq/m^3			^{90}Sr, kBq/m^3		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Pripyat River (Dovlyady Village)	0.04	0.20	0.10	0.02	0.27	0.09
Pripyat River (Chernobyl)	0.03	0.38	0.12	0.10	0.53	0.23
Uzh River (Cherevach Village)	0.03	0.22	0.09	0.06	0.53	0.18
Braginka River (Dam № 39)	0.21	2.90	1.30	0.73	3.10	1.7
Sahan River (Novo-Shepelichi Village)	0.11	0.65	0.22	0.45	7.40	1.50
Chernobyl NPP cooling pond	0.23	7.6	2.10	0.28	3.50	1.50
Glinitsa River	0.15	0.57	0.31	1.60	7.70	4.60
Semihodovsky Zaton	0.50	1.80	1.30	10	23	16
Pripyat Zaton	1,050	4.00	2.70	17	37	26
Lake Azbuchin	6.10	12	9.90	100	120	110
Diversion channel of Stage 3 of ChNPP	150	240	190	12	48	38
Polder near Zimovische Village	1.40	7.20	3.90	1.50	43	16
Lake Glubokoye	2.40	11	7.10	59	96	79

The brief radio-ecological characteristics of the main watercourses of the eastern, southern and western sectors of the 30-kilometer zone around the CSFSF site are shown in Tables 2.18 and 2.19.

Table 2.18. **Outflow Of ^{90}Sr With The River Runoff In The Area Around The CSFSF Site In The Years Of Different Dryness [77].**

The River And The Observation Point	Outflow Of The ^{90}Sr Per 1 km^2 Of The Catchment, GBq/year		
	Dry year (1995)	Average-water year (1996)	High-water year (1999)
Ilya River (Rudnya-Ilinetskaya Village)	0.08	0.22	0.08
Uzh River (Cherevach Village)	0.02	0.04	0.03
Sahan River (Novo-Shepelichi Village)	0.50	0.08	0.21

Table 2..19. **The Amounts Of Runoff And Outflow Of ^{90}Sr By The Watercourses In The Area Around The CSFSF Site In A High-Water Year, 1999 [77]**

The River And The Observation Point	Catchment Area, km^2	The initial amount of ^{90}Sr in the catchment area, TBq	Runoff, million m^3/year	Outflow of ^{90}Sr, GBq
Ilya River (Rudnya-Ilinetskaya Village)	381	13	40.6	32
Uzh River (Cherevach Village)	8,080	290	1,011	236
Sahan River (Novo-Shepelichi Village)	200	328	19.4	41

The data set out in the tables shows that the values of outflow of ^{90}Sr are determined by a complex interaction of various factors and often depend on the amount of the annual river runoff.

Since 2000, there has been a clear trend towards decrease in the outflow of the main dose-forming radionuclides ^{137}Cs and ^{90}Sr with the surface water, primarily via Pripyat River, which reached its historical minimum (for the period of post-eccident observations) in 2012 and amounted to $0{,}44 \cdot 10^{12}$ Bq/year of ^{137}Cs and $0{,}87 \cdot 10^{12}$ Bq/year of ^{90}Sr. The average specific value of activity of the water was, respectively, 0.04 and 0.08 kBq/m^3 [73].

2.5.1.3 Radioactive Contamination Of Groundwaters

The processes of migration of the radionuclides within the vadose zone and the water-saturated soil layer (unlike their behavior in the air and surface waters) are characterized by slowness and inertia. The rate of vertical migration through the unsaturated zone does not exceed a few meters per year, while the horizontal flow rate in the groundwater layer reaches 30–40 meters per year.

The contamination of aquifer of the Eocene and Cenomanian-Lower Cretaceous deposits with the Chernobyl radionuclides was not measured exactly.

The first from the top aquifer system of the Quaternary deposits is composed of sand of different particle size with the spotted layers of sandy loam and loam of small thickness. The unconfined groundwater level is at a depth of 11 to 20 m. The direction of groundwater flow is north-west, towards the Pripyat River; the slope angle is 0.002 [74].

The confining layer for the Quaternary aquifer complex is composed of the Kyiv clay with the average thickness of 6.9 m and the filtration coefficient of 10^{-2} to 10^{-4} m/d [74].

The basic laws of radioactive contamination of groundwater with the radionuclides in the area around the CSFSF site are the same as for the SSE “Chornobyl NPP” site.

The closest to the CSFSF site point of stationary observations of the groundwater pollution is located at a distance of 1.1 km (south-west) on the territory of nuclear waste burial facility “Buryakovka”.

The analysis of observed data at the nuclear waste burial facility “Buryakovka” during the year shows a significant variation in the level of ground water pollution with ^{137}Cs (2 to 14 times) and ^{90}Sr (2 to 53 times) depending on the monitoring well location and the season. The average activity of ^{90}Sr in the groundwater is significantly (3 to 90 times) higher than the average activity of ^{137}Cs, which proves the intensity of migration of ^{90}Sr in the groundwater (Table 2.20).

Table 2.20. **The Dynamics Of Volumetric Activity Of ^{137}Cs And ^{90}Sr In The Groundwaters Of Nuclear Waste Burial Facility "Buryakovka" In 2013 And 2014 [70-71].**

No. of the monitoring well,	Volumetric activity, Bq/m^3					
	^{137}Cs			^{90}Sr		
	Minimum	Maximum	Average	Minimum	Maximum	Average
2013						
5	10	20	10	130	2,700	900
14	10	30	20	100	1,600	640
22	40	510	170	110	860	460
35	10	140	40	80	1,200	480
53	10	40	30	40	2,100	730
2014						
5	10	20	10	140	370	250
14	10	50	20	40	320	150
22	10	80	40	130	810	370
35	10	20	10	60	130	90
53	10	20	20	30	120	80

Also, significant variation in the value of volumetric activity of ^{90}Sr in the groundwater is registers in other observation points within the 10-kilometer zone around the Chernobyl Nuclear Power Plant, which differs both in the initial level of contamination of soil and its properties [Table 2.21].

Table 2.21. **The Mean Values Of The Volumetric Activity Of ^{90}Sr In The Groundwater Stationary Observation Points In 2013 And 2014 [70,** 71**]**

Point of observation	Distance from the CSFSF site	Range of volumetric activity of ^{90}Sr, kBq/m^3
2013		
NWBF "Podlesny"	11 km northeast	0.1 to 0.8
NWBF "Phase 3 of ChNPP"	13 km northeast	0.9 to 1.8
NWBF "Buryakovka"	1.1 km southwest	0.2 to 0.9
2014		
NWBF "Podlesny"	11 km northeast	0.4 to 1.6
NWBF "Phase 3 of ChNPP"	13 km northeast	0.4 to 0.7
NWBF "Buryakovka"	1.1 km southwest	0.1 to 0.4

2.5.1.4 Radioactive Contamination Of Soil In The CSFSF Area

Over the past 10 years, the dynamics of the radioactive soil contamination density in the area of natural ecosystems around the CSFSF site was determined mainly by the processes of natural decay of the radionuclides and vertical and horizontal migration. Figures 2.7 and 2.8 show the predicted values (as of 07.01.2016) of distribution of the ^{137}Cs and ^{90}Sr contamination density in the soil in the areas adjacent to the CSFSF construction site (without regard to their horizontal migration).

The analysis of the data on soil contamination, shown in Figures 2.7 and 2.8, shows that the surrounding areas [62] are characterized by the following values of soil contamination:

- contamination with ^{137}Cs..... 70 to 280 kBq/m²;
- contamination with ^{90}Sr..... 35 to 70 kBq/ m².

It should be noted that, in the past 10 years, the value and nature of soil contamination with long-lived transuranic elements (TUE) have not changed significantly [63-66].

The analysis of the observed data on the vertical distribution of the radionuclides in the soil profile in the areas adjacent to the CSFSF construction site shows that the major activity of ^{137}Cs and TUE (over 50 % of the stock) is currently concentrated in the upper 5-cm soil layer. On the contrary, the main supply of ^{90}Sr (over 50 %) has been observed in the 5–10-cm soil layer (Tables 2.22, 2.23) due to its higher migratory capacity compared to ^{137}Cs and TUE.

Table 2.22. **The Density Of Radioactive Contamination Of Soils (0–5-cm Layer) On The Stationary Observation Points In 2013 And 2014 [70,** 71**]**

Date	Radionuclides Contamination Density, kBq/m^2									
	^{137}Cs		^{90}Sr		^{238}Pu		$^{239+240}$Pu		^{241}Am	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
NWBF "Buryakovka"										
2013	7,900	2,900	560	280	8.5	5.0	22	13.0	38	20.0
2014	2,000	2,980	320	110	7.3	2.4	18	5.9	28	9.6
NWBF "Chistogalovka"										
2013	1,400	750	130	58	3.5	2.3	8.3	5.7	13	8.5
2014	1,300	770	110	40	7.0	3.6	17.0	8.5	21	9.4

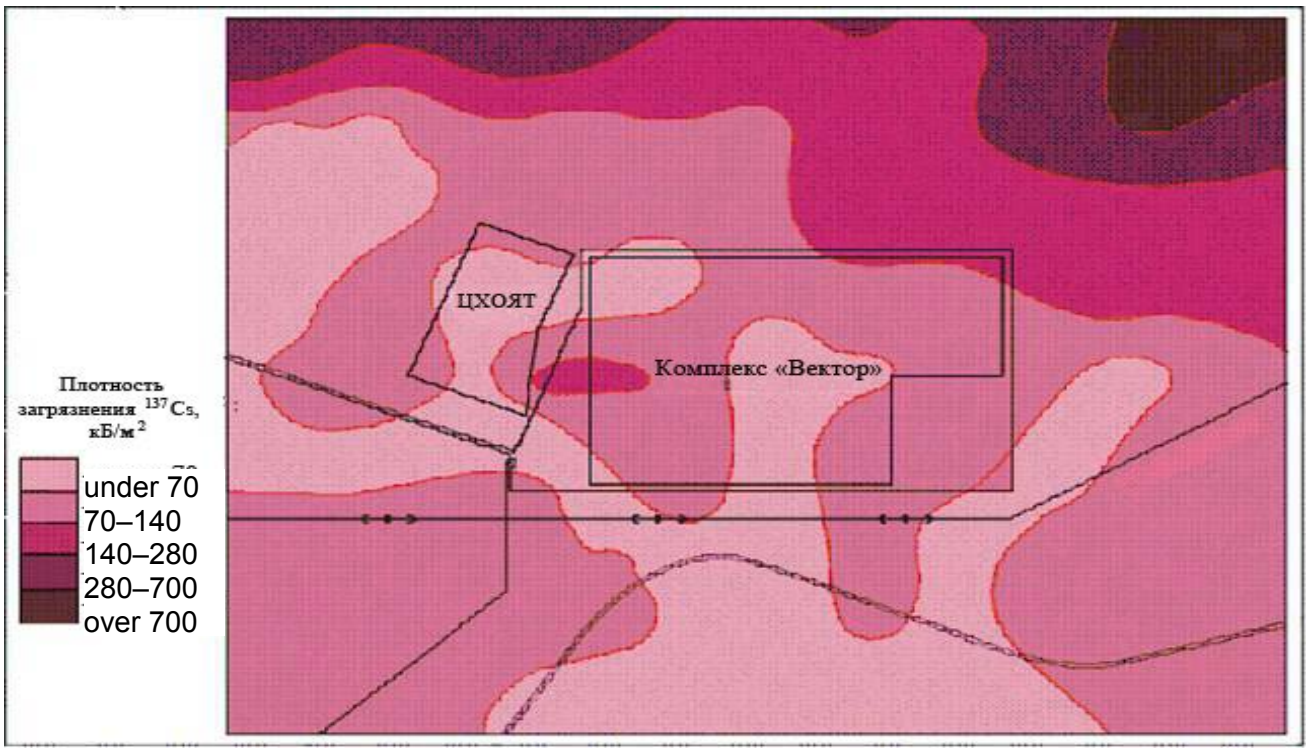


Figure 2.7. **Diagram Of ^{137}Cs Contamination Density Distribution In The Areas Adjacent To The CSFSF Construction Site. Forecast Of 07/01/2016 (According To The Report [47])**

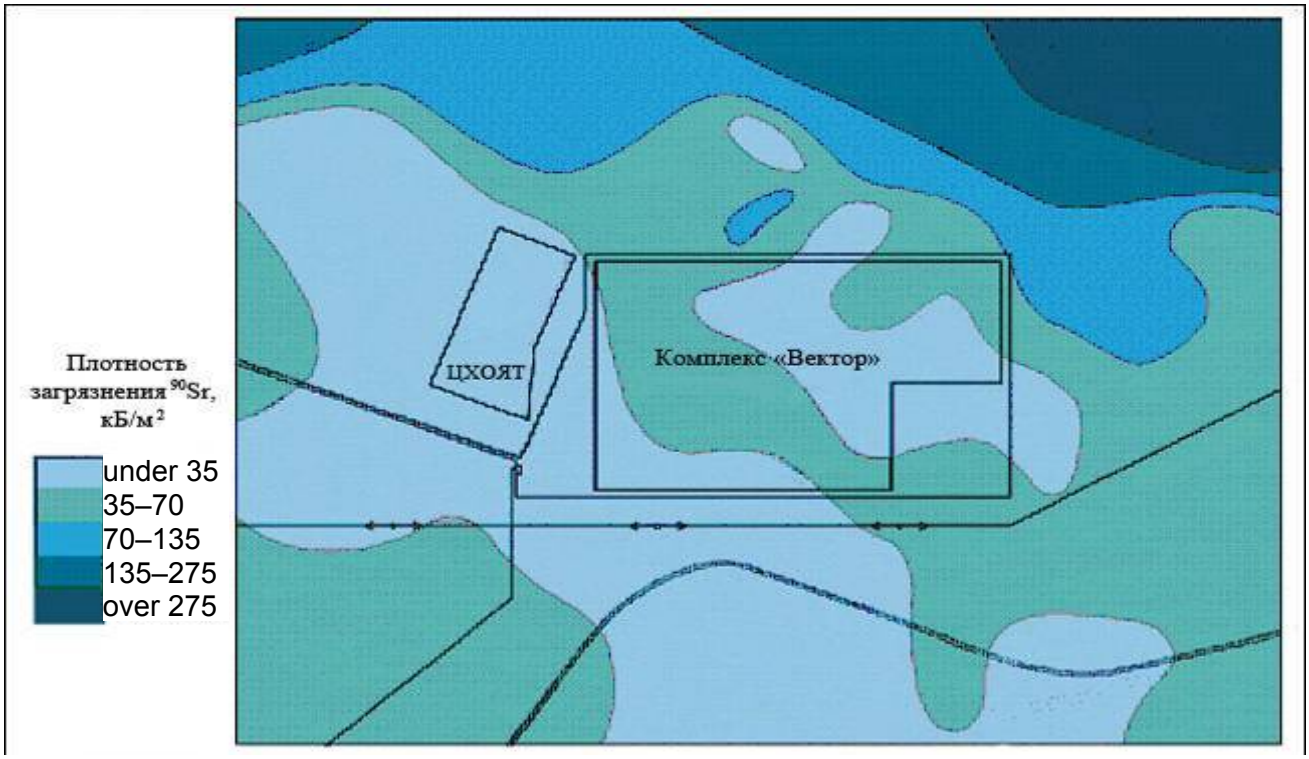


Figure 2.8. **Diagram Of ^{90}Sr Contamination Density Distribution In The Areas Adjacent To The CSFSF Construction Site. Forecast Of 07/01/2016 (According To The Report [47])**

Table 2.23. **The Density Of Radioactive Contamination Of Soils (0–10-cm Layer) On The Observation Points In 2013 And 2014 [70,** 71**]**

Date	Radionuclides Contamination Density, kBq/m^2									
	^{137}Cs		^{90}Sr		^{238}Pu		$^{239+240}$Pu		^{241}Am	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
NWBF "Buryakovka"										
2013	9,600	5,300	2,300	980	-	-	-	-	-	-
2014	3,900	2,800	750	400	10	5	27	12	44	22
NWBF "Chistogalovka"										
2013	1,800	1,300	350	150	-	-	-	-	-	-
2014	1,900	1,400	340	140	12	7	30	17	41	23

According to the results of the measurements [70], the beta-particles flux density on the territory of the CSFSF site does not exceed 120 ppm cm^{-2} min^{-1}. The most common values are in the range of 50–80 ppm cm^{-2} min^{-1}. The average specific activity of ^{137}Cs and ^{90}Sr in the survey area, in accordance with [70], for the 20-centiimeter soil layer does not exceed 2.35 kBq/kg and 1.36 kBq/kg respectively. In the most contaminated area, the values are around 3 kBq/kg and 2 kBq/kg respectively.

2.5.2 Dangerous Phenomena Of Natural Origin

2.5.2.1 Seismicity And Neotectonics Of The Area

The seismicity and neotectonics of the CSFSF site is discussed in Section 2.1.4.3.

The predictive calculations of the intensity of seismic effects on the CSFSF industrial site at MDE according to the letter of Gosstroy of Ukraine [51] show that this area is homogeneous in the seismic context. Thus, the impact of potential adverse seismotectonic processes in the area of the CSFSF site will not lead to the changes in the normal conditions of the planned activities, provided the relevant protective measures are implemented.

2.5.2.2 Sand Storms

The air pollution caused by dust storms may reach significant values. The dust storms happen when the wind speed exceeds 10 m/s at the height of 1 m above the ground or 15 m/s at 10 m above the ground. The natural dust storms are often observed in late winter and early spring (the probability is 30 to 35 % per month). In terms of the number of days wit the wind that can lead to dust storms and high content of dust in the air, the most representative are the summer months. In Kyiv Province, the dust storms occur once in 10 years (their probability is 10 % per year). The dust storms begin between 12:00 and 18:00 with the probability of 33 to 35 %. The duration of dust storms is 12 to 96 hours with the probability of 20 to 25 %.

2.5.2.3 Tornadoes

The significant radioactive contamination of air is possible in case of tornado, but this dangerous phenomenon is quite rare (as described in Subsection 2.2.12 of this volume according to the regulatory requirements [55]).

According to the calculations, in case of tornado of Class 3.40 (on Fujita–Pearson scale) passing from north to south through the territory of the exclusion zone, the total activity of the raised air will be 0.5 TBq.

2.5.2.4 Fires

Forest fires and peat bogs fires are quite rare and seasonal. The majority of fires in the exclusion zone occur in the period from April to October. The occurrence of fires, as a rule, is linked to the drying of the upper layer of soil and vegetation, which takes place upon the occurrence of the dry, hot and windy weather. As designed, in the event of hazards, it is necessary to provide for the system of preventive measures (ambient air monitoring and warning) as well as the related activities to additionally protect the staff from radiation.

2.5.3 Dangerous Phenomena Of Technogenic Origin

The hazards of natural and technogenic origin, the consequence of which increase the concentrations of radioactive aerosols in the atmospheric boundary layer around the CSFSF site, include emissions from the anthropogenic activities on the territory adjacent to the site (RW, earthworks, etc.).

The technogenic emissions related to the activities in minimization of the consequences of the Chernobyl disaster are strictly controlled in terms of their impact on the neighboring sites. In addition, according to the predictive analysis, their cumulative radiation exposure will have no significant impact on the area near the CSFSF site and the projected activity.

•

3 GENERAL DESCRIPTION OF THE DESIGNED FACILITY

3.1 General Description of the Planned Activity and Its Alternatives

The CSFSF is intended for disposal and long-term (at least 100 years) storage of the spent nuclear fuel from VVER reactors of Rivne, Khmelnitsky, and South Ukraine NPPs in sealed casks.

The planned activity and the designed facilities are categorized under Resolution of the Cabinet of Ministers of Ukraine # 808 of August 28, 2013, [20] as increased environmental risk activities and facilities.

The following options have been reviewed with regard to the designed facility:

- Option 1: without the planned activity ("zero option");
- Option 2: with the planned activity.

The zero option has not been considered because the performance of the planned activity will contribute to the sustained operation of Ukraine's NPP in the long term, make it possible to make use of own spent nuclear fuel storage facilities, and avoid dependence from spent nuclear fuel storage services provided abroad. In relation to the object of design, the CSFSF investment feasibility study [24] was performed as approved by the State expert appraisal board (conclusion by SE "Ukrderzhbudekspertyza" No. 84/54/288 of 26.08.2008 [25]) and endorsed by the Instruction of the Cabinet of Ministers No. 131-p of 04.02.2009 [22].

Thus, Option 2 calling for the performance the planned activity was chosen as a result of the review of alternatives and options.

3.2 Conformity of the Planned Activity to City Development Documents

The planning requirements and restrictions have been issued for the CSFSF design (Annex Г, Volume 12.2 Environmental Impact Assessment, Part 2. Annexes).

Planning requirements and restrictions are as follows:

1) The maximum allowed building height shall be ***under 50 m.***

2) The maximum allowed land use ratio: ***is not specified.***

3) The maximum permitted population density (for residential areas): ***is not specified.***

4) Distances from the designed facility to frontage line boundaries and building regulation lines ***are not specified.***

5) Planning restrictions (protection areas of the cultural heritage, protected landscapes, historical areas, coastal protective areas, sanitary protection, and other protected areas) shall be as follows:

- the protection area of Vector Production Facilities which is the source of contaminant emission and ionizing radiation shall be 50 m along the perimeter;
- the sanitary protection area of water lines shall be 50 m;
- there are no sanitary protection zones of underground and open-air sources of water supply, water intake and water treatment facilities, recreation facilities, etc.;
- there are no protection zones of cultural heritage, archaeological areas, and historical quarters of a settlement;
- there are no coastal protective areas and water protection areas;
- there are no other protection areas (around especially valuable natural objects, hydro-meteorological stations, communication and power transmission lines, transport facilities, etc.);
- there **are no** special land use regime areas around military facilities of the Armed Forces of Ukraine and other military formations or in the border area;

6) **No** minimum distances from facilities under design to existing buildings and structures **are specified within the land plot.**

7) Protected areas of utility lines: ***the distance from the power transmission line to the Western side of the CSFSF site is at least 20 m.***

8) Requirements for engineering surveys in accordance with state building code DBN A.2.1-1-2008 “Engineering Surveys for Construction”: ***Engineering surveys have to be carried out to develop the project.***

9) Beautification (including for the beautification restoration) is ***required in accordance with applicable regulatory documents.***

10) Transportation/pedestrian links: access roads ***shall be provided in accordance with requirements of regulatory documents.***

11) Requirements for the provision of parking space: ***none.***

12) Requirements for the cultural heritage protection: ***none.***

3.3 Positive Environmental, Sanitary/Epidemiological, Social, and Economic Aspects of the Implementation of Planned Activity

The design calls for technical facilities and organizational measures supposed to make sure that individual exposure doses will not exceed the specified exposure limits, and that the level of discharges and emissions will not exceed the specified permitted levels under normal operating conditions, under conditions of the disturbance of the regular operation and design-basis accidents; all these are positive environmental and sanitary/epidemiological aspects of the planned activity. A sanitary protection (buffer) area and a supervised area are specified for the CSFSF.

Positive social and economic aspects of the planned activity include the assurance of the sustained long-term operation of Ukraine’s nuclear power plants. The CSFSF construction will make it possible to make use of own spent nuclear fuel storage facilities, and avoid dependence from spent nuclear fuel storage services provided abroad.

3.4 Brief Description of the Planned Activity

3.4.1 Core Function

The Central Spent Fuel Storage Facility (CSFSF) is a nuclear facility of national importance.

The CSFSF is intended to store spent nuclear fuel (SNF) from VVER reactors installed at units Rivne 1 to 4, Khmelnitsky 1 to 2, South Ukraine 1 to 3 (i.e., the actual load of cooling basins, the fuel loaded into reactors and fuel that will be made up during the operation of all the units taking into account the operation extension by 15 years) by means of the gradual increase in the storage volume.

The CSFSF life (operating) cycle is divided into the following two stages that differ from each other in terms of the process implemented there:

- the first stage is the active operation stage with the acceptance of the spent nuclear fuel received according to a time schedule from NPPs for the long-term (up to 100 years) storage. Stage 1 is about 50 to 60 years long depending on the pace of filling the entire storage area (the installation of all the HI-STORM casks intended for the long-term storage of the spent nuclear fuel);
- Stage 2 is the stage of the passive operation of the CSFSF when no new CSFSF is received from nuclear power plants, and only the process of the spent nuclear fuel storage in HI-STORM storage casks takes place.

The target capacity of the CSFSF is 16,529 spent fuel assemblies from VVER reactors of nuclear power plants of Ukraine, including:

- 12,010 VVER-1000 spent fuel assemblies; .....
- 4,519 VVER-440 spent fuel assemblies. .....

3.4.2 Brief Process Description

The CSFSF is based on the technology by Holtec International Technology (hereinafter — Holtec). Main elements of the technology:

- MPC—multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT) (transfer vehicle);
- car transporter for the HI-STAR.

The project provides for the reception of HI-STARs with an MPCs, concrete-casting of the HI-STORMs' shells, transfer of the MPCs from the HI-STARs to HI-STORMs, and the storage of the HI-STORMs, filled with spent nuclear fuel on the territory of the CSFSF.

Overall, this technology includes the following stages:

- Stage 1. Transfer and process operations at the NPP unit to load spent nuclear fuel into the container;
- Stage 2. Transfer of the spent nuclear fuel to the CSFSF in casks with a special train;
- Stage 3. Transfer and process operations with the spent nuclear fuel cask within the CSFSF;
- Stage 4. Storing spent fuel assemblies using dry storage technology from Holtec.

This design document covers Stages 3 and 4. Background data updated for the design phase have been provided by Holtec.

The description of the SNF management technology at units submitted by the technology Provider is set out in Volume 1.3 "NPP Unit Spent Nuclear Fuel Management Technology Description". The binding of the technology to a specific nuclear power unit will be made under the projects of modification in accordance with the current legislation in the field of nuclear energy.

In accordance with the Design Brief, the SFA management technology in the CSFSF includes:

- the reception of a car of a special cask train at the CSFSF;
- the completion of a HI-STORM cask;
- the transfer of the MPC from the HI-STAR transfer cask into the HI-STORM storage cask in the reception building;
- the placement of the HI-STORM cask with the MPC on the storage area using a transfer vehicle;
- the long-term storage of HI-STORM casks with spent fuel assemblies.

The spent nuclear fuel storage system is fully passive, and performs the following three functions:

- the safe and sealed containment of the radioactive fissile material using two MPC static barriers that prevent radionuclides from leaking into environment from spent fuel assemblies;
- the safe long-term MPC storage in a protective structure (HI-STORM cask) that prevents direct impact of the ionizing radiation generated by the spent fuel assemblies on personnel and environment;
- the protection of spent fuel assemblies from extreme impacts of natural and artificial origin in the course of their storage in the HI-STORM cask.

In the CSFSF, provisions are made for the completion of a HI-STORM cask by concrete-casting the received shells and equipping them with the appropriate temperature control equipment and MPCs. HI-STORM casks are unified for MPC-31 and MPC-85. The design calls for a concrete

plant for concrete-casting HI-STORM shells to deliver concrete of the quality required (in accordance with HOLTEC requirements).

3.4.3 Buildings and Structures on the CSFSF Site

The CSFSF comprises the following buildings and structures; most important of them make up dedicated functional zones:

- the reception building;
- the SNF cask storage area;
- the maintenance building with a storage area and a HI-STORM shell concrete-casting facility;
- buildings and structures for storage and maintenance of the transfer vehicle and the fleet (a garage, a filling station);
- the electrical equipment building;
- the office building;
- the security equipment buildings and structures (a set of security structures with the guardhouse, checkpoints 1 and 2, trench shelters, physical protection equipment);
- water supply and waste water disposal buildings and structures (fire water supply pump station, fire water tanks, storm water facilities, waste water pump station, oil drain tanks (separators), etc.;
- holding and marshaling tracks for spent nuclear fuel rail cars;

The total fenced area of the CSFSF site is 13.20 hectares.

Two access roads are designed to the CSFSF site: the main one from the south and the service access from the north, as well as the rail access track on the northern side of the site. Site entrances have checkpoints and inspection platforms for cars/trucks and rail cars respectively.

3.4.4 CSFSF Operation Description

The following technology processes are designed to take place at the CSFSF:

- spent fuel handling:
  - reception of a train with spent nuclear fuel at the CSFSF;
  - reception of a car with spent nuclear fuel in the reception building;
  - transfer of the MPC from a HI-STAR cask into a HI-STORM cask;
  - transfer of a loaded HI-STORM cask and its placement in the storage area;
  - long-term storage of spent nuclear fuel;
  - nuclear materials control and logging system;
- MPC delivery and reception;
- delivery of shells and HI-STORM cask completion;
- preparation of a train for the departure to an NPP;
- maintenance and repair.

CSFSF functional diagram is provided on Figure 3.1. Th technology is described in detail in Volume 3.1 (571402.201.003-TX01 of this CSFSF Design).

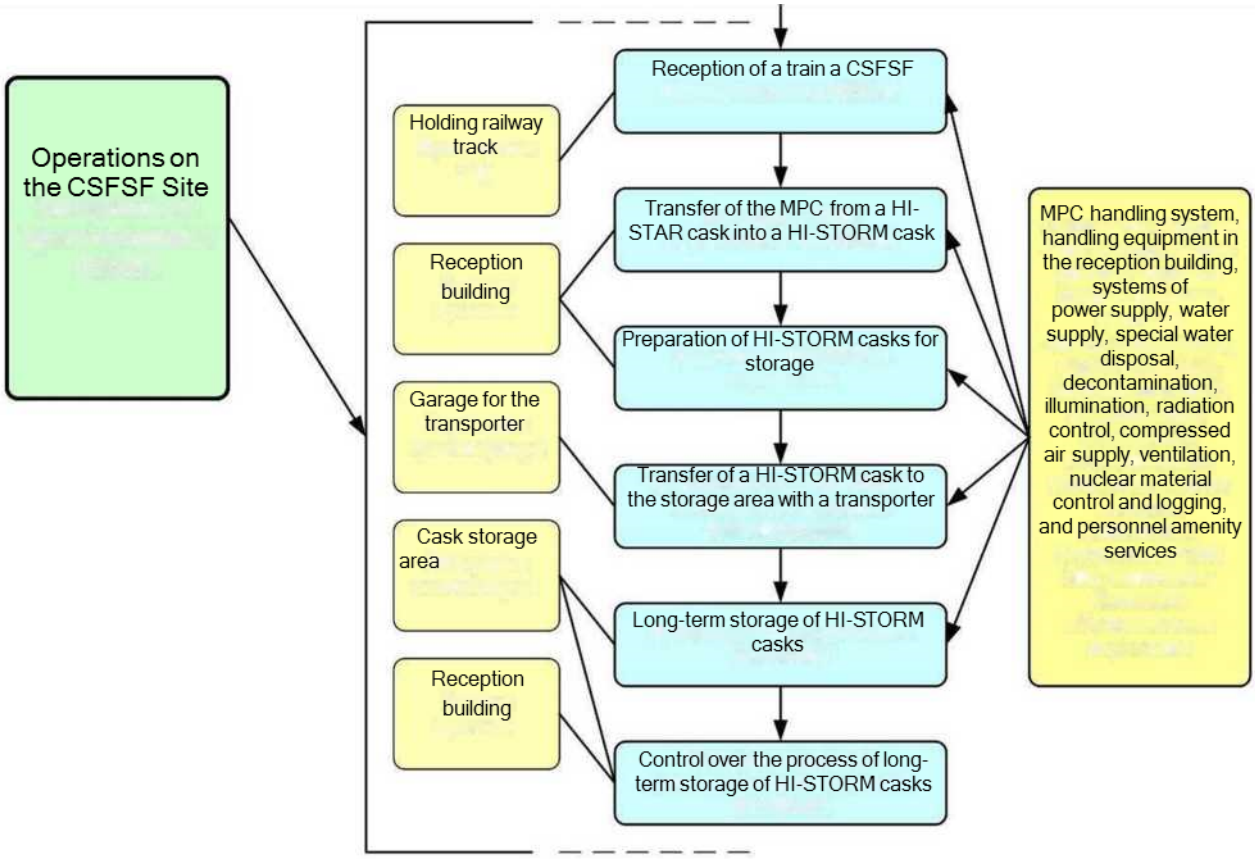


Figure 3.1—**CSFSF Functional Diagram**

3.4.4.1 Spent Fuel Handling

Spent fuel handling comprises the following major operations:

- reception of a train with spent nuclear fuel at the CSFSF;
- reception of a rail car with a HI-STAR cask loaded with an MPC with the spent fuel assemblies in the reception building;
- transfer of the MPC with spent fuel assemblies from the HI-STAR transfer cask into the HI-STORM transfer cask using cask transfer equipment in the cask transfer facility;
- placement of a loaded HI-STORM cask in the storage area using a vertical cask transporter (transfer vehicle);
- long-term storage of spent nuclear fuel;
- nuclear materials control and logging system;
- IAEA Guarantees.

Reception of a Train with Spent Nuclear Fuel at the CSFSF

Spent nuclear fuel is delivered from NPPs to the CSFSF by rail using a special cargo train.

In accordance with the applicable regulations and technology requirements, a special train consists of:

- not more than five cars for the delivery of HI-STAR casks;
- one platform car for a HI-TRAC transfer cask;
- one platform car with auxiliary equipment;
- one escort car;
- two buffer cars.

There shall not be more than 10 cars. The total train length is about 254 m.

The train uses both national public railroads and railroads within the exclusion and compulsory resettlement zone. For the purposes of this project, the reception of a special train prior to its entry into the CSFSF site is considered.

Reception of a Car with Spent Nuclear Fuel in the Reception Building

A car with spent nuclear fuel is received in the reception building after the performance of the following operations:

- cars with spent nuclear fuel are placed in an especially important layover zone for cars with HI-STAR casks loaded with MPCs with the spent nuclear fuel (track no. 6);
- HI-STORM casks that will receive the arriving MPCs have been identified and all documents have been processed;
- all the necessary auxiliary equipment has been brought into the reception building;
- auxiliary systems of the reception building are functional and provide the conditions required for work;
- there is personnel permitted to manage spent nuclear fuel;
- personnel has been issued a radiation work permit;
- the main crane of the reception building has been checked, is functional, and ready to perform transfer process operations;
- the physical protection service has been notified of the work performance, and its personnel is present in areas where it is prescribed by the relevant procedures;
- the locomotive for the handling of cask cars is ready for use.

The reception building is a process building intended to accommodate core production process of the CSFSF. All operations related to the MPC transfer from a transfer cask are carried out in the central hall of the reception building.

Reception of a car with spent nuclear fuel in the reception building includes the following operation groups:

- HI-STORM cask delivery to the reception building, and preparation;
- auxiliary equipment delivery to the reception building, and preparation;
- delivery and preparation of a cask car with spent nuclear fuel for the load transfer in the reception building.

The reception of a car with spent nuclear fuel is completed after the HI-STAR is placed on the working platform.

Transfer of the MPC from a HI-STAR Cask into a HI-STORM Cask

MPCs are transferred from a HI-STAR cask into a HI-STORM cask after the completion of the following operations:

- the HI-STAR cask is placed at the CTF into a HI-STAR well;
- the HI-STORM cask is placed at the CTF into a HI-STORM well;
- a cask transfer device (CTD) is placed above the HI-STAR well in the CTF (cask transfer facility).

Only one loaded MPC-31 or MPC-85 cask may be available within the central hall of the reception building at a time.

Transfer of a Loaded HI-STORM Cask and Its Placement in the Storage Area

A loaded HI-STORM cask can be placed after the completion of the following operations:

- a cap is placed on the HI-STORM cask;
- two lifting lugs are installed and attached on the HI-STORM cap;
- the stationary temperature control system equipment is installed and attached to the HI-STORM cask;
- two temporary IAEA seals are placed on a HI-STORM cask between the cap and the body;
- a HI-STORM cask is placed on the floor in the central hall of the reception building in an area accessible by a vertical wheeled transfer vehicle;
- a set of fasteners for the HI-STORM cap is prepared;
- the place for the placement of the HI-SSTORM cask in the cask storage area has been defined;
- the passport of the HI-STORM has been prepared;
- a mobile working platform or a truck with a telescopic lift is delivered to the HI-STORM installation location;
- an opening to fit an IAEA anchor has been prepared in the foundation slab of the storage area.

The gate of the reception building opens in the presence of the physical protection personnel to admit vertical cask transporter (VCT). The VCT enters and the gate closes.

Once in the reception building, telescopic support columns of the VCT's lifting beam are set to appropriate height, while gripping mechanisms are set to the proper level to grip lifting lugs of a HI-STORM cask.

The transporter approaches HI-STORM so that its lifting beam with gripping mechanisms is located directly above fasteners of the HI-STORM cap.

Personnel controls or carries out the connection of gripping mechanisms of the VCT with HI-STORM lifting lugs from a platform at the VCT top.

VCT's load lifting mechanism lifts the HI-STORM cask to the transfer height. For transfer purposes, the gap between the lifted HI-STORM cask bottom and the floor level shall not exceed 280 mm.

To avoid lateral shifts during the transfer, the HI-STORM storage container is attached to the VCT using hydraulically tensioned hold-down belts.

Two video surveillance cameras operating permanently are placed on the VCT lifting beam to provide IAEA guarantees. (Video surveillance cameras can be turned off in case of scheduled breaks in excess of six months). Radiation control equipment may also be installed on the VCT.

The HI-STORM with two provisional seals may be removed from the reception building by the VCT transfer vehicle and moved to the storage area under control of these cameras.

In presence of the personnel of the CSFSF and the physical protection personnel, the gate of the reception building is opened and the VCT loaded with a filled HI-STORM cask proceeds from the reception building to the gate of the cask storage area along a dedicated road.

Since the storage area is an especially important area subject to access control procedures, the gate of the cask storage area is opened in the presence of the physical protection personnel only. The physical protection control system checks equipment and documents, and identifies personnel escorting the VCT. After that, the VCT with the HI-STORM cask and the escorting personnel proceed to the HI-STORM long-term storage location within the storage area.

Once the HI-STORM is placed on its specified storage location in strict conformity to markers applied to the concrete pavement, the VCT disconnects from HI-STORM lifting lugs and moves somewhat away.

Personnel raises to the height of the HI-STORM cask's cap using a mobile working platform (from a truck with an extensible boom platform) or ladder. Using hand tools, they loosen nuts on HI-STORM lifting lugs and unscrew lifting studs until they are detached from lifting blocks of the HI-STORM cask body. The following operation makes it possible to remove lifting lugs from the HI-STORM cap: the lifting stud with the nut are slightly raised, and a limiting tube is placed under the nut. This operation is repeated for four openings. After that, the VCT moves above the HI-STORM cask and connects its gripping mechanisms with lifting lugs. The VCT removes lifting lugs from the HI-STORM cap. The VCT leaves the storage area and removes lifting lugs to the dedicated storage facility.

Personnel raises to the height of the HI-STORM cask's cap using a mobile working platform to attach the cap to the body with a fastening kit. Spacers are placed on the top of cap openings; after that, bolts are screwed in using hand tools to connect the cap to the body. Safety caps are placed on heads of fastening bolts.

The stationary temperature control system equipment installed on the HI-STORM is connected to the CSFSF temperature control system. The function test of the system with the new connection is carried out.

After that, provisional IAEA seals affixed in the reception building are replaced with permanent seals. All details of the cask are entered into the nuclear material management system.

Long-term Storage of Spent Nuclear Fuel

The long-term storage of the spent nuclear fuel is designed to take place in the cask storage area. The design calls for the construction of foundations for filling the CSFSF to its designed capacity of 458 HI-STORM containers plus positions reserved for the placement of spent nuclear fuel casks from Khmelnitsky NPP-3 and NPP-4 units.

On the site, the spent nuclear fuel is stored in dedicated HI-STORM storage casks. HI-STORM casks provide physical protection, heat dissipation, and radiation protection of MPCs. Through ventilation openings made in the bottom of HI-STORM storage cask walls and cap ensure natural air circulation to remove heat from MPCs and the spent nuclear fuel.

The cask storage area is designed to withstand regular operating loads and extreme (design-basis) loads. The foundation slab is designed for the placement of loaded HI-STORM casks and the dynamic load from a transfer vehicle carrying a loaded HI-STORM cask. The foundation slab is

designed to eliminate influence of the container placement in the process of filling up the storage facility. Non-combustible materials suitable for storage conditions are used to design the storage area.

3.4.4.2 MPC Delivery and Reception

Two types of MPCs are used in the CSFSF: MPC-31 cask is designed to store VVER-1000 spent fuel assemblies, while MPC-85 cask is designed to store VVER-440 spent fuel assemblies.

MPCs are supplied as a package including:

- a MPC body assembly with the fuel basket;
- MPC inner and outer caps (custom caps for each MPC);
- a drainage pipe (custom pipes for each MPC);
- a set of hold-down devices.

Procedure of MPCs Reception in CSFSF

A rail platform car (or a truck) with a packaged metal structure of an MPC is received in accordance with an instruction manual developed on the basis of Holtec HSP-168 standard operating procedure.

The platform car with the equipment is delivered to room 101 of the MPC Maintenance and Storage Building. All MPC handling operations in room 101 are carried out using an electric bridge crane with the load-lifting capacity of 50/5 tonnes.

The MPC body is placed on the platform car in packaging horizontally on supports (cradles). The inside of the MPC body is protected with a provisional shipping cover. The removable shipping cover protects the inner space of an empty MPC from foreign matter. The shipping cover is used during the storage of an empty MPC and the transportation of an empty MPC to the unit. It is removable using regular hand tools or by hand.

Inner and outer caps of an MPC cask are shipped in packages separately. Inner and outer MPC caps are “matched by marking” to a specific MPC body making up an individual set.

Caps for drains and vents, the drain pipe, the tool for the drain pipe installation, and hold-down devices are shipped as a set matching a specific MPC body in separate boxes.

Shipment fasteners of MPC bodies, cap packages and equipment boxes consist of general strapping components and can be removed manually without any special training or tools.

The received equipment is removed from a rail platform car with a crane, and is stored on the floor, in racks, and boxes on the floor in dedicated areas. Each unit must be inspected on entry for the completeness of the delivery package, including a set of cover and process documents, and the lack of visible defects. Equipment shall be controlled visually for potential damage during the shipment. Each MPC is identified by its unique serial number indicated on the body, inner and outer caps, and components. Damage to, or lack of, components is a criterion for the rejection of the delivered MPCs.

MPC bodies are supplied as finished products in an assembly with a fuel basket without the need for extra work.

For storage purposes, the outer process cap of an MPC may be stacked on the inner cap of the same MPC. Stacking caps on a different basis is prohibited. Cap props are supplied separately. MPCs, caps, and components are stored in the MPC maintenance and storage building in a dedicated storage area.

If a large batch of MPCs arrives, they may be stored in an open-air storage area under any weather conditions provided that they are covered to rule out the ingress of foreign matter. There are no temperature requirements.

Empty MPCs may be lifted, moved, turned around or repositioned using auxiliary lifting accessories supplied together with MPCs. Auxiliary lifting accessories for operations with empty MPCs are welded carbon steel structures with anti-corrosion finish.

MPC Warehouse

The design envisions an MPC warehouse accommodated within the maintenance building to store MPCs and components supplied together with MPCs. MPC warehouse is treated as a vital area under the Terms of Reference for the Physical Protection System. For this reason, the design calls for limiting the number and the range of persons authorized to access the MPC warehouse, and the equipment maintenance and storage area in general.

3.4.4.3 HI-STORM Cask Delivery to the Reception Building, and Preparation

The HI-STORM cask delivery and preparation include the following major stages:

- HI-STORM shells delivery to, and reception at, the CSFSF;
- preparation of HI-STORM casks for service;
- storage of HI-STORM casks ready for service.

HI-STORM casks may be transported by any mode of transport (by air, rail, sea or road). This design deals with the HI-STORM shell delivery to the CSFSF by rail.

Rail platform cars with HI-STORM shells are to be received at the CSFSF in the maintenance building that accommodates the MPC storage facility.

The preparation of HI-STORM casks for service includes:

- concrete casting of HI-STORM shells;
- installing temperature control equipment on HI-STORM casks.

A vertical cask transporter is used to transfer empty and loaded HI-STORM containers. The vertical cask transporter grips a cask at lifting lugs installed on the cap of the HI-STORM cask and attached to the HI-STORM cask body. At its lifting beam, the vertical cask transporter has two gripping mechanisms that are connected (attached) to HI-STORM lifting lugs.

HI-STORM shells with caps installed on them are transported vertically using the VCT to the cask concrete-casting shop.

HI-STORM shells with caps are transferred with the VCT to the concrete-casting shop either from the maintenance building, or from the cask storage area. The concrete-casting shop is designed for concrete-casting at least five HI-STORM shells (one shell per day). Up to 30 HI-STORM shells are cast with concrete per year during warm seasons (t≥10 °C).

HI-STORM casks ready for service are designed to be stored in the cask storage area.

HI-STORM casks can be stored in the cask storage area in the following configurations:

- as an empty HI-STORM cask ready for service;
- as a HI-STORM shell prior to concrete-casting with a cap;
- as a HI-STORM cask ready for service with an empty MPC placed inside—if the MPC warehouse is unable to accommodate the received MPCs;
- as a HI-STORM shell prior to concrete-casting with a cap ready for service with an empty MPC placed inside—if the MPC warehouse is unable to accommodate the received MPCs;
- as a HI-STORM cask with an MPC with spent nuclear fuel—in line with the designated purpose of the cask storage area.

The design calls for the storage of HI-STORM casks without spent nuclear fuel on foundations situated closer to major buildings and structures of the CSFSF site in the storage area. The design calls for the placement of HI-STORM containers with nuclear fuel on foundations situated as far away as possible from the main personnel routes.

Empty HI-STORM casks ready for use shall be aligned with markers in the cask storage area in the same manner as HI-STORM casks filled with nuclear fuel. However, nuclear material logging and control procedures and IAEA guarantees are not required for empty casks.

A diagrammatic storage area cask placement map shall be used to position empty casks. The diagrammatic map must clearly indicate places for the placement of empty casks and casks filled with the spent nuclear fuel.

3.4.4.4 Preparation of a Train for the Departure to an NPP

A train shall be set up for the delivery of equipment to an NPP in accordance with a dedicated program and time schedule.

In accordance with the applicable regulations and technology requirements, a special train consists of:

- not more than five cars for the delivery of HI-STAR casks;
- one platform car for a HI-TRAC transfer cask;
- one platform car with auxiliary equipment;
- one escort car;
- two buffer cars.

There shall not be more than 10 cars. The total train length is about 254 m.

The train shall be prepared for the transportation using both national public railroads and railroads within the exclusion and compulsory resettlement zone.

Overall, the train preparation includes the following work stages:

- preparation of a HI-STAR cask and a car for the transportation of a HI-STAR cask;
- preparation of cars with auxiliary equipment;
- preparation of a car with a HI-TRAC cask;
- preparation of escort and buffer cars;
- setting up a train at the CSFSF production site;
- dispatch of a train from the CSFSF.

A HI-STAR cask and a car for the transportation of a HI-STAR cask shall be prepared in the central hall of the reception building after the completion of operations related to the transfer of MPCs with spent nuclear fuel from a HI-STAR cask into a HI-STORM cask when the HI-STORM cask with spent nuclear fuel has been transferred by the VCT outside the reception building.

The preparation of cars with auxiliary equipment shall take place in the maintenance building.

The preparation of a car with a HI-TRAC cask shall take place in the reception building.

Escort and buffer cars shall be prepared in the maintenance building.

The train shall be dispatched from the CSFSF via the CSFSF on-site tracks. The train shall be set up using a locomotive. Once the train is set up, it must pass the inspection platform and the CSFSF gate in the presence of the physical protection personnel, and leave the CSFSF.

3.4.4.5 Maintenance and Repair

The specific features of the maintenance and repair of the CSFSF main and auxiliary process equipment for the spent nuclear fuel management are affected by the fact that:

- some equipment used in the CSFSF is categorized as rolling stock;
- some equipment and components are stored and used in the CSFSF;
- some equipment and components are stored in the CSFSF but only used at NPP units for loading;
- some equipment is subject to maintenance or repairs;
- the maintenance and repair of the storage area and HI-STORM casks.

The general CSFSF maintenance and repair system has been described in Volume 1.1 Explanatory Note.

3.4.5 Description of Main CSFSF Buildings

The following main buildings and structures have been identified on the CSFSF site:

- the reception building;
- the cask storage area;
- the maintenance building with an MPC warehouse:
  - the HI-STORM shell storage area;
  - the HI-STORM shell concrete-casting shop;
- the office building (subject to civil protection);
- the electrical equipment building;
- the garage;
  - the garage for the transfer vehicle;
  - the garage for 4 cars/trucks;
- the filling station;
- the fire water supply structures;
- the security structures;
- the storm water treatment structures;
- the concrete plant.

3.4.5.1 Reception Building

The reception building is the main structure where a HI-STAR cask car is unloaded, an MPC with the spent fuel assemblies is transferred from a HI-STAR transfer cask into a HI-STORM storage cask, and a HI-STORM cask is prepared for storage.

The reception building is located in the center of the site; it has a railway entrance gate and an entrance gate for the transporter that transfers HI-STORM casks with MPCs from the reception building to the storage area. The reception building consists of two unit: the central unit and the ancillary multi-floor unit. In addition to main process rooms, this building accommodates rooms for electrical equipment, ventilation, water supply, compressed air supply, et al. buildings. The railway entrance gate of the reception building is used for pushing a car with a single HI-STAR cask with a diesel locomotive into the transfer/process corridor of the central unit. The gate is opened on the basis of the request by personnel in charge of the spent nuclear fuel reception. Once a car with the cask is placed into the central unit, the marshaling locomotive leaves the reception building and the gate closes. All other operations (the receipt inspection of the HI-STAR transfer cask, the cover documents analysis, the transfer of an MPC from a HI-STAR cask into a HI-STORM cask, etc.) within the reception building take place with the gate closed.

Once the transfer of an MPC from a HI-STAR cask into a HI-STORM cask is completed, the HI-STORM cask is removed by the transfer vehicle to the storage area, and the HI-STORM cask is placed on its assigned foundation for the long-term storage. There is only one MPC with spent nuclear fuel within the reception building at a time.

3.4.5.2 Cask Storage Area

The cask storage area is intended for the long-term storage of MPCs in HI-STORM casks. It consists of cast-in-situ foundation slabs on which casks are placed. The storage area is rectangular in shape and extends along the CSFSF site in north to south direction up to its central part. The cask storage area has its own wire-mesh fence with radiation control along perimeter and a set of the physical protection equipment. Holding and marshaling tracks run along the eastern side of the storage area.

3.4.5.3 Maintenance Building with an MPC Warehouse

The at-hand reserve of empty MPCs is to be stored in the maintenance building located south of the reception building. The maintenance building has a rail entrance used to deliver shells of HI-STORM casks and MPC casks to the CSFSF site. Cars of trains arriving at the CSFSF are repaired and maintained in the maintenance building.

Shells of HI-STORM casks will be stored and filled with concrete on an open-air site near the maintenance building. The HI-STORM cask concrete-casting shop is designed for concrete-casting at least five HI-STORM shells (one shell per day).

The concrete-casting shop has a ramp for the vertical cask transporter (VCT) and truck mixers. At the shop, there are parking areas for a truck crane and a truck-mounted concrete pump, as well as an area for the provisional storage of caps for HI-STORM casks on props, working platforms (2 sets) and mobile scaffolds (2 pieces).

HI-STORM shells are delivered to the concrete-casting shop, and concreted casks are transferred to the storage area with the vertical cask transporter (VCT).

3.4.5.4 Electrical Equipment Building

The electrical equipment building is intended for the installation of the 10 kV switchgear, as well as 10/0.4 transformers and 0.4 kV main switchgears designed to supply electric power to the auxiliary structures of the CSFSF.

The power is designed to be supplied from switchgears in the electrical equipment building to the following structures:

- the reception building (Category I loads);
- the guardhouse;
- the office building;
- the maintenance building with an MPC warehouse:
- the fire water supply pump station;
- checkpoint 1 and checkpoint 2;
- the concrete plant.
- the garage;
- the telecommunication tower with a modular building;
- the wastewater pump station.

The electrical equipment building also accommodates a diesel power plant (room 106). This diesel power plant is designed to supply electric power without interruption in the case of electric power failures at the facility (in the stand-by mode). The diesel power plant operates automatically and is normally unattended. Each diesel power plant can be controlled from a local or central control panel.

3.4.5.5 Garage

The garage is designed for the day-to-day transportation activities, the storage, daily maintenance and minor repairs of the CSFSF-owned fleet, namely:

- a vertical cask transporter (VCT) used to transfer HI-STORM storage casks;
- a truck crane with the load-lifting capacity of 25 tonnes;
- a truck with an extensible boom platform;
- a sweeping truck (winter/summer);
- a minibus for the CSFSF personnel.

The vertical cask transporter is designed to transfer both empty and loaded HI-STORM 190 UA storage casks.

The empty HI-STORM 190 UA casks are moved between the maintenance building with the MPC warehouse, the storage area, the HI-STORM shell concrete-casting shop, and the reception building.

Loaded HI-STORM 190 UA casks are moved between the reception building and the long-term storage area.

A truck with an extensible boom platform is designed to carry out process operations with lifting lugs on the HI-STORM 190 UA cask caps in HI-STORM storage areas at a height of about 5 to 6 m.

A minibus will be used to transport personnel over the long-term storage area for the daily visual control over the condition of ventilation ducts of the loaded HI-STORM casks.

The CSFSF minibus will also deliver the personnel from the reception building and the office/amenity building to the concrete plant site (the distance is about 600 m).

The sweeping truck (winter/summer) is intended for removing snow and debris the HI-STORM storage area in order to rule out clogging of HI-STORM cask vents.

The truck-mounted load-lifting crane will be used for load handling in the course of HI-STORM shell concrete casting.

Garage for the Transfer Vehicle

The garage for the transfer vehicle is designed for the under-roof parking, ongoing maintenance and repairs of the vertical cask transporter (VCT).

The transporter is shown on Figure 3.2.

The VCT is a special heavy large vehicle used to transfer a HI-STORM storage cask loaded with a multipurpose cask containing spent nuclear fuel vertically to the storage area. The wheeled transporter is also used to move HI-STORM cask shells to the concrete-casting ground, and remove empty HI-STORM casks to the reception building for loading.

Figure 3.2 – **Transporter General View**

Garage for 4 Cars/Trucks

Room 101 is designed as a closed parking for two out of four cars/trucks (at discretion) operating on the CSFSF site:

- a truck crane with the load-lifting capacity of 25 tonnes;
- a truck with an extensible boom platform;
- a sweeping truck (winter/summer);
- a minibus for the CSFSF personnel.

There are 2 parking slots in the room.

The other cars/trucks are to be parked in room 102 (maintenance and repair shop) and room 103 (washing and decontamination room) after the completion of work in the relevant areas.

Cars/trucks coming back from the site are washed, if necessary, and parked. Cars/trucks due for maintenance or being in need of repairs shall be directed to the maintenance workshop located in the garage building at the maintenance and repair shop (room 102).

3.4.5.6 Filling Station

A filling station for one fuel type is designed to support automobile operations on the CSFSF site.

The filling station consists of a single filling pump (with a capacity of 50 to 60 liters per minute with the minimum fuel dosage of 2 l) and two underground steel double-walled fuel tanks (one for summer diesel fuel and one for winter diesel fuel) with a capacity of 5 cubic meters and installation depth of 3.5 m each.

The filling pump is designed to issue and meter out fuel into vehicle fuel tanks or jerry-cans.

The filling pump is designed to operate in explosive areas where explosive mixtures can form.

The filling pump consists of the following units:

- a filter;
- a pump with an electric drive;
- a readout unit (two-sided one-arrowed dial);
- a volumeter;
- an indicator;
- a gas purger;
- a float chamber;
- a dispenser with a hose (4 m long).

The fuel for the filling station is delivered by a tank truck; the fuel is emptied into the fuel tank directly. A tank truck access ground is organized to receive fuel. The ground has a 150-300 mm high perimeter board, and is sloped toward a trap designed to receive potential fuel leaks into the oil-polluted water disposal system. The ground has solid water-impermeable and non-sparking pavement.

Each tank is equipped with vent, breather, and safety valves with flame arresters to make sure that the overpressure within the tank does not exceed 2 kPa, temperature and level gauges, and bottom and top level alarms, and the fuel temperature ceiling alarm.

3.4.5.7 Security Structures

Security structures include a guardhouse, a drill ground, a loading area, a dog kennel, etc.; they are surrounded by a dedicated mesh fence on the southwestern side of the site near the main entrance.

3.4.5.8 Concrete Plant

Buildings and structures of the concrete plant include:

- a concrete mixing plant (CMP) supplied as a package (a concrete mixer with the loader volume of 0.7 m3, a three-section hopper for the inert materials, silo-type cement bulk storage facilities 2×50=100 tonnes, the operators' room, etc.);
- a drive-in ramp;
- an open-air aggregate storage ground;
- a recycling plant with a settling pond;
- a checkpoint;
- a car parking lot with five parking slots;
- a fence;
- roads.

Concrete is produced on an automated concrete mixing plant with a capacity of 15 m^3 per hour.

Concrete mix components (aggregates, cement, and water) are mixed in the mixing unit and delivered into the mixing drum of a truck concrete mixer for the subsequent transportation to the cask shell concrete-casting shop.

The aggregate (sand and crushed rock) is loaded via the drive-in ramp by a diesel-fueled front-loader into a three-section inert material hopper with a capacity of 3×15=45 cubic meters (this capacity of the inert material hopper supports the preparation of the mix for concrete casting of a single cask).

An auger conveyor supplies cement from silos into the mixing unit. Cement is delivered and loaded into silos by cement trucks. The capacity of silo-type cement storage facilities (2×50=100 tonnes) were adopted on the basis of a seven-day reserve in accordance with recommendations of DBN A.3.1-8-96 [79].

The water is supplied to the mixing unit in the volume of $V = 3\ м^3$ from the inner process water supply network of the CSFSF.

An open-air storage ground is designed as a part of the concrete plant for the interim (stand-by) storage of aggregates (crushed rock, sand). The storage ground is divided into three sections to ensure separate storage of three types of aggregates depending on their type and grain size. Sand and crushed rock are delivered to the concrete plant site by dump trucks; they are moved to open-air storage grounds by the diesel-fueled front-loader.

The storage ground capacity is 3×120 m³= 360 m³ equivalent to a seven-day inventory in accordance with recommendations of DBN A.3.1-8-96 [79].

A recycling plant capable of separating solids from liquids for re-use will be installed to process waste from washing the mixing unit and truck mixers.

The concrete plant is designed to operate during the warm season (t≥10 °C) which is 170 days long in Kyiv Oblast. The operating hours were determined on the basis of the shell concrete-casting technology adopted for the project as: 4 to 5 hours per day for 5 to 6 days per month, or 30 days per year.

3.4.6 Water Supply and Wastewater Disposal Systems

The following systems are designed for the CSFSF:

- water supply systems:
- utility and drinking water;
- fire water;
- hot water;
- process water;
- waste water disposal systems:
- domestic waste water;
- storm water;
- process waste water.

All the water supply and waste water disposal systems under design are systems of regular operation that do not affect safety in accordance with requirements of NP 306.2.105-2004 [13]. In terms of seismic resistance, the systems under design are categorized as Category 3 under PNAE H-5-006-87 [80]. Design solutions for water supply and waste water disposal systems have been adopted in accordance with requirements of [35, 37, 81].

Outer pipelines for all systems under design will be laid underground.

The CSFSF personnel number for the design of water supply and waste water disposal systems has been assumed to be 125 persons in the strongest shift on the basis of Letter # 03-46/479 of May 20, 2015, from PC Atomproektinzhiniring, including the number of the National Guard

personnel on the basis of Letter # 3/6/2-4365 of June 18, 2015, from the General Directorate of the National Guard.

3.4.6.1 Utility and Drinking Water Supply System

The utility and drinking water supply system is designed to provide the targeted sanitary and amenity conditions for the work of the CSFSF personnel and the supply of the potable water to sanitary installations.

The potable water will be supplied to the following buildings and structures:

- the reception building;
- the maintenance building with an MPC warehouse:
- the office building (subject to civil protection);
- the 4 car/truck garage;
- the fire water supply pump station;
- the guardhouse;
- checkpoint 1;
- the concrete plant.

The feed (process) water at the CSFSF site is sourced from artesian wells on the KP Vector site. Since the feed water quality does not meet the potable water standards, a water treatment (iron removal) plant is designed in accordance with DSANPIN 2.2.4-171-10 [82]. The equipment for the potable water preparation is accommodated in room 021 of the office building basement.

The feed water is supplied to the site via two ND 65 and ND 80 water lines. Specifications for connections are specified in Volume 8 “Water Supply and Sanitation” (571402.201.008-VK) of this CSFSF Design.

The feed (process) water is supplied to a strainer. Before water is fed to the iron removal plant, sodium hypochlorite is added to prevent biological fouling of potable water tanks; after that, the treated water is fed to two filtration plants loaded with AS-type adsorbent (heavy-duty multifunctional aluminosilicate-based adsorbent).

As per paragraph 10.27.1 of DBN V.2.5-74:2013 [37], the Design makes provisions for the storage of a one-month supply of grade A sodium hypochlorite supplied in polyethylene 20 dm^3 barrels. A metal cabinet ventilated in accordance with requirements of GOST 11086-76 [83] is designed for storing sodium hypochlorite in room 021 of the office building.

While managing sodium hypochlorite, personnel must comply with safety requirements of GOST 11086-76 [83].

After the treatment, water is supplied to potable water tanks made of corrosion-resistant steel with a total capacity of 10 m^3 (two tanks of 5 m^3 each).

From tanks, water is pumped to fine filters and the UV-disinfection unit, and supplied to consumers at the CSFSF site.

The disinfection of water with bactericidal ultraviolet radiation (UV-disinfection) is required under paragraph 10.18.24 of DBN V.2.5-74:2013 [37] downstream of potable water tanks before water is supplied to consumers. The UV-disinfection unit consists of two UV lamps.

Big Blue 20’ (2 pcs.) cartridge filters with 5 um cartridges are used as water fine filters.

Potable water consumption at the CSFSF site is metered by a custody transfer metering unit at the inlet into each building or structure.

Hot water is prepared in electric storage water heaters.

The design utility and drinking water flow rates are as follows:

- the maximum daily rate is 13.09 m^3 per day;.....
- the maximum hourly rate is 7.384 m^3 per hour; .....

including

- the maximum hot water daily rate is 6.32 m^3 per day; ....
- the maximum hot water hourly rate is 3.83 m^3 per hour.

3.4.6.2 Fire Water Supply System

The fire water supply line is designed for the outer and inner fire fighting in buildings and structures of the CSFSF site. A high-pressure fire water line is designed at the site. Fire water networks are connected to buildings equipped with inner fire water lines. To prevent failures of the equipment and the clogging of fire water supply lines, automatic self-cleaning filters will be installed at inlets of each building and structure on the CSFSF site.

Underground fire hydrants are intended for fire fighting outside.

The target water flow rate is 25 liters per second (90 m^3 per hour). It is dictated by the water flow rate required for outer and inner fire fighting at a building with the highest risk of fire on the site which is the garage:

- 15 liters per second for fire fighting outside; .....
- 2 streams of 5 liters per second each for fire fighting inside.

The required water head in the fire water system is 80 m.

Fire water supply is stored in four 200 m^3 fire water tanks (two of them are buffer tanks with 100 percent water supply).

Fire water tanks are designed to be filled by the process water supply line using fire hoses.

Water is supplied to the on-site network by fire pumps accommodated in a standalone fire water supply pump station. Fire water pumps are actuated automatically by the pressure drop in the fire water supply line and by position sensors on the opening of fire hydrants. The permanent pressure in the fire water supply system on the site is ensured by a membrane-type tank installed in the machinery room of the fire water pump station.

On-site fire water supply lines are designed in steel pipes. Networks are designed with ring topology with the installation of fire hydrants spaced not more than 120 m from each other. Networks are laid mainly at a distance of not more than 2.5 m from the roadway edge.

3.4.6.3 Process Water Supply System

The Design provides for the feed (process) water supply for process needs to:

- the concrete plant:
- for the concrete mixing plant;
- for dust suppression at the open-air aggregate warehouse;
- for the recycling plant operation;
- for the decontamination in the reception building and the garages for 4 cars/trucks and the transporter.

The design process water consumption is 21.12 m^3 per day.

3.4.6.4 Domestic Waste Water Disposal System

The domestic waste water disposal system is designed to remove domestic waste water from buildings on the CSFSF site.

All domestic waste water from buildings and structures (other than checkpoint 2) flow by gravity via lines (ND 100 to 150) to the domestic waste water pump station; therefrom, it is pumped to the domestic waste water purification works at the KP Vector site. The amount of the waste water has been assumed in accordance with Annex Г(H), paragraph 13, to DBN V.2.5-75:2013 [81]. The waste water pump station is a round plastic well 2.3 m in diameter without an above-ground part. The

pump station is supplied as a package. The inlet sewer is laid at the elevation of -6.000 m. The pump station is -7.000 m deep.

There are two Grundfos SEG 40.12.2.50B pumps (one main pump, one stand-by pump) with a capacity of 18 m^3 per hour and a head of 20 m each, and an electric motor capacity of 1.2 kW. A local control cabinet is installed near the waste water pump station on the site.

On-site domestic waste water disposal networks are designed in cast-iron pipes.

The waste water from the canteen is discharged via a dedicated well inlet into utility/domestic waste water disposal network.

The domestic waste water from washstands and showers of the restricted area in the reception building is drained into control tanks installed in room 110. Lacking radiological contamination in excess of maximum allowed concentrations, the waste water is discharged from control tanks into the outer domestic waste water disposal network.

The design domestic waste water flow rate is 13.09 m^3 per day (maximum).

3.4.6.5 Storm Water Disposal System

The storm water disposal system is designed to collect and abstract atmospheric precipitation from pavements of on-site roadways of the CSFSF site, and building roofs.

In accordance with calculations made in Volume 8 “Water Supply and Sanitation” (571402.201.008-VK) of this Design, the storm water inflow rate is 1,905 m^3 per day, including 1,118 m^3 per day of polluted storm water and 787 m^3 per day of notionally clean storm water.

Storm water from the site flows via storm water inlets by gravity into the storm water sewer. Via sewers, storm water flows into a balancing tank and, further, into a separation well. In the separation well, the polluted portion of the storm water (20 minute storm water) is fed into polluted storm water accumulation tanks, while the notionally clean portion of the storm water is fed into the clean storm water accumulation tank. All tanks are equipped with pumps for pumping water to the relevant networks of KP Vector, bag filters with storm water supply pumps, and stirrers for sludge breaking. The notionally clean storm water can be used for watering the site; to this end, a well is designed downstream of the notionally clean tank to enable connection of portable watering units or hoses.

The amount of the polluted storm water is assumed in accordance with Annex Г(Н), paragraph 60, to DBN V.2.5-75:2013 [81] as that of a Group 1 industrial facility:

- suspended solids—400 mg per liter; .....
- dissolved solids—200 mg per liter; .....
- oil products—30 mg per liter; .....
- COD of a filtered sample—100 mg per liter; .....
- BOD_{20} of a filtered sample—20 mg per liter; .....

Quality of notionally clean storm water meets the requirements of Table 1 of SANPIN 4630-88 [84] (0.3 mg per liter of oil products).

Accumulating tanks for the polluted storm water (2 pcs.) are underground reinforced concrete tanks with a capacity of 615 m^3 each. An accumulating tank is divided into four cells. Its specifications are as follows:

- laying depth is -10.100 m; .....
- usable height is 5.8 m; .....
- neck height is 4.3 m; .....
- the inlet sewer is laid at an elevation of -5.200 m. .....

Accumulating tanks for the clean storm water (2 pcs.) are underground reinforced concrete tanks with a capacity of 436 m^3 each. An accumulating tank is divided into four cells.

The following are specifications of a clean storm water accumulating tank:

- laying depth is -6.000 m;.....
- usable height is 4.3 m;.....
- neck height is 1.7 m;.....
- the inlet sewer is laid at an elevation of -5.200 m.....

Polluted storm water accumulating tanks and clean storm water accumulating tanks are controlled from a local control cabinet installed on site near tanks.

3.4.6.6 Oil Product Contaminated Waste Water Disposal System

The oil-product contaminated waste water disposal system is designed to drain waste water from washing floors of the diesel power plant (room 106) in the electrical equipment building, cars and the transporter in the garage building, and the filling station area. Via traps, waste water is fed into an oil separator. Partly purified waste water is drained into the outer storm water disposal system and, further on, into polluted storm water accumulating tanks.

The separator purifies waste water to the following content levels:

- not more than 0.3 mg per liter of oil products; .....
- not more than 15 mg per liter of suspended solids.....

3.5 Process Waste and Opportunity for Their Reuse, Recycling, Decontamination or Safe Disposal

Radioactive and non-radioactive waste is generated in the course of the CSFSF operation with their features detailed in Volume 3 “Process”, Part 2. Waste Management During Operation (571402.201.003-TH02).

In accordance with NP 306.2.105-2004 [13], the design calls for the separate management of radioactive and non-radioactive waste, safe and reliable handling of all types of radioactive waste generated in the course of the CSFSF operation, the possibility of the mechanized loading of the radioactive waste, and the removal thereof by special vehicles for subsequent storage or treatment.

Radioactive waste management systems that ensure radioactive waste collection, categorization, and shipment to special facilities within the exclusion zone have been designed at the CSFSF to meet regulatory requirements. No long-term radioactive waste storage on the CSFSF site is planned.

The assessment of the waste impact during the operation is provided in Section 4.7.

The assessment of the waste impact in the course of construction activities is provided in Section 8.4.

The range, volumes, hazard classes of non-radioactive waste are set out in Annex Φ, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

3.6 Assessment of the Potential of the Emergence and Development of Accidents

A detailed accident analysis for the CSFSF is provided in the Preliminary Safety Analysis Report (POAB) in accordance with requirements of NP 306.2.105-2004 [13].

Holtec International have analyzed accidents and presented the results in Report HI-2083899 [85]. Report HI-2083899 [85] contains a list of accident initiator events determined on the basis of requirements of NP 306.2.105-2004 [13], PNAE H-14-029-91 [89], RD 306.8.02/2.067-2003 [90].

The following accident initiator events giving rise to the disturbance of regular operating conditions and design-basis accidents have been reviewed in Report HI-2083899 [85] in accordance with requirements of NP 306.2.105-2004 [13]:

- natural phenomena:
  - flooding;
  - tornadoes and objects carried by tornadoes;
  - earthquake;
  - extreme snowfall;
  - extreme increase in ambient temperature;
- technology-related external events:
  - fire or explosion at a neighboring facility (a passing vehicle);
  - blackout;
  - airplane fall on a HI-STORM cask;
- technology-related internal events:
  - fire;
  - flying objects generated by other accidents;
  - human error;
  - failures of fuel management and storage systems;
  - fall of objects;
  - clogging of HI-STORM vents;
  - HI-STORM tripping;
  - accident during transportation;
  - MPC jamming during transfers.

A brief description of results of the probable accident and emergency situation development analysis based on the initiator events is provided hereinbelow in Table 3.1 on the basis of materials from Report HI-2083899 [85].

It is demonstrated in HI-2083899 [85] that all the reviewed disturbances of regular operating conditions and design-basis accidents will not exceed safe operation limits and will not give rise to the discharge of radioactive substances into the environment.

Table 3.1 – **Analysis of Emergency Situations and Accidents in Accordance with Report [85]**

Initiator Event (IE)	IE Parameters	Acceptance Criteria Used for Analysis	Analysis Results
Design-basis natural IEs			
Earthquake	Spectra of seismic reactions for the CSFSF site: - vertical ground oscillation has a zero period acceleration (ZPA) of 0.1 g; - the related horizontal ground oscillation has a zero period acceleration (ZPA) of 0.127 g; a conservative ZPA of 0.2 g was used for analysis. Ceiling of the static friction coefficient μ was determined to be 0.53 for a free-standing HI-STORM 190 storage cask on a reinforced concrete slab	A HI-STORM 190 cask must remain stable and must not trip. The docking mechanism should not be damaged during the transfer of an MPC from a HI-STAR cask	The HI-STORM 190 stability analysis and the docking mechanism strength analysis confirmed that the acceptance criterion is amply met.
Tornadoes and objects carried by tornadoes	An impact of a flying object against the cask top accompanied by the simultaneous wind of permanent intensity or a rapid pressure drop resulting in an additional impact that increases the initial angular velocity that came into existence because of the flying object impact. Tornado features are as follows: • wind rotation speed is 467 kph; • translational velocity is 113 kph; • maximum wind velocity is 580 kph; • pressure difference is 20.7 kPa. Objects carried by a tornado: • a 1800 kg car at a speed of 203 kph; • a 125 kg, D200 mm steel cylinder at a speed of 203 kph; • a 0.22 kg, D25 mm steel cylinder at a speed of 203 kph.	The cask should not trip. The collision with objects carried by a tornado must not result in the damage that will increase the exposure rate at the site boundary.	The analysis of the stability and the impact of flying objects confirmed that the simultaneous impact of an extreme wind and a flying object impact would not knock over a HI-STORM 190 cask and reduce efficiency of the containment shell for the MPC, and, accordingly, would not increase the exposure rate at the site boundary.

Initiator Event (IE)	IE Parameters	Acceptance Criteria Used for Analysis	Analysis Results
Extreme increase in ambient temperature	from -40 °C to +40 °C	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis confirmed that the temperature behavior of a HI-STORM 190 cask filled with spent nuclear fuel from VVER reactors with the design-basis heat output in a MPC-31 or MPC-85 would ensure that all the design-basis temperature limits are met at extreme values of the ambient temperature.
Extreme snowfall	Snow load: 4.8 kPa (100 lbs per square foot). Complete clogging of vents	The container system must remain structurally integral. Fuel element temperatures must not exceed limits set for accident conditions.	The snow load considered is negligible in comparison with other loads under review; for this reason no additional strength analysis for the snow load is called for. The thermal analysis of the HI-STORM 190 storage system in case of the clogging of vents demonstrated that temperature values would not exceed the allowed limit even in case of the conservative overstatement of the time needed for unclogging vents.
Flooding	Water level increase velocity: 4.57 meters per second (15 feet per second) Water level increase height: 109.9 m	The cask should not trip. The fuel element shell temperature must not exceed the maximum level.	The strength analysis and the stability analysis demonstrated that flooding would not knock over or displace a HI-STORM 190 cask. Flooding would not affect thermal properties of the system negatively. The heat abstraction will improve.

Initiator Event (IE)	IE Parameters	Acceptance Criteria Used for Analysis	Analysis Results
Design-basis technology related initiator events (external)			
Fire or explosion at a neighboring facility, passing of a vehicle with flammable or explosive cargo	A loaded HI-STORM 190 is moved to the CSFSF storage area by a VCT. An assessment of the impact of the ignition/explosion of combustible substances available in a VCT has been carried out	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions. The event must not result in a substantial increase in the exposure rate at the site boundary	The thermal analysis demonstrated that the fire would not affect the integrity of the containment shell of the MPC and the shell of a fuel element. The stability analysis confirmed that the explosion would not knock over a HI-STORM 190 cask.
Blackout	Suspended operation of electrically driven mechanisms, such as cranes; stopped process operations	The fuel element shell temperature must not exceed the maximum level.	A blackout would not result in the development of emergency conditions or a design-basis accident. There would be no impact on the exposure rate at the site boundary; there is no hazard to human safety.
Airplane fall on a HI-STORM 190 cask	Airplane velocity, mass, angle of entry, and amount of fuel aboard	Preserved integrity of the containment shell of the MPC	The strength and thermal analysis for a fall of a 20-tonne airplane at an impact velocity of 215 meters per second demonstrated the lack of substantial damage to the cask and the preservation of its functional integrity.
Accidents at nuclear facilities located in vicinity	HI-STORM 190 casks will be stored in an open-air CSFSF concrete storage area, and may be affected by accidents at neighboring nuclear installations	Preserved integrity of the containment shell of the MPC. The fuel element shell temperature must not exceed the maximum level.	Fire or explosion at a neighboring facility (a passing vehicle); Thermal and strength analysis confirmed that such an event would not result in the development of emergency conditions or a design-basis accident.

Initiator Event (IE)	IE Parameters	Acceptance Criteria Used for Analysis	Analysis Results
Design-basis technology related initiator events (internal)			
Partial clogging of fresh air inlets	50% of the area of fresh air inlets are clogged	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis confirmed the conformity with the temperature and pressure limits for deviations from normal conditions
Complete clogging of vents	100% clogging of vents with debris	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis demonstrated that temperature values would not exceed the allowed limit even in case of the conservative overstatement of the time needed for unclogging vents (30 hours).
Flying objects generated by other accidents	Site conditions	An impact of a flying object must not result in the damage that will increase the exposure rate at the site boundary.	The impact of such an event is lower than the impact of flying objects carried by a tornado
Sticking of spent fuel assemblies	Fuel basket cell size and spent fuel assembly size	Making sure that a spent fuel assembly fits basket cells easily	Taking into account the MPC geometry and manufacturing tolerances, it can be concluded that this event is not probable.
Operator's mistake when loading spent fuel assemblies	Incorrect positioning of a spent fuel assembly in the fuel basket	The fuel element shell temperature must not exceed the maximum level.	Thermal analysis of a HI-STORM 190 cask for incorrect positioning conditions confirms that the temperature and pressure limits are met

Initiator Event (IE)	IE Parameters	Acceptance Criteria Used for Analysis	Analysis Results
Falling objects	Potential collapses of building structures and process equipment	The impact resulting from a fall of an object should not result in the damage resulting in a change in the position of a fuel assembly, disturbing its integrity and shells of fuel elements.	The impact of falling objects on HI-STORM 190 in case of the long-term storage is less unfavorable than the impact from flying objects carried by a tornado
Failure of load gripping mechanisms when moving spent fuel assemblies	Load lifting capacity and duplication	Assurance of the necessary load lifting capacity and duplication	No need to analyze this accident because lifting and crane equipment is protected against once-off failures
Fall of HI-STORM 190	Lifting mechanisms and a HI-STORM 190 cask have a design that prevents a fall of a loaded HI-STORM 190 cask.	Preserved integrity of the containment shell of the MPC. The event must not result in a substantial increase in the exposure rate at the site boundary	A fall of a HI-STORM 190 cask would not result in the development of emergency conditions or a design-basis accident.
Initiator events for the analysis of beyond-design-basis accidents			
Self-sustained chain reaction	Ingress of water or water/steam mix into the MPC. The fuel basket is loaded with the fresh fuel with the maximum enrichment under the least favorable combination of manufacturing tolerances	Not exceeding the value of K_{eff} = 0.95	HI-STORM storage system nuclear safety analysis demonstrated that the maximum value of K_{eff} is not exceeded under all regular operating conditions, disturbances of the regular operations, and accidents.
Fall of process equipment and building structures onto a spent nuclear fuel storage cask	Functional potential of the equipment and building structures	The impact of the equipment and building structure fall must not result in the damage that will increase the exposure rate at the site boundary.	The impact of falling objects on HI-STORM 190 in case of the long-term storage is less unfavorable than the impact from flying objects carried by a tornado

For the purposes of this EIA, an accident with the contamination of the MPC surface with water of the cooling pond in excess of the allowed levels has been treated as a design-basis accident with the maximum radiation impact. It is assumed that the situation has not been detected during the loading of an MPC cask into a HI-STAR cask at the NPP. This accident is assumed to result in a discharge of radioactive substances into environment.

The density of the radioactive MPC surface contamination with beta-ray emitters is conservatively estimated as 4.0 Bq per cm^2. This value has been determined on the basis of the permitted level (safe operation limit) of the volumetric activity of the cooling pond water of Rivne NPP units (ASRK accident boundary) [91]. With the surface area of the potential MPC-31 container contamination of 3.63 E5 cm^2, the discharge activity will total 1.45 E6 Bq. Conservatively, the discharge consists solely of ^{60}Co radionuclide. The discharge is possible both from the ground level and via the exhaust stack of the reception building. Further, a ground-level discharge was assumed because a discharge via the exhaust stack of the reception building would pass a system of filters capable of reducing aerosol activity by at least two orders of magnitude. The discharge was assumed to last two hours.

Out of beyond-design-basis accidents listed as initiator events in NP 306.2.105-2004 [13], only an initiator event associated with the development of a self-sustained chain reaction is applicable to CSFSF.

The subcriticality of the spent nuclear fuel management at the CSFSF subject to all conservative assumptions stated in requirements of NP 306.2.105-2004 [85] has been demonstrated in Report HI-2083899 [86] and Report HI-2083899 [13].

For the purposes of this EIA, a hypothetic accident with the destruction of all fuel elements in a storage cask with the subsequent loss of MPC tightness has been treated as a beyond-design-basis accident with the maximum radiation impact.

This accident would amount to an absolutely hypothetical event of the destruction of all fuel elements in an MPC with the subsequent release of gaseous fission products. It is impossible to identify any realistic initiator events whose direct consequences would bring about simultaneous damage to the MPC and all fuel elements therein. Only a substantial external dynamic impact (e.g., the use of special ammunition, etc.) is an impact on a HI-STORM storage cask capable of damaging an MPC cask and all fuel elements therein at the same time. This accident is only considered for the demonstration of relatively insignificant radiation consequences of accidents in the CSFSF even in case of hypothetic initiator events.

The impact assessment was carried out on the basis of an accident with an MPC-31 cask filled with VVER-1000 spent fuel assemblies with the depletion of 55,000 MW×day/tonne (U) with the cooling period of 6 years and the enrichment level of 4.34%. With this configuration, the MPC contains maximum potential activity as specified in the Radiation Protection Analysis Report HI-2084031 [87].

The following radionuclide release fraction into the MPC was assumed in accordance with recommendations set forth in NUREG/CR-6487 [92]:

- ^{85}Kr 0.3;
- ^{60}Co 1.0;
- ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{106}Ru 2E-4;
- others ..... 3E-5.

In this case, the maximum leak from the MPC in case of this accident amounts to 1.05E-3 cm^3/sec in accordance with NUREG/CR-6487 [92].

According to [87], the activity of the fuel under consideration (VVER-1000 spent fuel assemblies with the depletion of 55,000 MW×day/tonne (U) with the cooling period of 6 years and the enrichment level of 4.34%) is as follows in g per one spent fuel assembly:

- ^{85}Kr ..... 1.23 E01 Bq;
- ^{90}Sr ..... 3.40 E02 Bq;

- ^{106}Ru ..... 2.15 E00 Bq;
- ^{125}Sb..... 1.50 E00 Bq;
- ^{134}Cs..... 1.64 E01 Bq;
- ^{137}Cs..... 8.51 E02 Bq;
- ^{144}Ce ..... 1.04 E00 Bq;
- ^{147}Pm..... 2.11 E01 Bq;
- ^{154}Eu..... 1.77 E01 Bq;
- ^{238}Pu..... 2.53 E02 Bq;
- ^{241}Pu..... 9.13 E02 Bq;
- ^{241}Am..... 3.51 E02 Bq;
- ^{244}Cm ..... 6.31 E01 Bq.

The amount of ^{60}Co is caused by the maximum surface contamination level of a spent fuel assembly, which amounts to 5.18 E06 Bq/cm² according to HI-2084031 Radiation Protection Analysis Report [87].

The hypothetic accident under review will release the following amounts into the air:

- ^{85}Kr..... 8.17 E12 Bq;
- ^{60}Co..... 7.40 E09 Bq;
- ^{90}Sr..... 5.13 E10 Bq;
- ^{106}Ru ..... 7.63 E09 Bq;
- ^{125}Sb..... 2.53 E08 Bq;
- ^{134}Cs..... 2.33 E10 Bq;
- ^{137}Cs..... 8.05 E10 Bq;
- ^{144}Ce ..... 5.54 E08 Bq;
- ^{147}Pm..... 3.18 E09 Bq;
- ^{154}Eu..... 7.70 E08 Bq;
- ^{238}Pu..... 7.07 E08 Bq;
- ^{241}Pu..... 1.54 E10 Bq;
- ^{241}Am..... 2.02 E08 Bq;
- ^{244}Cm ..... 8.40 E08 Bq.

Calculations assumed for this accident an even release during 30 days [115] from a height of 6 m within the storage area.

3.7 List and Descriptions of Potential Sources of Environmental Impact

Potential sources of the environmental impact of the planned activity are as follows:

- CSFSF technology;
- CSFSF infrastructure;
- road and rail transport used to haul casks.

Potential sources of the environmental impact of the planned activity have the following features broken down by impact types:

- radiation impact;
- contaminant emissions;
- acoustical impact;
- impact of electric and electromagnetic fields;
- generation of waste.

Quantitative features of impact sources, results of the analysis and assessment of changes in components of the environment are covered in Sections 4, 5, and 6.

4 ESTIMATED IMPACT OF THE PLANNED ACTIVITY ON THE NATURAL ENVIRONMENT

4.1 Climate and Microclimate

No thermal pollution or evaporation is expected during operation of the CSFSF. The CSFSF operation does not affect the sunlight exposure intensity, temperature, wind velocity, humidity, atmospheric inversions, fog duration, and other climate features. For this reason, the CSFSF influence on climate and microclimate is not considered.

4.2 Air Environment

4.2.1 Radiation Impact of the CSFSF on Air Environment

4.2.1.1 Contamination of the Atmosphere Ground Layer near the CSFSF Site

Currently, the highest content of radionuclides in the aerosols of the boundary layer of the atmosphere in the exclusion and compulsory resettlement zone is detected in the nearest 10-kilometer zone around Chernobyl. As a result of natural processes of decomposition and accumulation, the share of the main dose-forming radionuclides (^{137}Cs and ^{90}Sr) is relatively stable against the dynamics of the content of alpha-emitting nuclides (^{241}Pu and ^{241}Am).

A Radiation Impact Source Map is provided in Annex И, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

4.2.1.2 Radiation Impact under Normal Operating Conditions

Radionuclide discharges are possible during the normal operation of the CSFSF due to two processes:

- HI-STAR surface contamination during the travel via the contaminated exclusion and compulsory resettlement zone;
- a discharge resulting from the leakage of radioactive materials with the design-basis containment of the MPC.

In the case of the HI-STAR surface contamination, the discharge occurs from the reception building, while the discharge resulting from the leakage of radioactive materials from the MPC can occur from both the reception building and the storage area.

When considering additional surface contamination of a rail platform car with a HI-STAR cask during the travel via the contaminated exclusion and compulsory resettlement zone, a conservative assumption has been used that the entire surface contamination of the platform car with ^{137}Cs (as the main dose forming radionuclide) is emitted into the environment via the ventilation stack of the reception building in the VVER spent nuclear fuel storage facility. The following assumptions were used to calculate the platform car contamination:

- the surface area of the outer surface of a rail platform car with a HI-STAR cask is 90 m^2;
- the duration of travel via the exclusion and compulsory resettlement zone is 1 hour;
- the maximum intensity of ^{137}Cs fallout from atmosphere (in the most contaminated locations along the route) is 3.4 Bq/(m^2•day).

In this case, the contamination of one HI-STAR cask will amount to 13 Bq of ^{137}Cs, while the aggregate activity in the case of the receipt of 16 HI-STAR casks per year that enters the reception building due to the contamination of the HI-STAR cask surface will amount to 204 Bq per year. Taking into account the filtration of the discharge from the reception building, the maximum discharge due to the surface contamination of the HI-STAR cask will amount to about 2 Bq per year ^{137}Cs.

A discharge resulting from the leakage of radioactive materials with the design-basis containment of the MPC is defined by the activity level of the radioactive contents of an MPC and the leakage velocity. The maximum spent nuclear fuel activity assumed for calculation purposes is specified in Section 3.6. The leakage velocity depending on pressure is defined by the MPC design.

An MPC is designed as a tight cask. ANSI N14.5 [93] defines tightness as the "degree of package containment assured by a shell that practically rules out any substantial leakage of the radioactive material. The attainment of this degree of containment must be demonstrated by the leakage velocity that equals, or is less than, 1×10^{-7} cm^3/sec, in terms of air, with a pressure of 1 atm within the shell and a pressure of 0.01 atm or lower outside the shell". Thus, the design of the MPC makes sure that leakage velocity never exceeds 1×10^{-7} cm^3/sec with the pressure differential of 100 atm between the inner space of the MPC and the environment. The design pressure within the MPC does not exceed 7 atm, so the actual leakage velocity under normal operating conditions will be much lower than 1×10^{-7} cm^3/sec. However, the leakage velocity is conservatively assumed to equal 1×10^{-7} cm^3/sec for calculation purposes.

The discharge caused by the MPC leakage was determined on the basis of the following assumptions:

- the maximum leakage velocity from an MPC cask is 1E-7 cm^3/sec;
- gas leakiness of a fuel element is 1% (safe operation limit);
- radionuclide release fraction from fuel under the fuel element shell [92] is:
  - ^{85}Kr 0.3;
  - ^{90}Sr, ^{134}Cs, ^{137}Cs..... 2E-4;
- fuel features are in line with those stated in Section 3.6.

In this case, the release of radioactive isotopes from a single MPC will amount to:

- ^{85}Kr..... 4.71 E06 Bq/year;
- ^{90}Sr..... 2.95 E04 Bq/year;
- ^{134}Cs..... 1.34 E04 Bq/year;
- ^{137}Cs..... 4.64 E04 Bq/year;

The annual discharge from the reception building, if 16 HI-STAR casks are received per year, will be as follows if the ventilation system filters operation is taken into account:

- ^{85}Kr..... 7.54 E07 Bq/year;
- ^{90}Sr..... 4.73 E03 Bq/year;
- ^{134}Cs..... 2.15 E03 Bq/year;
- ^{137}Cs..... 7.42 E03 Bq/year;

The annual discharge from the storage area filled up completely (with 458 HI-STORM casks) disregarding trends of filling up the storage area and, accordingly, disregarding radioactive fission, will be as follows:

- ^{85}Kr..... 2.16 E09 Bq/year;
- ^{90}Sr..... 1.35 E07 Bq/year;
- ^{134}Cs..... 6.14 E06 Bq/year;
- ^{137}Cs..... 2.12 E07 Bq/year;

The additional annual average volumetric activity of the bottom layer of air along the trail axis depending on the distance due to a discharge in the course of the normal operation is specified below in Table 4.1.

Annual average weather conditions were used to determine air volumetric activity: the atmospheric stability category of D at a wind velocity of $V = 2{,}1\ м/с$.

Table 4.1 – **Additional Annual Average Volumetric Activity in the Bottom Layer of Air along the Trail Axis in the Course of the Normal CSFSF Operation, Bq/m³**

Radionuclide	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
90Sr	4.04E-04	2.53E-04	1.18E-04	3.80E-05	8.42E-06	2.02E-06	1.77E-06	8.10E-07
134Cs	1.85E-04	1.18E-04	5.31E-05	1.77E-05	3.96E-06	9.27E-07	8.00E-07	3.70E-07
137Cs	6.31E-04	4.04E-04	1.85E-04	5.99E-05	1.35E-05	3.19E-06	2.77E-06	1.26E-06

Values presented in Table 4.1 have been obtained under the following conservative conditions:

- the storage area is filled up and the trends of the spent nuclear fuel arrivals are disregarded;
- the maximum MPC leakage velocity is observed at a pressure difference substantially above the design-basis value;
- the discharge direction remains unchanged;
- results are provided for the trail axis.

Under more realistic conditions, additional radionuclide concentrations in the air in case of the normal operation of the CSFSF will be lower than those obtained by several orders of magnitude.

4.2.1.3 Radiation Impact in Case of a Maximum Design-Basis Accident

An accident with the contamination of the MPC surface has been treated as a design-basis accident with the maximum radiation impact in Section 3.6.

Conservatively, this accident was assumed to discharge 1.45 E6 Bq of ^{60}Co. A ground-level discharge with a two-hour duration was assumed for the calculation of radiation impacts.

Radiation impacts were calculated for two types of weather conditions:

- without precipitation, with an atmosphere stability category of F, a wind velocity of $V = 2\ м/с$, and a surface roughness parameter of $z_0 = 0{,}1\ м$;
- with precipitation, with an atmosphere stability category of D, a wind velocity of $V = 3\ м/с$, a surface roughness parameter of $z_0 = 0{,}1\ м$, and a rainfall intensity of $\Lambda = 2\ мм/сут$.

Calculations were done using GENII Version 2.10 software and presented in Annex K, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Values of the temporal integral of a volumetric activity of ^{60}Co in the ground-level air layer along the trail axis (Bq×sec/m³) in case of such an accident are presented in Table 4.2 below.

Table 4.2 — **Temporal Integral of Volumetric Activity of ^{60}Co in the Ground-level Air Layer along the Trail Axis Depending on Distance (MDBA Case), Bq×sec/m³**

Weather	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
Without precipitation	1.30E+03	8.30E+02	3.80E+02	1.20E+02	2.90E+01	6.60E+00	5.70E+00	2.60E+00
With precipitation	1.80E+03	1.50E+02	6.10E+01	1.90E+01	3.90E+00	7.30E-01	6.20E-01	2.30E-01

Additional average annual volumetric activity of the ground-level layer of the air along the trail axis depending on the distance due to the discharge is specified in Table 4.3.

Table 4.3 — **Additional Annual Average Volumetric Activity of ^{60}Co in the Ground-level Air Layer along the Trail Axis Depending on Distance (MDBA Case), Bq/m³**

Weather	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
Without precipitation	4.15E-05	2.65E-05	1.21E-05	3.83E-06	9.26E-07	2.11E-07	1.82E-07	8.30E-08
With precipitation	5.75E-05	4.79E-06	1.95E-06	6.07E-07	1.25E-07	2.33E-08	1.98E-08	7.34E-09

Results of the calculation of the additional volumetric activity of ^{60}Co in the ground-level layer of the air due to the propagation of an accidental discharge for two types of weather conditions under review are presented on Figure 4.1.

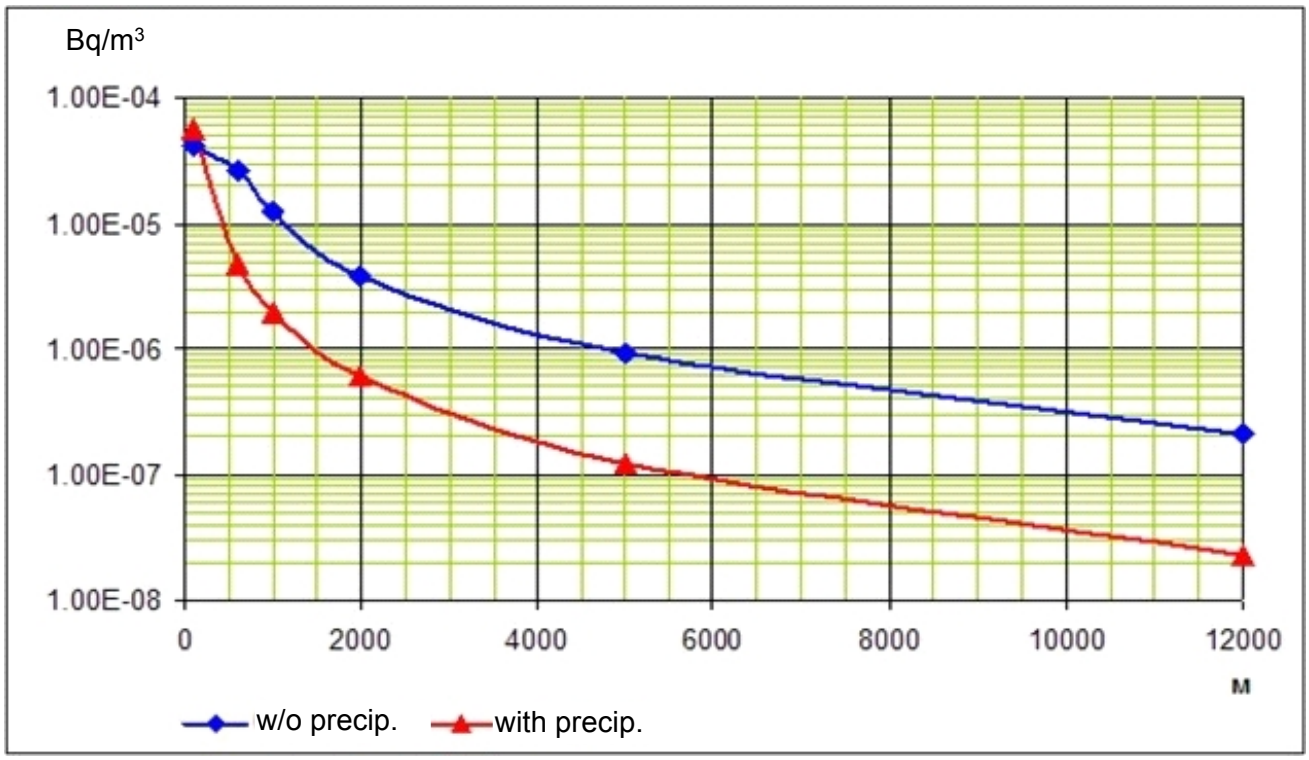


Figure 4.1 — **Dependence of Volumetric Activity of ^{60}Co in the Air along the Trail Axis Depending on Distance (MDBA Case), Bq/m³**

4.2.1.4 Radiation Impact in Case of a Beyond-Design-Basis Accident

A hypothetic accident with the destruction of all fuel elements in a storage cask with the subsequent loss of MPC tightness has been treated as a beyond-design-basis accident with the maximum radiation impact in Section 3.6.

This accident has been assumed to result in a 30-day long discharge from a height of 6 m within the storage area.

A discharge covered in Section 3.6 has been assumed for this accident.

Radiation impacts were calculated for two types of weather conditions:

- without precipitation, with an atmosphere stability category of F, a wind velocity of $V = 2\ м/с$, and a surface roughness parameter of $z_0 = 0{,}1\ м$;

- with precipitation, with an atmosphere stability category of D, a wind velocity of $V = 3\ м/с$, a surface roughness parameter of $z_0 = 0{,}1\ м$, and a rainfall intensity of $\Lambda = 2\ мм/сут$.

Calculations were done using GENII Version 2.10 software and presented in Annex K, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Values of the temporal integral of a volumetric activity of radionuclides in the ground-level air layer along the trail axis (Bq×sec/m³) in case of such an accident are presented in Table 4.4 below.

Table 4.4 — **Temporal Integral of Volumetric Activity of Radionuclides in the Ground-level Air Layer along the Trail Axis Depending on Distance (BDBA Case), Bq×sec/m³**

Radionuclides	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
Without precipitation								
^{60}Co	6.90E+06	4.40E+06	2.00E+06	6.50E+05	1.50E+05	3.50E+04	3.00E+04	1.40E+04
^{90}Sr	4.80E+07	3.00E+07	1.40E+07	4.50E+06	1.00E+06	2.40E+05	2.10E+05	9.60E+04
^{134}Cs	2.20E+07	1.40E+07	6.30E+06	2.10E+06	4.70E+05	1.10E+05	9.50E+04	4.40E+04
^{137}Cs	7.50E+07	4.80E+07	2.20E+07	7.10E+06	1.60E+06	3.80E+05	3.30E+05	1.50E+05
^{238}Pu	6.60E+05	4.20E+05	1.90E+05	6.20E+04	1.40E+04	3.30E+03	2.90E+03	1.30E+03
^{241}Pu	1.40E+07	9.10E+06	4.10E+06	1.40E+06	3.10E+05	7.20E+04	6.20E+04	2.90E+04
^{241}Am	1.90E+05	1.20E+05	5.30E+04	1.70E+04	4.00E+03	9.20E+02	8.00E+02	3.70E+02
With precipitation								
^{60}Co	9.10E+06	7.70E+05	3.10E+05	9.90E+04	2.00E+04	3.80E+03	3.20E+03	1.20E+03
^{90}Sr	6.30E+07	5.30E+06	2.20E+06	6.90E+05	1.40E+05	2.60E+04	2.20E+04	8.30E+03
^{134}Cs	2.90E+07	2.40E+06	9.90E+05	3.10E+05	6.40E+04	1.20E+04	1.00E+04	3.80E+03
^{137}Cs	9.90E+07	8.40E+06	3.40E+06	1.10E+06	2.20E+05	4.10E+04	3.50E+04	1.30E+04
^{238}Pu	8.70E+05	7.30E+04	3.00E+04	9.50E+03	1.90E+03	3.60E+02	3.00E+02	1.20E+02
^{241}Pu	1.90E+07	1.60E+06	6.50E+05	2.10E+05	4.20E+04	7.80E+03	6.60E+03	2.50E+03
^{241}Am	2.50E+05	2.10E+04	8.50E+03	2.70E+03	5.50E+02	1.00E+02	8.60E+01	3.30E+01

The additional annual average volumetric activity of the bottom layer of air along the trail axis depending on the distance due resulting from the discharge is specified below in Table 4.5.

Table 4.5 — **Additional Annual Average Volumetric Activity of Radionuclides in the Ground-level Air Layer along the Trail Axis Depending on Distance (BDBA Case), Bq/m³**

Radionuclides	Distance, m							
	100	**600**	**1000**	**2000**	**5000**	**12000**	**13000**	**20000**
Without precipitation								
^{60}Co	2.20E-01	1.40E-01	6.39E-02	2.08E-02	4.79E-03	1.12E-03	9.58E-04	4.47E-04
^{90}Sr	1.53E+00	9.58E-01	4.47E-01	1.44E-01	3.19E-02	7.66E-03	6.70E-03	3.07E-03
^{134}Cs	7.02E-01	4.47E-01	2.01E-01	6.70E-02	1.50E-02	3.51E-03	3.03E-03	1.40E-03
^{137}Cs	2.39E+00	1.53E+00	7.02E-01	2.27E-01	5.11E-02	1.21E-02	1.05E-02	4.79E-03
^{238}Pu	2.11E-02	1.34E-02	6.07E-03	1.98E-03	4.47E-04	1.05E-04	9.26E-05	4.15E-05
^{241}Pu	4.47E-01	2.91E-01	1.31E-01	4.47E-02	9.90E-03	2.30E-03	1.98E-03	9.26E-04
^{241}Am	6.07E-03	3.83E-03	1.69E-03	5.43E-04	1.28E-04	2.94E-05	2.55E-05	1.18E-05
With precipitation								
^{60}Co	2.91E-01	2.46E-02	9.90E-03	3.16E-03	6.39E-04	1.21E-04	1.02E-04	3.83E-05
^{90}Sr	2.01E+00	1.69E-01	7.02E-02	2.20E-02	4.47E-03	8.30E-04	7.02E-04	2.65E-04
^{134}Cs	9.26E-01	7.66E-02	3.16E-02	9.90E-03	2.04E-03	3.83E-04	3.19E-04	1.21E-04
^{137}Cs	3.16E+00	2.68E-01	1.09E-01	3.51E-02	7.02E-03	1.31E-03	1.12E-03	4.15E-04
^{238}Pu	2.78E-02	2.33E-03	9.58E-04	3.03E-04	6.07E-05	1.15E-05	9.58E-06	3.83E-06
^{241}Pu	6.07E-01	5.11E-02	2.08E-02	6.70E-03	1.34E-03	2.49E-04	2.11E-04	7.98E-05
^{241}Am	7.98E-03	6.70E-04	2.71E-04	8.62E-05	1.76E-05	3.19E-06	2.75E-06	1.05E-06

Results of the calculation of the additional annual average volumetric activity of the ground-level layer of the air due to the propagation of an accidental discharge in case of a hypothetic beyond-design-basis accident for two types of weather conditions under review are presented on Figures 4.2 to 4.5.

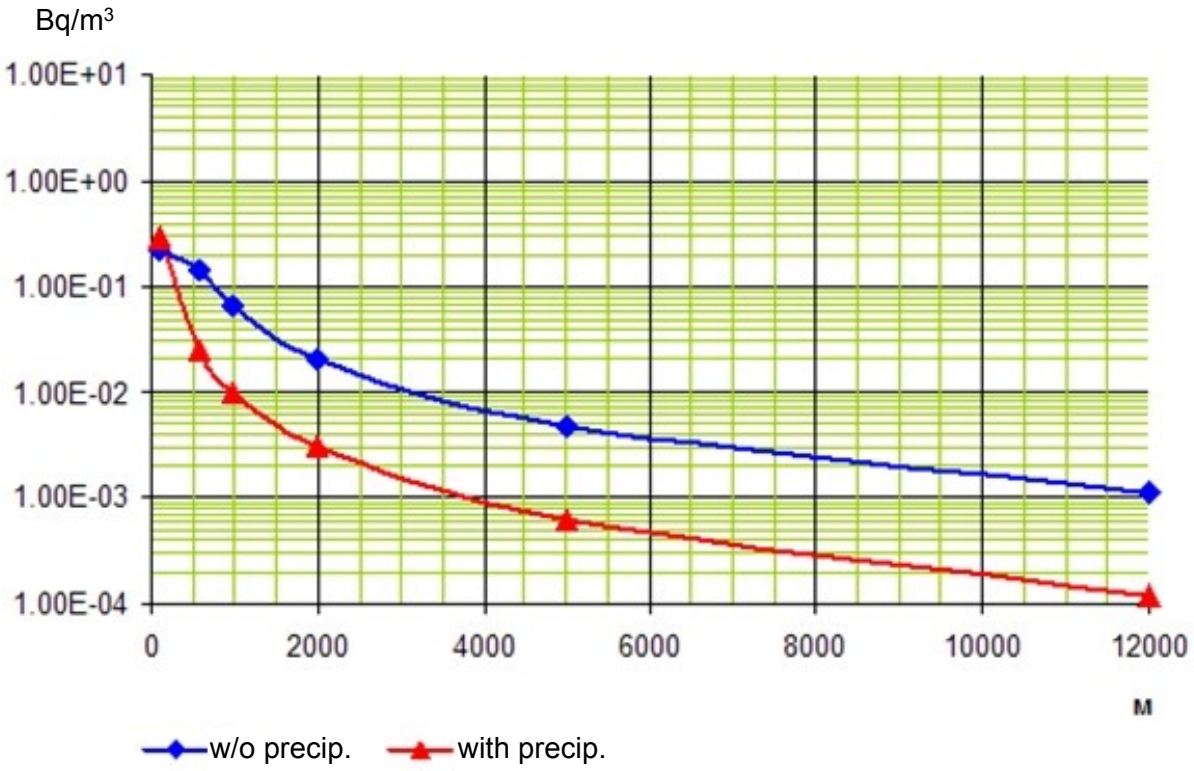


Figure 4.2 – **Annual Average Volumetric Activity of ^{60}Co in the Bottom Layer of the Atmosphere along the Trail Axis Depending on the Distance (BDBA Case), Bq/m³**

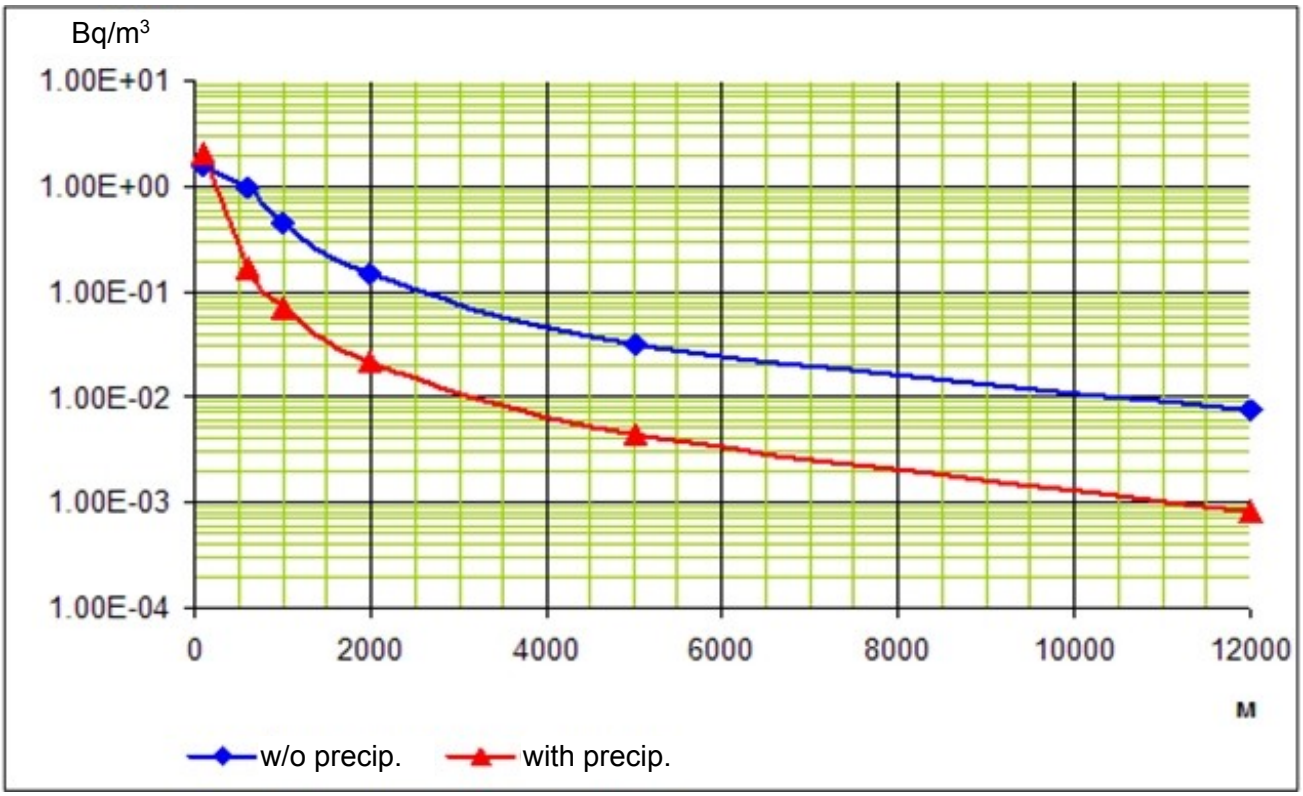


Figure 4.3 – **Annual Average Volumetric Activity of ^{90}Sr in the Bottom Layer of the Atmosphere along the Trail Axis Depending on the Distance (BDBA Case), Bq/m³**

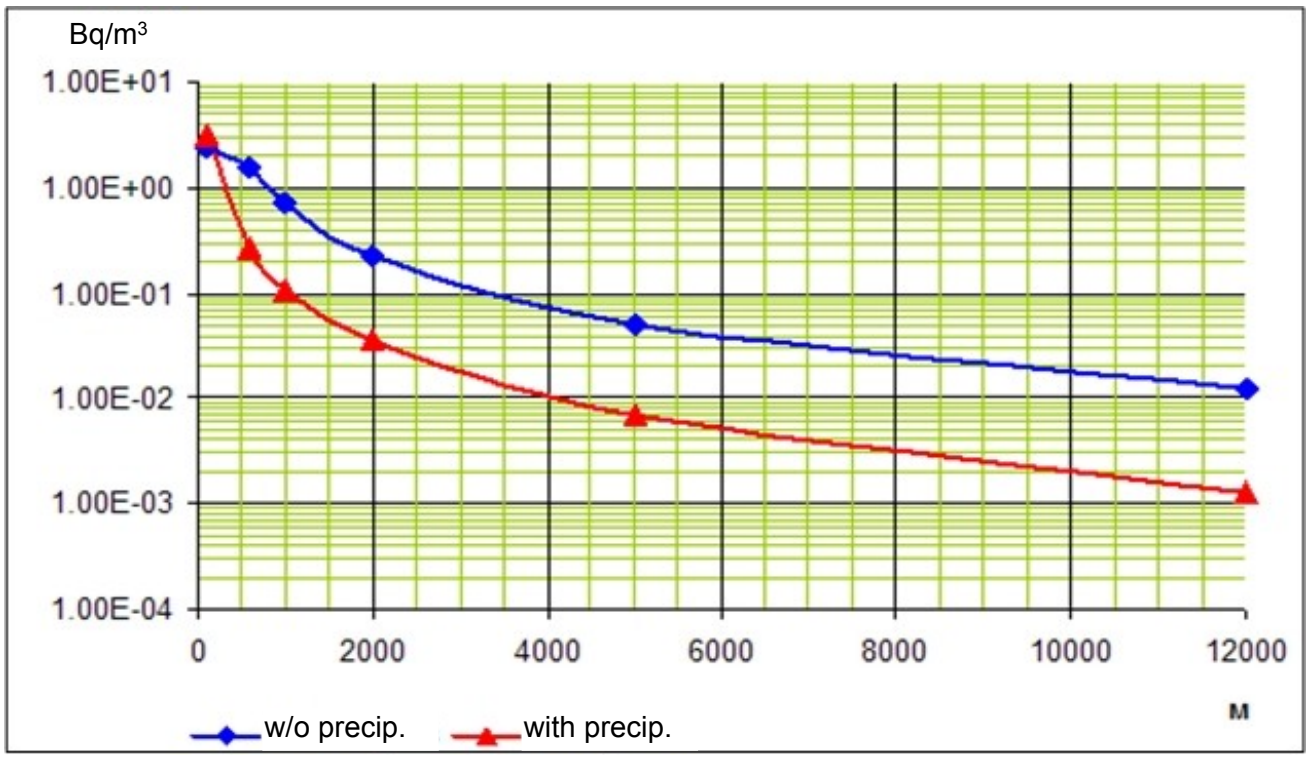


Figure 4.4 – **Annual Average Volumetric Activity of ^{137}Cs in the Bottom Layer of the Atmosphere along the Trail Axis Depending on the Distance (BDBA Case), Bq/m³**

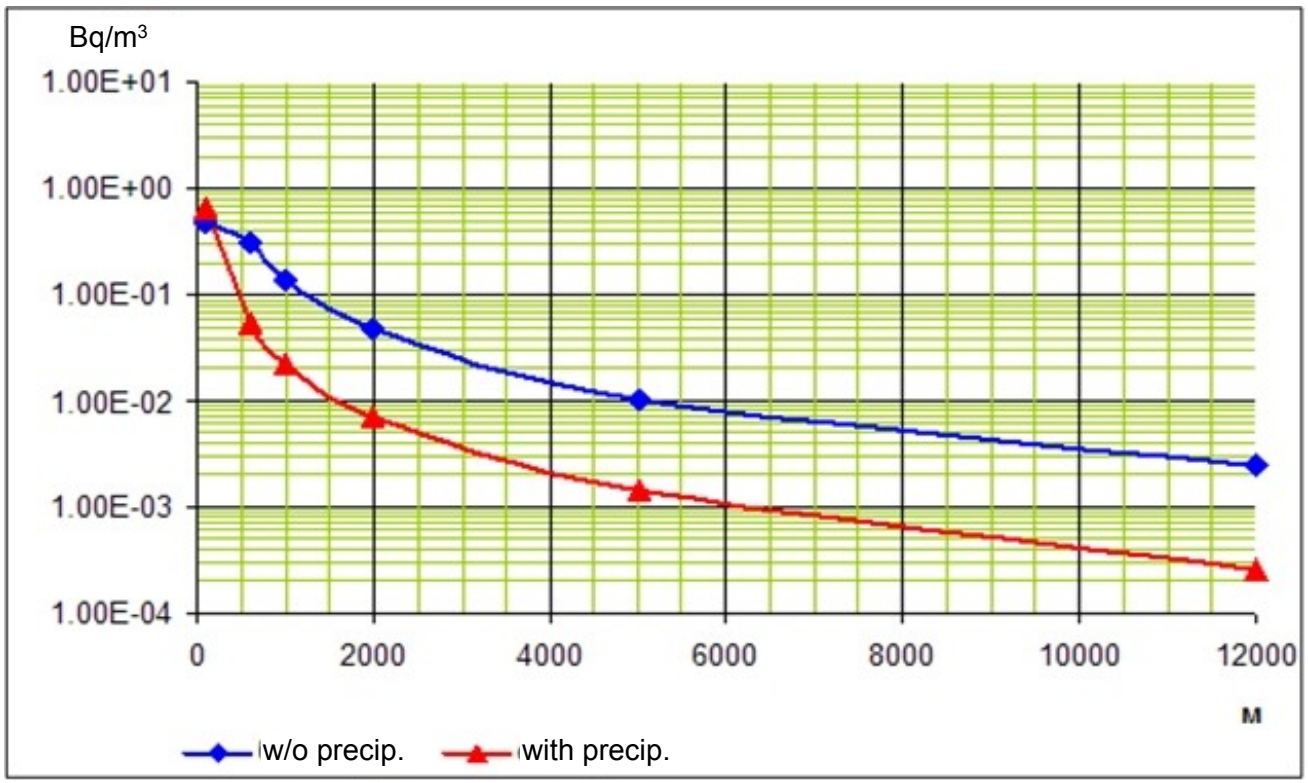


Figure 4.5 – **Annual Average Volumetric Activity of TE in the Bottom Layer of the Atmosphere along the Trail Axis Depending on the Distance (BDBA Case), Bq/m³**

4.2.1.5 Conclusions of the Assessment of the Radiation Impact of the CSFSF on Air Environment during Operation

Normal Operation

The maximum design values of the additional radionuclide concentrations in the boundary air layer at a distance of 100 m from the CSFSF site boundary are at the level of the existing average concentrations in the case of the normal operation of the CSFSF.

With an increase in the distance from the CSFSF site, additional concentrations of radionuclides will be going down and drop to values two or three orders of magnitude below the existing averages at a distance of 12 km (at the exclusion zone boundary).

It should be borne in mind that the calculation has been based on extremely conservative assumptions: the storage area is filled up and the trends of the spent nuclear fuel arrivals are disregarded, the maximum MPC leakage velocity is observed at a pressure difference substantially above the design-basis value, the discharge direction remains unchanged, and results are provided for the trail axis. Additional concentrations in case of the normal operation will be several orders of magnitude below the obtained values under more realistic conditions of the release of radioactive materials from the MPC cask, the consideration of changes in the wind direction during a year, and the averaging of results over the entire discharge plume.

Thus, the impacts of a discharge in case of a normal operation of the CSFSF on the air environment are acceptable.

Maximum Design-Basis Accident

As data on the air environment contamination with ^{60}Co within the CSFSF area are unavailable, allowed concentrations of this isotope in the air for personnel and population have prescribed by DHN 6.6.1-6.5.001-98 [14] have been adopted as a criterion.

Under DHN 6.6.1-6.5.001-98 [14], permitted air concentrations of ^{60}Co amount to 70 Bq/m^3 for personnel and 1 Bq/m^3 for the population.

It follows from the comparison of the ^{60}Co air contamination levels specified in Section 4.2.1.3 with concentrations allowed under DHN 6.6.1-6.5.001-98 [14] that the air contamination with ^{60}Co accidental discharges is insignificant.

Hypothetic Beyond-Design-Basis Accident

Maximum accidental radioactive contamination of the lower layer of the atmosphere with radioactive aerosols will be observed in a close vicinity of the CSFSF site with the aggregate air activity up to 10 Bq/m^3.

However, at a distance of 12 km (at the exclusion zone boundary), the levels will be much lower and will not exceed 5E-3 Bq/m³.

Values of allowed concentrations in air for the population for the most radiologically significant radionuclides present in an accidental discharge as per DHN 6.6.1-6.5.001-98 [14] are provided below:

- ^{60}Co ..... 1.0 Bq/m³;
- ^{90}Sr ..... 2.0 E-1 Bq/m³;
- ^{134}Cs ..... 1.0 Bq/m³;
- 137Cs ..... 8.0 E-1 Бк/м³;
- 238Pu ..... 4.0 E-4 Бк/м³;
- 241Pu ..... 2.0 E-2 Бк/м³;
- 241Am ..... 4.0 E-4 Бк/м³.

The volumetric activity of accidental discharge radionuclides at the nearest exclusion zone boundary (12 km away) will not exceed allowed concentrations in the air for the population prescribed by DHN 6.6.1-6.5.001-98 [14].

Taking into consideration a low probability of the hypothetic beyond-design-basis accident and a relatively low value of the aggregate volumetric activity of radionuclides in the air of residential areas, the radiation impacts of an accidental discharge as a result of such an accident should be deemed acceptable.

4.2.2 Impact of Contaminant Emissions from the CSFSF on Air Environment

4.2.2.1 Contaminant Emission Sources

The following will be the main contaminant emission sources at the CSFSF site:

- the diesel power plant;
- the filling station;
- load-lifting machinery, mechanisms, cars and trucks on the site;
- the rail transport;
- the vehicles at the concrete plant site;
- the concrete plant (silo);
- the warehouses of the concrete plant.

A map indicating sources of contaminant emissions at the CSFSF site is provided in Annex M, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

4.2.2.2 Justification of Assessment Methodologies Applied

Diesel Power Plant Emissions

The amount of contaminant emissions into the air by the diesel power plant is calculated according to the following formulas:

$$E_б^{сек} = e_б \times G^{сек} \times 10^{-3} \ г/с \quad (1)$$

$$E_б^{год} = e_б \times G^{год} \times 10^{-6} \ т/год \quad (2)$$

where $E_б^{сек}$, $E_б^{год}$ are amounts of contaminants in grams per second and tonnes per year;

$e_б$ is the contaminant emission indicator in mg per nm^3;

$G^{сек}$, $G^{год}$ are flow rates of exhaust gases over the operating period, nm^3 per second, nm^3 per year.

Filling Station Emissions

The contaminant emissions from the filling station were calculated on the basis of the Methodological Guidance [97].

The amount of contaminant emissions into the air due to the fuel evaporation is calculated according to the following formula:

$$П_р = 2{,}52 \times V_ж^{год} \times Ps_{(38)} \times Mn \times (K_{5ж} + K_{5xm}) \times K_6 \times K_7 \times (1 - \eta) \times 10^{-9} \ кг/ч \quad (3)$$

where $V_ж^{год}$ is the volume of the liquid filled into the tank during a year, m^3 per year;

M_n is the molecular mass of liquid vapors;

$Ps_{(38)}$ is the equilibrium vapor pressure of the liquid;

η is the efficiency factor of the gas handling device of the tank, fraction;

$K_{5ж}$ и K_{5xm} are adjustment factors which depend on $Ps_{(38)}$ and the temperature of the vapor space during cold and warm seasons respectively;

K_6 is an adjustment factor which depends on $Ps_{(38)}$ and the annual tank turnover rate;

K_7 is an adjustment factor that depends on the technology intensity of the tank and its operating mode.

The amount of contaminant emissions into the air due to the fuel filling is calculated according to the following formula:

$$П_н = 2{,}52 \times V_ж^{год} \times Ps_{(38)} \times Mn \times (K_{5ж} + K_{5хт}) \times K_8 \times (1 - \eta) \times 10^{-9} \; кг/ч \quad (4)$$

where $V_ж^{год}$ is the volume of the liquid filled into the tank during a year, m³ per year;

K_8 is a factor that depends on $Ps_{(38)}$ and the climate zone.

Discharges from Internal Combustion Engines of Load-lifting Machinery, Mechanisms, and Transport

Discharges of contaminants from load-lifting machinery and mechanisms, vehicles and rail transport were calculated on the basis of methodologies [94, 95].

Specific gravity of discharges in g per km is converted into g per second according to the following formula for the calculation of the maximum once-off discharge mass:

$$g.V\ (г/с) = g\ (г/км) \times V\ (км/ч)/3600\ (с) \quad (5)$$

The amount of contaminant emissions from internal combustion engines was determined according to the following formula from the Methodological Guidance [97]:

$$M_i = K_i^t \times B^t \quad (6)$$

where M_i is the amount of contaminants, g, tonnes;

K_i^t is the specific emission of the i*-th* substance during the fuel combustion, g per g, tonne per tonne;

B^t is the volume of the consumed fuel in g or tonne;

Values of the K_i^t factor for various fuels are provided in Table 4.6.

Table 4.6 — **Value of the K_i^t Factor for Various Fuels**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			Diesel fuel	Gasoline
301	Nitrogen dioxide (NO_2)	0.2	0.04	0.04
328	Soot	0.15	0.0155	0.0158
330	Sulfur dioxide (SO_2)	0.5	0.02	0.002
337	Carbon monoxide (CO)	5.0	0.1	0.6
703	Benz(a)pyrene	1×E-5	0.00000032	0.00000023
2754	Non-methane volatile organic compounds	1.0	0.03	0.1

Emissions from the Concrete Plant (Silo)

The contaminant emissions from the concrete plant were calculated on the basis of the Methodological Guidance [96].

The contaminant emissions from the silo during the cement loading are calculated according to the following formulas:

$$E_{б}^{сек} = e_{б} \times G^{сек} \times 10^{-3} \ г/с \quad (7)$$

$$E_{б}^{год} = e_{б} \times G^{год} \times 10^{-6} \ т/год \quad (8)$$

where $E_{б}^{сек}$, $E_{б}^{год}$ are amounts of contaminants in grams per second and tonnes per year;

$e_{б}$ is the contaminant emission indicator in mg per nm^3;

$G^{сек}$, $G^{год}$ are air flow rates over the operating period, nm^3 per second, nm^3 per year.

Emissions from Warehouses of the Concrete Plant

The contaminant emissions from warehouses of the concrete plant were calculated on the basis of the Methodological Guidance [96].

The total amount of emissions is calculated according to the following formula:

$$q = A = \frac{k_1 \times k_2 \times k_3 \times k_4 \times k_5 \times k_7 \times G \times 10^6 \times B'}{3600} \quad (9)$$

where A are emissions during material handling (depositing, loading/unloading, moving), g per second;

k_1 is weight percentage of the dust fraction in the material. It is determined by washing and sieving of an average sample with the isolation of the 0-200 um dust fraction;

k_2 is a percentage of the dust (of the total dust mass) transformed into an aerosol;

k_3 is a factor that takes into account local weather conditions;

k_4 is a factor that takes into account local weather conditions, the degree of protection of the handling area against external impacts, and conditions of the dust generation;

k_5 is a factor that takes into account material moisture content;

k_7 is a factor that takes into account material coarseness;

G is the aggregate amount of the material handled, tonnes per hour;

B' is a factor that takes into account the pouring height.

4.2.2.3 Initial Input Data for the Calculation

Core activities at the CSFSF site will take place on a single-shift basis, five days a week, 220 days per year. The shift duration is eight hours.

A list of contamination sources within the CSFSF site is provided in Table 4.7.

Table 4.7 **List of Contamination Sources within the CSFSF Site**

CES Number	Contaminant Emission Source Name
001	Diesel power plant (DPP-1)
002	Filling station
003	Vehicles on the site
	• Transporter
	• Truck crane with load lifting capacity of 25 tonnes of KC-55713-K-4-02 type
	- Truck with an extensible boom platform of VS-18 type
	• Minibus for personnel of IVECO Bus 16+1 type
	• Sweeping truck (winter/summer) of PM-533701-1.02 type
	• Putzmeister BSF 28
004	**Vehicles of the concrete plant**
	• KrAZ-6511H4-0000120-000
	• KrAZ-6511H4-0000120-000
	• KrAZ-6511H4-0000120-000
	• AMKODOR 332V
005	**Rail vehicles**
	• TEM-2U or TEM-18 diesel locomotive
006	Concrete plant
007	Warehouses of the concrete plant

Initial Input Data for the Calculation of Emissions from the Diesel Power Plant

Diesel power plant parameters have been assumed on the basis of Caterpillar C13 index sheet as specified in Table 4.8. Diesel power plant emission parameters as per Caterpillar C13 index sheet are specified in Table 4.9.

Table 4.8 – **Diesel Power Plant Parameters (of Caterpillar C13 type)**

Parameter	Caterpillar C13
Power output, kVA	400
Power output, kW	320
Fuel consumption, liters per hour	83.50
Operating hours, hours per year	32
Specific fuel consumption, g per kWh	215
Fuel consumption, tonnes per year	2.204
Exhaust gas temperature, °C	666.9
Flow rate, m³/sec	1.05

Table 4.9 – **Diesel Power Plant Emission Parameters (of Caterpillar C13 type at 15% of O_2)**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			mg/nm³ per minute	mg/nm³ per sec
301	Nitrogen dioxide (NO_2)	0.2	2730.6	45.510
337	Carbon monoxide (CO)	5.0	750.5	12.508
2754	Non-methane volatile organic compounds	1.0	8.0	0.133

Initial Input Data for the Calculation of Emissions from the Filling Station

Details of the monthly average temperature on the CSFSF site are provided in Table 2.7; data on fuel temperature within the tank are provided in Table 4.10.

Table 4.10 – **Fuel Temperature within the Tank**

Period	Temperature, °C
6 cold months	10
6 warm months	20

Initial Input Data for the Calculation of Emissions from Vehicles on Site

All vehicles operating on site are equipped with diesel engines. The number, speed, operating hours of vehicles on the site, and the amount of the consumed fuel are specified in Table 4.11.

Table 4.11 – **Initial Input Data for the Calculation of Emissions from Vehicles on Site**

Description	Quantity	Speed	Operating hours	Fuel consumption				
		kph	hours	liters per hour	kg per hour	g per km	g per sec	tonnes per year
Transporter	1	1	70	35.00	28.875	5775.000	1.60416667	2.021
Truck crane with load lifting capacity of 25 tonnes of KC-55713-K-4-02 type	1	20	90	19.00	15.675	156.750	0.87083333	1.411
Truck with an extensible boom platform of VS-18 type	1	20	90	16.00	13.200	132.000	0.73333333	1.188
Minibus for personnel of IVECO Bus 16+1 type	1	20	210	8.00	6.600	66.000	0.36666667	1.386
Sweeping truck (winter/summer) of PM-533701-1.02 type	1	20	250	16.00	13.200	132.000	0.73333333	3.300
Putzmeister BSF 28	1	20	100	16.00	13.200	132.000	0.73333333	1.320
TOTAL	**6**				**90.750**	**6393.75**	**5.04166667**	**10.626**
Note: Diesel fuel standard density is 0.825 kg per liter.								

Initial Input Data for the Calculation of Emissions from Vehicles of the Concrete Plant

All vehicles operating on the concrete plant site are equipped with diesel engines. The number, speed, operating hours of vehicles on the concrete plant site, and the amount of the consumed fuel are specified in Table 4.12.

Table 4.12– **Initial Input Data for the Calculation of Emissions from Vehicles of the Concrete Plant**

Description	Quantity	Speed	Operating hours	Fuel consumption				
		kph	hours	liters per hour	kg per hour	g per km	g per sec	tonnes per year
KrAZ-6511H4-0000120-000	3	20	100	19.00	47.025	470.250	2.61250000	4.703
AMKODOR 332V	1	20	60	16.00	13.200	132.000	0.73333333	0.792
TOTAL	**4**				**60.225**	**602.25**	**3.34583333**	**5.495**
Note: Diesel fuel standard density is 0.825 kg per liter.								

Initial Input Data for the Calculation of Emissions from the Rail Transport

All rail locomotives operating on site are equipped with diesel engines. The number, speed, operating hours of vehicles on the site, and the amount of the consumed fuel are specified in Table 4.12.

Table 4.13 – **Initial Input Data for the Calculation of Emissions from the Rail Transport**

Description	Quantity	Speed	Operating hours	Fuel consumption				
		kph	hours	liters per hour	kg per hour	g per km	g per sec	tonnes per year
TEM-2U or TEM-18 diesel locomotive	1	10	150	100	82.500	825.000	2.29166667	12.375
TOTAL	**2**				**82.500**	**825.000**	**2.29166667**	**12.375**
Note: Diesel fuel standard density is 0.825 kg per liter.								

Initial Input Data for the Calculation of Emissions from the Concrete Plant

A system of cement (silo) hoppers with a capacity of 36 m^3 each has a system of sock filters with a throughput up to 7 nm^3 per minute (0.12 m^3 per second).

Residual dust content in the air downstream of the filter is 6 mg/m³.

Silo filling time totals 175 minutes.

The amount of dust emissions into the air from silos is calculated according to the following formulas:

$$E_{б}^{сек} = e_{б} \times G^{сек} \times 10^{-3} \ г/с \quad (10)$$

$$E_{б}^{год} = e_{б} \times G^{год} \times 10^{-6} \ т/год \quad (11)$$

where $E_{б}^{сек}$, $E_{б}^{год}$ are amounts of contaminants in grams per second and tonnes per year;

$e_{б}$ is the contaminant emission indicator in mg per nm^3;

$G^{сек}$, $G^{год}$ are air flow rates over the operating period, m^3 per second, m^3 per year.

Initial Input Data for the Calculation of Emissions from Warehouses of the Concrete Plant

Concrete plant warehouses are filled up during 30 days per year.

Details of volumes of the moved materials are provided in Table 4.14.

Table 4.14– **Details of Volumes of Moved Materials**

Description	Substance code	Material volume m^3	Material volume tonnes	Material volume %	Material volume %/tonne	Material volume tonnes per hour
Crushed rock	2902	240	652.8	66.67	24.02	21.76
Sand	2907	120	206.4	33.33	75.98	6.88
Suspended solids	**2902**	**360**	**859.2**	**100**	**100**	**28.64**
Note: According to the Methodology [96], no emissions need to be calculated for sand with the moisture content of more than 3%						

4.2.2.4 Calculation of Contaminant Emissions into Atmospheric Air during Operation

Calculation of Emissions from the Diesel Power Plant

$$E_{NOx}^{сек} = 45{,}51 \times 1{,}05 \times 10^{-3} = 0{,}0477855\ г/с$$

$$E_{NOx}^{год} = 45{,}51 \times 120960 \times 10^{-6} = 0{,}006\ т/год$$

$$E_{CO}^{сек} = 12{,}508 \times 1{,}05 \times 10^{-3} = 0{,}01313375\ г/с$$

$$E_{CO}^{год} = 12{,}508 \times 120960 \times 10^{-6} = 0{,}0015\ т/год$$

$$E_{НМЛОС}^{сек} = 0{,}133 \times 1{,}05 \times 10^{-3} = 0{,}00014\ г/с$$

$$E_{НМЛОС}^{год} = 0{,}133 \times 120960 \times 10^{-6} = 0{,}000016\ т/год$$

Volumes of contaminant emissions from the diesel power plant into atmospheric air during operation are specified in Table 4.15.

Table 4.15 – **Volumes of Contaminant Emissions from the Diesel Power Plant into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
301	Nitrogen dioxide (NO_2)	0.2	0.04778550	0.00550489
337	Carbon monoxide (CO)	5.0	0.01313375	0.00151301
2754	Non-methane volatile organic compounds	1.0	0.00014000	0.00001613

The aggregate volume of emissions is consolidated in Table 4.24.

Calculation of Emissions from the Filling Station

The equilibrium vapor pressure of the liquid $Ps_{(38)}$ is calculated as follows:

$$t_{экв} = t_{нк} + \frac{t_{кк} - t_{нк}}{8{,}8} \qquad (12)$$

where $t_{кк}$ *u* $t_{нк}$ are fuel initial and end boiling points

For summer diesel fuel:

$$t_{нк} = 180\ ^{\circ}C$$

$$t_{кк} = 300^{\circ}C$$

$$t_{экв} = 180 + \frac{300 - 180}{8{,}8} = 193{,}6\ ^{\circ}C$$

For winter diesel fuel:

$$t_{нк} = 180\ ^{\circ}C$$

$$t_{кк} = 310^{\circ}C$$

$$t_{экв} = 180 + \frac{310 - 180}{8{,}8} = 194{,}7\ ^{\circ}C$$

The equilibrium vapor pressure of the liquid $Ps_{(38)}$ is determined on the basis of Table P.6.1 [97].

At temperature $t_{экв} = 193{,}6\ ^{\circ}C$, pressure is $Ps_{(38)} = 1{,}68$

At temperature $t_{экв} = 194{,}7\ ^{\circ}C$, pressure is $Ps_{(38)} = 1{,}62$

The molar mass is determined on the basis of Table 2.7 [97].

$M_n = 146$ г/моль

Calculation of factors $K_{5x}\ u\ K_{5m}$

Calculation of the average temperatures of the cold and warm seasons:

6 cold month average temperature:

$$t_{ax} = \frac{-6{,}7 + (-5) + (-0{,}13) + (-2{,}7) + 1{,}7 + 7{,}5}{6} = -0{,}94\ ^{\circ}C$$

6 warm month average temperature:

$$t_{am} = \frac{7{,}5 + 14{,}3 + 17{,}7 + 19{,}1 + 18{,}2 + 13{,}1}{6} = 15{,}0\ ^{\circ}C$$

Factors $K_1 - K_3$ are taken from Table P.3.1 [97] as specified in Table 4.16

Table 4.16 — $K_1 - K_3$ **Factors for 6 Warm and 6 Cold Months**

For warm months		For cold months	
K_1	1.62	K_1	6.1
K_2	0.19	K_2	0.17
K_3	0.74	K_3	0.36

Average cold-month temperature is calculated according to the following formula:

$$t_{cx} = K_1 + K_2 \cdot t_a + K_3 \cdot t_{рез} \quad (13)$$

where: $K_1 - K_3$ are factors for 6 warmest months;

t_a is the 6-month average atmospheric air temperature;

$t_{рез}$ is fuel temperature within the tank.

$t_{cx} = 6{,}1 + 0{,}17 \times (-0{,}94) + (0{,}36 \times 10) = 9{,}5\ ^{\circ}C$

Average warm-month temperature is calculated according to the following formula:

$$t_{cm} = K_4 \times (K_1 + K_2 \times t_a + K_3 \times t_{рез}) \quad (14)$$

where: $K_1 - K_3$ are factors for 6 warmest months;

K_4 is the reflection factor ($K_4 = 1$ in case of underground tanks);

t_a is the 6-month average atmospheric air temperature;

$t_{рез}$ is fuel temperature within the tank.

$t_{cx} = 1 \times (1{,}62 + 0{,}19 \times (15) + (0{,}74 \times 20)) = 19{,}3\ ^{\circ}C$

Factors K_{5x} и K_{5m} are determined from Table П.3.4 [97].

$K_{5x} = 0{,}106$, $K_{5m} = 0{,}243$

Factor K_6 is determined from Table П.2.4 [97] depending on the fuel tank turnover for different climate zones

Tank turnover rate $П$ is determined as follows:

$$П = \frac{V_ж}{V_p} \quad (15)$$

where $V_ж$ is the volume of the liquid filled into the tank during a year, m³ per year;

V_p is the tank volume in m³.

For summer fuel: $П = \frac{15}{5} = 3$, for winter fuel: $П = \frac{10}{5} = 2$.

$K_6 = 1{,}26$

Adjustment factor K_7 depends on the technology intensity of the tank and its operating mode.

The value of factor K_7 is taken from Table П.5.1 [97] depending on the availability of loss reduction equipment in the tank and its mode of operation.

The tank is equipped with a breather valve and operates in a measuring vessel mode.

In this case, $K_7 = 1$

The value of factor K_8 is taken from Table 2.7 [97] depending on the climate zone and the method of filling fuel in the tank.

The adjustment factor of 3.5 is used if fuel is poured from the top with an open jet.

With $Ps_{(38)}$ under 67 hPa, $K_8 = 0{,}5$ for the moderate climate zone.

$K_8 = 0{,}5 \times 3{,}5 = 1{,}75$ for the open-jet pouring from the top.

Calculation of the amount of contaminant emissions into the air due to the fuel evaporation

For summer fuel:

$$П^л_р = 2{,}52 \times 15 \times 1{,}68 \times 146 \times (0{,}106 + 0{,}243) \times 1{,}26 \times 1 \times (1 - 0) \times 10^{-9} = 0{,}0000040712 \text{ кг/ч}$$

$П^л_р = 0{,}00000113$ г/с, $П^л_р = 0{,}00003569$ т/год

For winter fuel:

$$П^з_р = 2{,}52 \times 10 \times 1{,}62 \times 146 \times (0{,}106 + 0{,}243) \times 1{,}26 \times 1 \times (1 - 0) \times 10^{-9} = 0{,}0000026172 \text{ кг/ч}$$

$П^з_р = 0{,}00000073$ г/с, $П^з_р = 0{,}00002294$ т/год

Total annual emissions from fuel evaporation equal the sum of emissions over summer and winter seasons.

$П^з_р = 0{,}00000113 + 0{,}00000073 = 0{,}00000186$ г/с

$П^з_р = 0{,}00002294 + 0{,}00003569 = 0{,}00005864$ т/год

Calculation of the amount of contaminant emissions into the air due to the fuel spilling

For summer fuel:

$$П^л_н = 2{,}52 \times 15 \times 1{,}68 \times 146 \times (0{,}106 + 0{,}243) \times 1{,}75 \times (1 - 0) \times 10^{-9} = 0{,}00000565 \text{ кг/ч}$$

$П^{л}_{н} = 0{,}00000157\ г/с$, $П^{л}_{н} = 0{,}00004957\ т/год$

For winter fuel:

$$П^{з}_{н} = 2{,}52 \times 10 \times 1{,}62 \times 146 \times (0{,}106 + 0{,}243) \times 1{,}26 \times 1 \times (1 - 0) \times 10^{-9} = 0{,}0000026172\ кг/ч$$

$П^{з}_{н} = 0{,}000000101\ г/с$, $П^{з}_{н} = 0{,}00003187\ т/год$

Total annual emissions from fuel filling equal the sum of emissions over summer and winter seasons.

$П_{н} = 0{,}00000157 + 0{,}00000101 = 0{,}00000258\ г/с$

$П_{н} = 0{,}00004957 + 0{,}00003187 = 0{,}00008144\ т/год$

Total annual contaminant emissions from the filling station equal the sum of emissions over summer and winter seasons.

$П_{о} = 0{,}00000258 + 0{,}00000186 = 0{,}00000444\ г/с$

$П_{о} = 0{,}00008144 + 0{,}00005864 = 0{,}00014007\ т/год$

Since diesel fuel is split into hydrocarbons and hydrogen sulfide during the evaporation, the following values are assumed in accordance with Table 2.11 [97].

Hydrogen sulfide

$П^{сек}_{сероводород} = 0{,}00000444\ г/с \times 0{,}0028 = 0{,}00000001\ г/с$

$П^{год}_{сероводород} = 0{,}00014007\ т/год \times 0{,}0028 = 0{,}00000039\ т/год$

Non-methane volatile organic compounds

$П^{сек}_{НМЛОС} = 0{,}00000444\ г/с \times 0{,}9972 = 0{,}00000443\ г/с$

$П^{год}_{НМЛОС} = 0{,}00014007\ т/год \times 0{,}9972 = 0{,}00013968\ т/год$

Volumes of contaminant emissions from the filling station into atmospheric air during operation are specified in Table 4.17.

Table 4.17 – **Volumes of Contaminant Emissions from the Filling Station into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
333	Hydrogen sulfide (H_2S)	0.0008	0.00000001	0.00000039
2754	Non-methane volatile organic compounds	1.0	0.00000443	0.00013968

Calculation of Emissions from Vehicles on Site

$M^{сек}_{NOx} = 5{,}04166667 \times 0{,}04 = 0{,}20166667\ г/с$

$M^{год}_{NOx} = 10{,}626 \times 0{,}04 = 0{,}425\ т/год$

$M^{сек}_{Сажа} = 5{,}04166667 \times 0{,}0155 = 0{,}07814583\ г/с$

$M^{год}_{Сажа} = 10{,}626 \times 0{,}0155 = 0{,}165\ т/год$

$M^{сек}_{SO_2} = 5{,}04166667 \times 0{,}02 = 0{,}10083333\ г/с$

$M^{год}_{SO_2} = 10{,}626 \times 0{,}02 = 0{,}213\ т/год$

$M^{сек}_{CO} = 5{,}04166667 \times 0{,}1 = 0{,}50416667\ г/с$

$M^{год}_{CO} = 10{,}626 \times 0{,}1 = 1{,}063\ т/год$

$M^{сек}_{Бенз(а)пирен} = 5,04166667 \times 0,00000032 = 0,00000161\ г/с$

$M^{год}_{Бенз(а)пирен} = 10,626 \times 0,00000032 = 0,00000340\ т/год$

$M^{сек}_{НМЛОС} = 5,04166667 \times 0,03 = 0,15125000\ г/с$

$M^{год}_{НМЛОС} = 10,626 \times 0,03 = 0,319\ т/год$

Volumes of contaminant emissions from vehicles on site into atmospheric air during operation are specified in Table 4.18.

Table 4.18 – **Volumes of Contaminant Emissions from Vehicles on Site into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
301	Nitrogen dioxide (NO_2)	0.2	0.20166667	0.425
328	Soot	0.15	0.07814583	0.165
330	Sulfur dioxide (SO_2)	0.5	0.10083333	0.213
337	Carbon monoxide (CO)	5.0	0.50416667	1.063
703	Benz(a)pyrene	1×E-5	0.00000161	0.00000340
2754	Non-methane volatile organic compounds	1.0	0.15125000	0.319

The aggregate volume of emissions is consolidated in Table 4.24.

Calculation of Emissions from Vehicles of the Concrete Plant

$M^{сек}_{NOx} = 3,34583333 \times 0,04 = 0,13383333\ г/с$

$M^{год}_{NOx} = 5,495 \times 0,04 = 0,220\ т/год$

$M^{сек}_{Сажа} = 3,34583333 \times 0,0155 = 0,05186042\ г/с$

$M^{год}_{Сажа} = 5,495 \times 0,0155 = 0,085\ т/год$

$M^{сек}_{SO_2} = 3,34583333 \times 0,02 = 0,06691667\ г/с$

$M^{год}_{SO_2} = 5,495 \times 0,02 = 0,110\ т/год$

$M^{сек}_{CO} = 3,34583333 \times 0,1 = 0,33458333\ г/с$

$M^{год}_{CO} = 5,495 \times 0,1 = 0,549\ т/год$

$M^{сек}_{Бенз(а)пирен} = 3,34583333 \times 0,00000032 = 0,00000107\ г/с$

$M^{год}_{Бенз(а)пирен} = 5,495 \times 0,00000032 = 0,00000176\ т/год$

$M^{сек}_{НМЛОС} = 3,34583333 \times 0,03 = 0,10037500\ г/с$

$M^{год}_{НМЛОС} = 5,495 \times 0,03 = 0,165\ т/год$

Table 4.19 – **Volumes of Contaminant Emissions from Vehicles of the Concrete Plant into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
301	Nitrogen dioxide (NO_2)	0.2	0.13383333	0.220
328	Soot	0.15	0.05186042	0.085
330	Sulfur dioxide (SO_2)	0.5	0.06691667	0.110
337	Carbon monoxide (CO)	5.0	0.33458333	0.549
703	Benz(a)pyrene	1×E-5	0.00000107	0.00000176
2754	Non-methane volatile organic compounds	1.0	0.10037500	0.165

The aggregate volume of emissions is consolidated in Table 4.24.

Calculation of Emissions from the Rail Transport

$$M_{NOx}^{сек} = 2{,}29166667 \times 0{,}04 = 0{,}09166667\ г/с$$

$$M_{NOx}^{год} = 12{,}375 \times 0{,}04 = 0{,}495\ т/год$$

$$M_{Сажа}^{сек} = 2{,}29166667 \times 0{,}0155 = 0{,}03552083\ г/с$$

$$M_{Сажа}^{год} = 12{,}375 \times 0{,}0155 = 0{,}192\ т/год$$

$$M_{SO_2}^{сек} = 2{,}29166667 \times 0{,}02 = 0{,}04583333\ г/с$$

$$M_{SO_2}^{год} = 12{,}375 \times 0{,}02 = 0{,}248\ т/год$$

$$M_{CO}^{сек} = 2{,}29166667 \times 0{,}1 = 0{,}22916667\ г/с$$

$$M_{CO}^{год} = 12{,}375 \times 0{,}1 = 1{,}238\ т/год$$

$$M_{Бенз(а)пирен}^{сек} = 2{,}29166667 \times 0{,}00000032 = 0{,}00000073\ г/с$$

$$M_{Бенз(а)пирен}^{год} = 12{,}375 \times 0{,}00000032 = 0{,}00000396\ т/год$$

$$M_{НМЛОС}^{сек} = 2{,}29166667 \times 0{,}03 = 0{,}06875000\ г/с$$

$$M_{НМЛОС}^{год} = 12{,}375 \times 0{,}03 = 0{,}371\ т/год$$

Emissions from rail vehicles on site are calculated in Table 4.20.

Table 4.20 – **Volumes of Contaminant Emissions from Rail Vehicles into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
301	Nitrogen dioxide (NO_2)	0.2	0.09166667	0.495
328	Soot	0.15	0.03552083	0.192
330	Sulfur dioxide (SO_2)	0.5	0.04583333	0.248
337	Carbon monoxide (CO)	5.0	0.22916667	1.238
703	Benz(a)pyrene	1×E-5	0.00000073	0.00000396
2754	Non-methane volatile organic compounds	1.0	0.06875000	0.371

The aggregate volume of emissions is consolidated in Table 4.24.

Calculation of Emissions from the Concrete Plant

$$E_{б}^{сек} = 6 \times 0{,}12 \times 10^{-3} = 0{,}00072\ г/с$$

$$E_{б}^{год} = 6 \times 1{,}26 \times 10^{-3} = 0{,}00756\ т/год$$

Emissions from silos of the concrete plant are calculated in Table 4.21.

Table 4.21 – **Volumes of Contaminant Emissions from Filling Silos with Cement into Atmospheric Air**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
2908	Inorganic dust containing silicon dioxide, %: 70-20 (chamotte, cement, etc.)	0.3	0.00072	0.00756

The aggregate volume of emissions is consolidated in Table 4.24.

Calculation of Emissions from Warehouses of the Concrete Plant

Dust emissions during the filling of warehouses of the concrete plant are presented in Table 4.22.

Table 4.22 – **Dust Emissions during the Filling of Warehouses of the Concrete Plant**

Description	Substance code	k_1	k_2	k_3	k_4	k_5	k_7	G	B'	q=A g per sec	q=A tonnes per year
Crushed rock	2902	0.4	0.02	2	0.1	0.6	0.6	21.76	0.5	**0.174**	**0.094**
Sum										**0.174**	**0.094**

Volumes of contaminant emissions are specified in Table 4.23.

Table 4.23 – **Volume of Contaminant Emissions into Atmospheric Air When Filling Warehouses of the Concrete Plant**

Contaminant Code and Name		MAC mg/m³	Specific emission	
			g per sec	tonnes per year
2902	Undifferentiated suspended substances in terms of composition	0.5	0.174	0.094

The aggregate volume of emissions is consolidated in Table 4.24.

4.2.3 Total Volume of Emissions during the Operation

Table 4.24 – **Consolidated Table of Contaminant Emissions into Atmospheric Air during the Operation**

Substance code and name		Contaminant specific emissions													
		Diesel power plant		Filling station		Vehicles on the site		Vehicles of the concrete plant		Rail vehicles		Concrete plant		Warehouses of the concrete plant	
		g per sec	tonnes per year	g per sec	tonnes per year	g per sec	tonnes per year	g per sec	tonnes per year	g per sec	tonnes per year	g per sec	tonnes per year	g per sec	tonnes per year
301	Nitrogen dioxide (NO_2)	0.04778550	0.00550489	–	–	0.20166667	0.425	0.13383333	0.220	0.09166667	0.495	–	–	–	–
328	Soot	–	–	–	–	0.07814583	0.165	0.05186042	0.085	0.03552083	0.192	–	–	–	–
330	Sulfur dioxide (SO_2)	–	–	–	–	0.10083333	0.213	0.06691667	0.110	0.04583333	0.248	–	–	–	–
333	Hydrogen sulfide (H_2S)	–	–	0.00000001	0.00000039	–	–	–	–	–	–	–	–	–	–
337	Carbon monoxide (CO)	0.01313375	0.00151301	–	–	0.50416667	1.063	0.33458333	0.549	0.22916667	1.238	–	–	–	–
703	Benz(a)pyrene	–	–	–	–	0.00000161	0.00000340	0.00000107	0.00000176	0.00000073	0.00000396	–	–	–	–
2754	Non-methane volatile organic compounds	0.00014000	0.00001613	0.00000443	0.00013968	0.15125000	0.319	0.10037500	0.165	0.06875000	0.371	–	–	–	–
2902	Suspended solids with undifferentiated composition	–	–	–	–	–	–	–	–	–	–	–	–	0.174	0.094
2908	Inorganic dust containing silicon dioxide, %: 70-20 (chamotte, cement, etc.)	–	–	–	–	–	–	–	–	–	–	0.00072	0.00756	–	–

4.2.3.1 Calculation of Ground-level Concentrations from Contaminant Emissions during the Operation

Justification of Estimation Methods and Software Used

The calculation of the ground-level concentration of contaminants are based on the currently used method (OND-86) [98] using “EOL 2000” software package listed among the programs recommended by the Ministry of Ecology and Natural Resources [99].

Allowed impact levels are taken in accordance with DSP-201-97 [100].

Initial Input Data for the Calculation

The meteorological characteristics are taken from the Reference by The Central Geophysical Observatory (CGO) No. 16-13/-82/05-06 of 15.01.2015 provided as input data in Letter from OP "Atomproektinzhiniring” No. 03-46/76 dated 22.01.2015 and presented in Annex Ж, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The data on background air pollution in the area of the project activity, in terms of contaminants, are taken from Reference by Department of Ecology and Natural Resources of Kyiv Province No. 061-11/4689 of 23.12.2014 provided as input data in Letter from OP "Atomproektinzhiniring” No. 03-46/76 dated 22.01.2015 and presented in Annex Ж, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes on other contaminants are based on Regulation [101], the values of the background concentrations are assumed at 0.4 MAC.

The amounts of emissions of contaminants into the air during operation is assumed at the rates indicated in Table 4.24.

Results of Calculations of Ground-level Concentrations from Contaminant Emissions during the Operation

The ground-level concentrations of contaminants during operation were calculated for the area of 3,000x3,000 m with the grid spacing of 100 m using “EOL 2000” software package.

The calculation of ground-level concentrations of contaminants during operation is presented in Annex H, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Concentrations of contaminants in reference points on the boundary of the SPZ during operation, excluding the background, are shown in Table 4.25.

Concentrations of contaminants in reference points on the boundary of the SPZ during operation, including background concentrations, are shown in Table 4.26.

Results of calculations of ground-level concentrations from contaminant emissions during the operation are provided in Table 4.27.

Table 4.25. **Concentrations of Contaminants in Reference Points on the SPZ Boundary during Operation (without Background Concentrations)**

Substance code and name		MAC mg/m³	Concentrations in reference points on the SPZ boundary without background concentrations (MAC fraction)									
			001	002	003	004	005	006	007	008	009	010
301	Nitrogen dioxide (NO_2)	0.2	0.3898	0.2482	0.3233	0.3619	0.4354	0.3730	0.3075	0.3037	0.4792	0.7558
328	Soot	0.15	0.1331	0.1306	0.1646	0.1860	0.2254	0.1920	0.1383	0.1527	0.1029	0.3949
330	Sulfur dioxide (SO_2)	0.5	0.0515	0.0506	0.0637	0.0720	0.0873	0.0743	0.0535	0.0591	0.0398	0.1529
333	Hydrogen sulfide (H_2S)	0.008	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86									
337	Carbon monoxide (CO)	5.0	0.0390	0.0248	0.0323	0.0362	0.0435	0.0373	0.0307	0.0304	0.0478	0.0755
703	Benz(a)pyrene	0.00001	0.0411	0.0404	0.0508	0.0575	0.0697	0.0593	0.0427	0.0471	0.0318	0.1222
2754	Non-methane volatile organic compounds	1.0	0.0585	0.0372	0.0485	0.0543	0.0653	0.0559	0.0461	0.0456	0.0718	0.1133
2902	Suspended solids with undifferentiated composition	0.5	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86									
2908	Inorganic dust containing silicon dioxide, %: 70-20 (chamotte, cement, etc.)	0.3	0.4931	0.3492	0.2331	0.1648	0.1106	0.1107	0.1111	0.3194	0.5796	0.5642
	Summation group No. 30		0.0482	0.0507	0.0634	0.0724	0.0864	0.0746	0.0547	0.0573	0.0397	0.1527
	Summation group No. 31		0.4678	0.2978	0.3880	0.4342	0.5225	0.4475	0.3690	0.3645	0.5750	0.9069

Table 4.26 **– Concentrations of Contaminants in Reference Points on the SPZ boundary during Operation, including Background Concentrations**

Substance code and name		MAC mg/m³	Concentrations in the reference points on the SPZ boundary (including background concentrations) (MAC fraction)									
			001	002	003	004	005	006	007	008	009	010
301	Nitrogen dioxide (NO_2)	0.2	0.4298	0.2882	0.3633	0.4019	0.4754	0.4130	0.3475	0.3437	0.5192	0.7958
328	Soot	0.15	0.5331	0.5306	0.5646	0.5860	0.6254	0.5920	0.5383	0.5527	0.5029	0.7949
330	Sulfur dioxide (SO_2)	0.5	0.0915	0.0906	0.1037	0.1120	0.1273	0.1143	0.0935	0.0991	0.0798	0.1929
333	Hydrogen sulfide (H_2S)	0.008	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86									
337	Carbon monoxide (CO)	5.0	0.1190	0.1048	0.1123	0.1162	0.1235	0.1173	0.1107	0.1104	0.1278	0.1555
703	Benz(a)pyrene	0.00001	0.0811	0.0804	0.0908	0.0975	0.1097	0.0993	0.0827	0.0871	0.0718	0.1622
2754	Non-methane volatile organic compounds	1.0	0.4585	0.4372	0.4485	0.4543	0.4653	0.4559	0.4461	0.4456	0.4718	0.5133
2902	Suspended solids with undifferentiated composition	0.5	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86									
2908	Inorganic dust containing silicon dioxide, %: 70-20 (chamotte, cement, etc.)	0.3	0.8931	0.7492	0.6331	0.5648	0.5106	0.5107	0.5111	0.7194	0.9796	0.9642
	Summation group No. 30		0.5478	0.3778	0.4680	0.5142	0.6025	0.5275	0.4490	0.4445	0.6550	0.9869
	Summation group No. 31		0.4882	0.4907	0.5034	0.5124	0.5264	0.5146	0.4947	0.4973	0.4797	0.5927

Table 4.27– **Results of Calculations of Ground-level Concentrations from Contaminant Emissions during the Operation (Source Contribution)**

Substance code and name		MAC mg/m³	Background concentrations, (MAC fraction)	Source contribution (MAC fraction)
301	Nitrogen dioxide (NO_2)	0.2	0.04	2.2116
328	Soot	0.15	0.4	1.1178
330	Sulfur dioxide (SO_2)	0.5	0.04	0.4327
333	Hydrogen sulfide (H_2S)	0.0008	0.4	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86
337	Carbon monoxide (CO)	5.0	0.08	0.2212
703	Benz(a)pyrene	0.00001	0.04	0.3459
2754	Non-methane volatile organic compounds	1.0	0.4	0.3318
2902	Suspended solids with undifferentiated composition	0.5	0.1	No calculation has been carried out for this substance due to irrelevance in accordance with paragraph 5.21 of OND-86
2908	Inorganic dust containing silicon dioxide, %: 70-20 (chamotte, cement, etc.)	0.3	0.4	6.3756
	Summation group No. 31			2.6540
	Summation group No. 30			0.4423

4.2.4 Conclusions on the Impact of CSFSF's Contaminant Emissions on Air during Operation

The analysis of the results of calculations of the ground-level concentrations of contaminants shows that the extent of CSFSF emissions effect on the air during operation will be local.

The chemical air pollution zone will not exceed the recommended sanitary standards for the spatial gap between the industrial and residential areas.

On the border of the sanitary protection zone (100 m), the hygienic requirements as to each specific contaminant are complied with.

Thus, on the strength of all the above data, the projected environmental impact in the form of emission of contaminants into the atmosphere, is acceptable.

4.2.5 Noise Pollution of Air during Construction

The noise control regime that meets the requirements of sanitary standards is governed by DBN V.1.1-31:2013 [102]. The criteria for evaluation of the noise discomfort zones on the designed facilities are based on the acceptable levels of human exposure.

4.2.5.1 Acoustic Background, Substantial Existing Noise Sources, and Layout Situation

The closest residential area is situated beyond the exclusion and compulsory resettlement zone boundary 12 km to southwest. According to the plan of construction, the CSFSF site is located within the sanitary protection zone (SPZ) of a radiation-dangerous object—the facilities for decontamination, transportation, processing and disposal of the radioactive waste from the areas contaminated by the Chernobyl NPP accident—production facilities “Vector”. The plot area is 18.2 hectares. The shortest distance from the CSFSF structures to the structures of “Vector” is 160.00 m.

The acoustic situation in the facility area is dictated by sources associated with the CSFSF infrastructure, road and rail transport.

The area directly adjacent to the CSFSF site is characterized by the prevalence of forest vegetation of various species. Sound is partly reflected from trees and undergoes multiple scattering; in addition, it is absorbed by loose soil and leaves. As a result, the acoustic impact of the industrial facility is mitigated; thus, the layout situation in the CSFSF area can be described as favorable.

4.2.5.2 Sources of Noise Pollution

Separate noise source groups were made up to account for process, road transport, and rail transport noise sources.

The following will be the most important acoustic impact sources at the CSFSF site:

- diesel power plants;
- compressors;
- the filling station;
- load-lifting machinery and mechanisms;
- the concrete plant;
- road and rail vehicles;
- ventilation and air conditioning systems of the CSFSF infrastructure;
- pumping equipment.

A schematic map of locations of noise sources and reference points on the CSFSF site is provided in Annex П, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

4.2.5.3 Justification of Assessment Methodologies Applied

Allowed noise impact levels are taken in accordance with DSN 3.3.6.037-99 [103] and SN No. 3077-84 [104]. The area of noise impact is assumed as the area on the border of which the sources of the projected enterprise create the noise levels that differ from the background noise levels.

For the purpose of estimation, the most significant areas were selected in terms of noise impact of the on-site sources that determine the size of the impacting factor footprint. Due to the fact that, according to the formula used, in case of sound level difference of over 20 dB additional 0 dB is added to the higher lever, the low-level noise sources are not considered.

As a criterion for evaluating the noise generated during operation of the facility, the equivalent sound level LA_{eq} (dB) and the maximum sound level LA_{max} (dB) in the residential areas in the direction of the reference point are accepted. Since the operation regime of the facility is non-stop, but with

some types of works carried out only during the day, the evaluation and regulation of the noise impact should be carried out according to the daytime and nighttime standards.

Allowed noise levels are shown in Table 4.28.

Table 4.28. **Allowed Noise Levels in Reference Points**

Scope of regulation	Sound Pressure Levels, dB, in Octave Bands with Center Frequencies, Hz									Sound Level $La_{экв}$, dBA (equivalent sound level), dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
Performance of all types of activities on permanent workplaces in the production premises and on the territories of the enterprises (DSN 3.3.6.037-99 [103])	107	95	87	82	78	75	73	71	69	80
Recreation areas on the territory of districts and residential houses groups, rest houses, boarding houses, boarding houses for the elderly and disabled, kindergartens' playgrounds, schools and other educational institutions SN No. 3077-84 [104]	67	67	57	49	44	40	37	35	33	45

Initial Input Data for the Calculation

Dimensions of buildings and structures of the CSFSF site are set out in Table 4.29.

Materials of outer walls of buildings and structures of the CSFSF site are set out in Table 4.31.

Acoustic insulation properties of materials of outer walls of buildings and structures of the CSFSF site are set out in Table 4.32.

Barrier coordinates are listed in Table 4.30.

A list of process equipment noise sources and their acoustic characteristics is provided in Table 4.33.

A list of road transport noise sources and their acoustic characteristics is provided in Table 4.34.

A list of rail transport noise sources and their acoustic characteristics is provided in Table 4.35.

Table 4.29 – **Dimensions of Buildings and Structures of the CSFSF Site**

Master Plan No.	Description		Barrier No.	Length m	Width m	Height m
1	Reception building	(axes А-Б)	001	27.050	42.600	20.800
		(axes Б1-Г)	002	15.500	42.600	15.980
3	Maintenance building with an MPC warehouse	(axes 1-3)	003	25.120	13.220	6.300
		(axes 4-13)	004	24.400	53.720	18.200
4	Office building (subject to civil protection)		005	36.620	15.620	6.300
5	Electrical equipment building		006	30.470	9.500	4.000
6.1	Garage for 4 cars/trucks	(axes 1-7)	007	18.764	36.240	6.000
6.2	Garage for the transfer vehicle	(axes 7a-9)	008	18.764	12.706	14.590
8.1	Fire water supply pump station		009	13.070	7.100	5.130
9.1	Guardhouse (subject to civil protection)		010	13.200	49.200	6.330
10.1	Checkpoint 1		011	13.320	19.320	6.300
10.2	Checkpoint 2		012	6.900	10.900	3.000

Table 4.30 – **List of Barriers with Coordinates on the CSFSF Site**

Barrier No.	Description	Coordinates				Width (m)	Height (m)
		point 1		point 2			
		X (m)	Y (m)	X (m)	Y (m)		
001	Reception building (axes Б1-Г)	40743.00	424845.30	40758.50	424845.30	42.60	15.98
002	Reception building (axes А-Б)	40759.00	424845.30	40786.05	424845.30	42.60	20.80
003	Maintenance building with an MPC warehouse (axes 4-13)	40774.00	424779.86	40798.40	424779.86	53.72	18.20
004	Maintenance building with an MPC warehouse (axes 1-3)	40774.00	424745.61	40799.12	424745.61	13.22	6.30
005	Office building (subject to civil protection)	40754.50	424692.81	40791.12	424692.81	15.62	6.30
006	Electrical equipment building	40827.00	424698.25	40857.47	424698.25	9.50	4.00
007	Garage (axes 1-7)	40681.00	424868.12	40699.76	424868.12	36.24	6.00
008	Garage (axes 7a-9)	40681.00	424893.35	40699.76	424893.35	12.71	14.59
009	Fire Water Supply Pump Station	40842.00	424759.55	40855.07	424759.55	7.10	5.13
010	Guardhouse (subject to civil protection)	40682.00	424736.10	40695.20	424736.10	49.20	6.33
011	Checkpoint 1	40720.00	424674.66	40733.32	424674.66	19.32	6.30
012	Checkpoint 2	40824.00	425306.45	40830.90	425306.45	10.90	3.00

Table 4.31 – **Material of Outer Walls of CSFSF Buildings and Structures**

Description	Outer wall material
Reception building	• Reinforced concrete • IZOVAT-145 mineral wool board thermal insulation
Maintenance building with an MPC warehouse	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation • Corrugated sheets
Office building (subject to civil protection)	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Electrical equipment building	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Garage for 4 cars/trucks	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Garage for the transfer vehicle	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Fire water supply pump station	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Guardhouse (subject to civil protection)	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Checkpoint 1	• Foamed concrete bricks • IZOVAT-145 mineral wool board thermal insulation
Checkpoint 2	• Foamed concrete bricks • IZOVAT-80 mineral wool board thermal insulation

Table 4.32 – **Acoustic Insulation Properties of Materials of Outer Walls of CSFSF Buildings and Structures**

Outer wall material	Density kg/m³	Thickness mm	Acoustic insulation dBA
Reinforced concrete	2500	300	80
Foamed concrete bricks	700	300	55
IZOVAT-145 mineral wool board thermal insulation	145	50	31
IZOVAT-145 mineral wool board thermal insulation	145	100	36
IZOVAT-80 mineral wool board thermal insulation	80	100	31
Corrugated sheets			22

Table 4.33 – **List of Process Equipment Noise Sources and Their Acoustic Characteristics**

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
001	Diesel power plant (DPP-1)	40829.50	424698.50	1.50	61.8	61.8	64.7	67.6	70.0	71.6	69.9	67.0	61.6	76.0	Yes
002	GA compressor	40745.50	424834.50	0.60	72.9	72.9	72.0	65.5	60.0	55.7	51.4	46.6	42.3	63.0	Yes
003	GA compressor	40746.00	424834.50	0.60	72.9	72.9	72.0	65.5	60.0	55.7	51.4	46.6	42.3	63.0	Yes
004	Filling station	40694.50	424824.00	0.60	60.0	58.0	60.0	59.0	61.0	60.0	60.0	56.0	47.0	66.0	Yes
005	Grundfos CM 10-1	40748.00	424851.00	0.00	54.2	54.2	54.3	52.2	48.0	44.3	38.9	33.2	27.2	50.0	Yes
006	Grundfos CM 10-1	40746.80	424851.00	0.00	54.2	54.2	54.3	52.2	48.0	44.3	38.9	33.2	27.2	50.0	Yes
007	Grundfos CM 10-1	40745.60	424851.40	0.00	54.2	54.2	54.3	52.2	48.0	44.3	38.9	33.2	27.2	50.0	Yes
008	Grundfos CM 10-1	40744.40	424851.40	0.00	54.2	54.2	54.3	52.2	48.0	44.3	38.9	33.2	27.2	50.0	Yes
009	10/0.4 kV transformer 1000 (garage)	40690.50	424854.00	0.75	68.9	68.9	68.0	61.5	56.0	51.7	47.4	42.6	38.3	59.0	Yes
010	10/0.4 kV transformer 1000 (reception building)	40745.00	424827.00	0.75	68.9	68.9	68.0	61.5	56.0	51.7	47.4	42.6	38.3	59.0	Yes
011	10/0.4 kV transformer 1000 (reception building)	40745.00	424827.00	0.75	68.9	68.9	68.0	61.5	56.0	51.7	47.4	42.6	38.3	59.0	Yes
012	10/0.4 kV transformer 1000 (electrical equipment building)	40842.00	424698.50	0.75	68.9	68.9	68.0	61.5	56.0	51.7	47.4	42.6	38.3	59.0	Yes
013	10/0.4 kV transformer 1000 (electrical equipment building)	40842.00	424698.50	0.75	68.9	68.9	68.0	61.5	56.0	51.7	47.4	42.6	38.3	59.0	Yes
014	Electric bridge crane with a load-lifting capacity of 185/20 tonnes	40770.00	424830.20	17.00	62.0	62.0	65.0	58.0	70.0	72.0	70.0	67.0	62.0	76.0	Yes
015	Electric bridge crane with a load-lifting capacity of 50/5 tonnes	40765.20	424836.90	14.50	58.0	58.0	61.0	64.0	66.0	68.0	66.0	63.0	58.0	72.0	Yes
016	Air supply unit (reception building)	40755.30	424824.50	11.10	74.0	74.0	74.0	86.0	80.0	77.0	76.0	75.0	68.0	84.0	Yes
017	Air supply unit (reception building, on stand-by)	40755.30	424828.30	11.10	74.0	74.0	74.0	86.0	80.0	77.0	76.0	75.0	68.0	84.0	No

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
018	Air supply unit (reception building)	40755.30	424862.00	0.00	72.0	72.0	67.0	73.0	84.0	73.0	71.0	68.0	63.0	82.3	Yes
019	Air supply unit (reception building)	40755.30	424863.10	0.00	72.0	72.0	66.0	78.0	75.0	67.0	66.0	62.0	58.0	75.6	Yes
020	Air supply unit (reception building)	40755.00	424831.50	11.10	70.0	70.0	66.0	74.0	78.0	70.0	68.0	65.0	60.0	77.5	Yes
021	Air supply unit (reception building, on stand-by)	40755.00	424834.50	11.10	70.0	70.0	66.0	74.0	78.0	70.0	68.0	65.0	60.0	77.5	No
022	Air handling unit VRAN 6-2.8	40752.80	424848.80	11.10	64.0	64.0	71.0	80.0	83.0	77.0	70.0	65.0	46.0	82.0	Yes
023	Air handling unit VRAN 6-2.8, stand-by	40754.00	424848.80	11.10	64.0	64.0	71.0	80.0	83.0	77.0	70.0	65.0	46.0	82.0	Yes
024	Air handling unit RSS-6.3/10	40752.90	424861.90	11.10	58.0	58.0	60.0	63.0	67.0	66.0	56.0	50.0	43.0	69.0	Yes
025	Air handling unit RSS-6.3/10, stand-by	40752.90	424860.80	11.10	58.0	58.0	60.0	63.0	67.0	66.0	56.0	50.0	43.0	69.0	No
026	Air handling unit VRAN 6-3.15	40753.40	424851.50	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	Yes
027	Air handling unit VRAN 6-3.15, stand-by	40753.40	424850.20	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	No
028	Air handling unit VDN10-1500 80/10	40755.80	424852.60	11.10	107.0	107.0	110.0	108.0	104.0	101.0	95.0	89.0	82.0	106.0	Yes
029	Air handling unit VDN10-1500 80/10, stand-by	40755.80	424849.60	11.10	107.0	107.0	110.0	108.0	104.0	101.0	95.0	89.0	82.0	106.0	No
030	Air handling unit VRAN 6-3.55	40752.70	424842.60	11.10	80.0	80.0	82.0	83.0	84.0	83.0	80.0	76.0	71.0	87.0	Yes
031	Air handling unit VRAN 6-3.55, stand-by	40754.00	424842.60	11.10	80.0	80.0	82.0	83.0	84.0	83.0	80.0	76.0	71.0	87.0	No
032	Air handling unit VRAN 6-3.15	40756.30	424843.40	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	Yes
033	Air handling unit VRAN 6-3.15, stand-by	40755.20	424843.40	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	No
034	Air handling unit VRAN 9-3.15	40753.50	424860.50	11.10	77.0	77.0	79.0	80.0	81.0	80.0	77.0	72.0	68.0	84.0	Yes
035	Air handling unit VRAN 9-3.15	40756.50	424841.70	11.10	77.0	77.0	79.0	80.0	81.0	80.0	77.0	72.0	68.0	84.0	Yes

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
036	Air handling unit VRAN 9-3.15, stand-by	40755.40	424841.70	11.10	77.0	77.0	79.0	80.0	81.0	80.0	77.0	72.0	68.0	84.0	No
037	Air handling unit VRAN 9-3.15	40752.80	424858.90	11.10	77.0	77.0	79.0	80.0	81.0	80.0	77.0	72.0	68.0	84.0	Yes
038	Air handling unit VRAN 6-3.15	40753.40	424856.00	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	Yes
039	Air handling unit VRAN 6-3.15, stand-by	40753.40	424854.70	11.10	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	No
040	Axial fan OSA300-4/200	40743.10	424835.20	2.50	43.0	43.0	51.0	62.0	61.0	57.0	51.0	43.0	35.0	62.0	Yes
041	Axial fan OSA300-5/250	40743.10	424839.00	2.50	77.0	77.0	79.0	80.0	80.0	80.0	76.0	72.0	68.0	84.0	Yes
042	Axial fan OSA300-6.3/250	40743.10	424842.40	2.50	71.0	71.0	73.0	74.0	74.0	74.0	71.0	66.0	62.0	78.0	Yes
043	Split-system air conditioner (Reception building (1) room 107) (indoor unit)	40756.80	424859.30	2.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
044	Split-system air conditioner (Reception building (1) room 107) (outdoor unit)	40755.20	424866.40	2.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
045	Split-system air conditioner (Reception building (1) room 301) (indoor unit)	40757.50	424824.50	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
046	Split-system air conditioner (Reception building (1) room 301) (outdoor unit)	40757.00	424822.70	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
047	Split-system air conditioner (Reception building (1) room 302) (indoor unit)	40755.00	424831.30	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
048	Split-system air conditioner (Reception building (1) room 302) (outdoor unit)	40753.90	424822.70	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
049	Split-system air conditioner (Reception building (1) room 303) (indoor unit)	40752.00	424842.30	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
050	Split-system air conditioner (Reception building (1) room 303) (outdoor unit)	40742.10	424842.60	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
051	Split-system air conditioner (Reception building (1) room 304) (indoor unit)	40757.50	424864.70	0.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
052	Split-system air conditioner (Reception building (1) room 304) (outdoor unit)	40757.60	424866.40	0.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
053	Split-system air conditioner (Reception building (1) room 305) (indoor unit)	40752.00	424854.60	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
054	Split-system air conditioner (Reception building (1) room 305) (outdoor unit)	40742.10	424854.70	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
055	Split-system air conditioner (Reception building (1) room 306) (indoor unit)	40752.00	424848.50	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
056	Split-system air conditioner (Reception building (1) room 306) (outdoor unit)	40742.10	424848.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
057	Split-system air conditioner (Reception building (1) room 307) (indoor unit)	40743.70	424859.50	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
058	Split-system air conditioner (Reception building (1) room 307) (outdoor unit)	40742.00	424858.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
059	Split-system air conditioner (Reception building (1) room 308) (indoor unit)	40743.70	424856.30	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
060	Split-system air conditioner (Reception building (1) room 308) (outdoor unit)	40742.10	424855.60	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
061	Split-system air conditioner (Reception building (1) room 309) (indoor unit)	40743.70	424853.10	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
062	Split-system air conditioner (Reception building (1) room 309) (outdoor unit)	40742.10	424852.40	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
063	Split-system air conditioner (Reception building (1) room 310) (indoor unit)	40743.70	424850.20	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
064	Split-system air conditioner (Reception building (1) room 310) (outdoor unit)	40742.10	424849.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
065	Split-system air conditioner (Reception building (1) room 311) (indoor unit)	40743.70	424847.10	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
066	Split-system air conditioner (Reception building (1) room 311) (outdoor unit)	40742.10	424846.40	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
067	Split-system air conditioner (Reception building (1) room 312) (indoor unit)	40743.70	424844.20	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
068	Split-system air conditioner (Reception building (1) room 312) (outdoor unit)	40742.10	424843.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
069	Split-system air conditioner (Reception building (1) room 313) (indoor unit)	40743.70	424841.10	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
070	Split-system air conditioner (Reception building (1) room 313) (outdoor unit)	40742.10	424840.40	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
071	Split-system air conditioner (Reception building (1) room 314) (indoor unit)	40743.70	424838.20	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
072	Split-system air conditioner (Reception building (1) room 314) (outdoor unit)	40742.10	424837.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
073	Split-system air conditioner (Reception building (1) room 315) (indoor unit)	40743.70	424835.10	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
074	Split-system air conditioner (Reception building (1) room 315) (outdoor unit)	40742.10	424834.40	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
075	Split-system air conditioner (Reception building (1) room 316) (indoor unit)	40743.70	424832.20	10.20	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
076	Split-system air conditioner (Reception building (1) room 316) (outdoor unit)	40742.10	424831.50	10.20	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
077	Air supply unit	40797.70	424750.90	3.30	70.0	70.0	64.0	69.0	74.0	65.0	64.0	61.0	57.0	73.4	Yes
078	Air supply unit	40797.70	424749.10	3.30	79.0	79.0	71.0	75.0	76.0	66.0	62.0	60.0	55.0	75.0	Yes
079	Air handling unit VRAN 6-3.15	40793.40	424750.70	3.30	64.0	64.0	70.0	82.0	86.0	78.0	74.0	66.0	46.0	85.0	Yes
080	Air handling unit VRAN 9-2.8	40793.40	424749.40	3.30	78.0	78.0	80.0	81.0	81.0	81.0	78.0	74.0	69.0	85.0	Yes
081	Axial fan OSA300-4/200	40774.10	424742.90	2.50	43.0	43.0	51.0	62.0	61.0	57.0	51.0	43.0	35.0	62.0	Yes
082	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 106) (indoor unit)	40786.00	424741.90	2.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
083	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 106) (outdoor unit)	40786.30	424738.70	2.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
084	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 206) (indoor unit)	40774.20	424750.00	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
085	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 206) (outdoor unit)	40773.30	424751.40	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
086	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 207) (indoor unit)	40774.20	424741.60	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
087	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 207) (outdoor unit)	40773.30	424740.10	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
088	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 208) (indoor unit)	40778.70	424739.60	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
089	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 208) (outdoor unit)	40777.30	424738.70	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
090	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 209) (indoor unit)	40781.80	424739.60	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
091	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 209) (outdoor unit)	40780.30	424738.70	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
092	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 211) (indoor unit)	40787.70	424739.60	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
093	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 211) (outdoor unit)	40786.30	424738.70	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
094	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 214) (indoor unit)	40793.10	424741.90	5.50	40.0	40.0	43.0	46.0	48.0	50.0	48.0	45.0	40.0	54.0	Yes
095	Split-system air conditioner (Maintenance building with an MPC warehouse (3) room 214) (outdoor unit)	40792.30	424738.70	5.50	41.0	42.0	43.0	44.0	44.0	44.0	41.0	36.0	32.0	48.0	Yes
096	Air supply unit (Garage (6))	40683.70	424883.10	3.55	70.0	70.0	66.0	74.0	80.0	71.0	69.0	66.0	61.0	79.1	Yes
097	Air supply unit (Garage (6)), stand-by	40683.70	424883.10	4.30	70.0	70.0	66.0	74.0	80.0	71.0	69.0	66.0	61.0	79.1	No
098	Air supply unit (Garage (6))	40682.20	424879.40	0.60	68.0	69.0	71.0	82.0	75.0	74.0	73.0	68.0	64.0	79.9	Yes
099	Air supply unit (Garage (6)), stand-by	40682.20	424879.40	1.95	68.0	69.0	71.0	82.0	75.0	74.0	73.0	68.0	64.0	79.9	No
100	Air supply unit (Garage (6))	40684.40	424885.60	4.00	74.0	74.0	76.0	77.0	79.0	79.0	77.0	73.0	70.0	83.6	Yes
101	Air supply unit (Garage (6)), stand-by	40684.40	424885.60	4.00	74.0	74.0	76.0	77.0	79.0	79.0	77.0	73.0	70.0	83.6	No
102	Rooftop fan KROV9-3.55 (Garage (6), roof above room 101)	40684.70	424858.80	6.60	73.0	73.0	76.0	74.0	70.0	65.0	61.0	55.0	48.0	72.0	Yes
103	Rooftop fan KROV9-3.55 (Garage (6), roof above room 101)	40697.30	424859.10	6.60	73.0	73.0	76.0	74.0	70.0	65.0	61.0	55.0	48.0	72.0	Yes
104	Rooftop fan KROV9-4 (Garage (6), roof above room 102)	40682.20	424870.80	6.60	66.0	66.0	68.0	69.0	70.0	69.0	66.0	62.0	57.0	73.0	Yes
105	Rooftop fan KROV9-4 (Garage (6), roof above room 102)	40697.30	424871.10	6.00	66.0	66.0	68.0	69.0	70.0	69.0	66.0	62.0	57.0	73.0	Yes
106	Rooftop fan KROV9-4 (Garage (6), roof above room 103)	40685.00	424876.80	6.60	66.0	66.0	68.0	69.0	70.0	69.0	66.0	62.0	57.0	73.0	Yes
107	Rooftop fan KROV9-4 (Garage (6), roof above room 103)	40697.30	424877.10	6.60	66.0	66.0	68.0	69.0	70.0	69.0	66.0	62.0	57.0	73.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
108	Rooftop fan KROV6-6.3 (Garage (6), roof above room 110)	40682.25	424898.90	15.50	88.0	88.0	81.0	89.0	85.0	82.0	76.0	70.0	63.0	87.0	Yes
109	Rooftop fan KROV6-6.3 (Garage (6), roof above room 110)	40696.30	424898.60	15.50	88.0	88.0	81.0	89.0	85.0	82.0	76.0	70.0	63.0	87.0	Yes
110	Axial fan OSA300-5/250 (Garage (6), roof above room 111)	40681.60	424854.70	3.00	77.0	77.0	79.0	80.0	80.0	80.0	76.0	72.0	68.0	84.0	Yes
111	Air supply unit (Electrical equipment building (5))	40848.80	424701.10	0.35	70.0	70.0	64.0	69.0	74.0	65.0	64.0	61.0	57.0	73.0	Yes
112	Air supply unit (Electrical equipment building (5)), stand-by	40848.80	424701.10	0.35	70.0	70.0	64.0	69.0	74.0	65.0	64.0	61.0	57.0	73.0	No
113	Rooftop fan KROS9-3.55 (Electrical equipment building, roof above room 106)	40853.90	424699.70	4.70	73.0	73.0	76.0	74.0	70.0	65.0	61.0	55.0	48.0	72.0	Yes
114	Rooftop fan KROS9-3.55 (Electrical equipment building, roof above room 106), stand-by	40853.90	424696.20	4.70	73.0	73.0	76.0	74.0	70.0	65.0	61.0	55.0	48.0	72.0	No
115	Axial fan OSA300-6.3/250 (Electrical equipment building, room 102)	40837.60	424694.70	3.00	71.0	71.0	73.0	74.0	74.0	74.0	71.0	66.0	62.0	78.0	Yes
116	Axial fan OSA300-4/200 (Electrical equipment building, room 103)	40837.40	424701.20	3.00	43.0	43.0	51.0	62.0	61.0	57.0	51.0	43.0	35.0	62.0	Yes
117	Air supply unit KLG015 (Checkpoint 1 (10.1))	40731.50	424675.60	6.30	35.3	35.3	43.3	51.3	56.3	57.3	56.3	54.3	53.3	62.6	Yes
118	Air supply unit KLG015 (Checkpoint 1 (10.1))	40731.50	424676.40	6.30	35.3	35.3	43.3	51.3	56.3	57.3	56.3	54.3	53.3	62.6	Yes
119	Rooftop fan Maico GRD 22 (checkpoint 1 (10.1))	40723.15	424675.45	7.50	74.0	74.0	77.0	74.0	72.0	67.0	62.0	56.0	49.0	73.0	Yes
120	Rooftop fan Maico GRD 22 (checkpoint 1 (10.1))	40726.25	424677.90	7.50	74.0	74.0	77.0	74.0	72.0	67.0	62.0	56.0	49.0	73.0	Yes
121	Axial fan OSA 301-04/A-45-N-000018/4 (checkpoint 1 (10.1))	40720.40	424669.40	3.00	43.0	43.0	51.0	62.0	61.0	57.0	51.0	43.0	35.0	62.0	Yes
122	Split-system air conditioner (checkpoint 1 (10.1) room 106) (indoor unit)	40721.00	424668.60	3.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
123	Split-system air conditioner (checkpoint 1 (10.1) room 106) (outdoor unit)	40719.60	424667.50	3.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
124	Split-system air conditioner (checkpoint 1 (10.1) room 107) (indoor unit)	40723.50	424672.70	3.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
125	Split-system air conditioner (checkpoint 1 (10.1) room 107) (outdoor unit)	40719.60	424672.40	3.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
126	Split-system air conditioner (checkpoint 1 (10.1) room 108) (indoor unit)	40721.05	424674.20	3.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
127	Split-system air conditioner (checkpoint 1 (10.1) room 108) (outdoor unit)	40719.60	424673.50	3.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
128	Split-system air conditioner (checkpoint 1 (10.1) room 111) (indoor unit)	40721.00	424680.10	3.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
129	Split-system air conditioner (checkpoint 1 (10.1) room 111) (outdoor unit)	40719.60	424679.50	3.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
130	Split-system air conditioner (checkpoint 1 (10.1) room 203) (indoor unit)	40720.40	424668.50	3.60	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
131	Split-system air conditioner (checkpoint 1 (10.1) room 203) (outdoor unit)	40719.40	424668.20	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
132	Split-system air conditioner (checkpoint 1 (10.1) room 208) (indoor unit)	40732.30	424680.50	3.60	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
133	Split-system air conditioner (checkpoint 1 (10.1) room 208) (outdoor unit)	40733.05	424679.50	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
134	Split-system air conditioner (checkpoint 1 (10.1) room 209) (indoor unit)	40731.70	424674.20	3.60	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
135	Split-system air conditioner (checkpoint 1 (10.1) room 209) (outdoor unit)	40733.05	424673.50	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
136	Split-system air conditioner (checkpoint 1 (10.1) room 210) (indoor unit)	40731.70	424671.15	3.60	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
137	Split-system air conditioner (checkpoint 1 (10.1) room 210) (outdoor unit)	40733.05	424670.50	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
138	Split-system air conditioner (checkpoint 1 (10.1) room 211) (indoor unit)	40731.70	424668.15	3.60	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
139	Split-system air conditioner (checkpoint 1 (10.1) room 211) (outdoor unit)	40733.05	424667.50	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
140	Split-system air conditioner (checkpoint 2 (10.2) room 3) (indoor unit)	40826.20	425308.00	3.00	42.0	42.0	45.0	48.0	50.0	51.0	50.0	47.0	42.0	56.0	Yes
141	Split-system air conditioner (checkpoint 2 (10.2) room 3) (outdoor unit)	40825.15	425308.50	3.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
142	Air supply unit (Office building (4) room 219)	40775.20	424687.00	6.92	80.0	80.0	81.0	82.0	83.0	83.0	80.0	73.0	70.0	86.8	Yes
143	Air supply unit (Office building (4) room 219)	40773.60	424687.00	8.50	67.0	67.0	69.0	69.0	70.0	70.0	67.0	60.0	58.0	73.8	Yes

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
144	Air supply unit (Office building (4) room 219)	40774.60	424687.00	8.50	64.0	64.0	66.0	67.0	67.0	67.0	64.0	60.0	55.0	71.2	Yes
145	Rooftop fan Maico GRD 22 (Office building (4), roof above room 203)	40768.15	424687.80	14.00	74.0	74.0	77.0	74.0	72.0	67.0	62.0	56.0	49.0	73.0	Yes
146	Rooftop fan Maico GRD 31 (Office building (4), roof above room 210)	40766.40	424690.10	7.30	75.0	75.0	78.0	76.0	72.0	69.0	63.0	57.0	50.0	74.0	Yes
147	Rooftop fan Maico GRD 22 (Office building (4), roof above room 215)	40784.40	424693.90	7.30	74.0	74.0	77.0	74.0	72.0	67.0	62.0	56.0	49.0	73.0	Yes
148	Rooftop fan Maico GRD 31 (Office building (4), roof above room 216)	40785.25	424693.90	7.30	75.0	75.0	78.0	76.0	72.0	69.0	63.0	57.0	50.0	74.0	Yes
149	Split-system air conditioner (Office building (4) room 022) (indoor unit)	40772.40	424686.40	-1.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
150	Split-system air conditioner (Office building (4) room 022) (outdoor unit)	40772.70	424683.90	3.00	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
151	Split-system air conditioner (Office building (4) room 112) (indoor unit)	40758.00	424691.00	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
152	Split-system air conditioner (Office building (4) room 112) (outdoor unit)	40754.10	424690.40	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
153	Split-system air conditioner (Office building (4) room 112) (indoor unit)	40758.00	424696.80	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
154	Split-system air conditioner (Office building (4) room 112) (outdoor unit)	40757.80	424700.10	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
155	Split-system air conditioner (Office building (4) room 112) (indoor unit)	40763.70	424696.80	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
156	Split-system air conditioner (Office building (4) room 112) (outdoor unit)	40763.80	424700.10	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
157	Split-system air conditioner (Office building (4) room 113) (indoor unit)	40776.10	424698.00	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
158	Split-system air conditioner (Office building (4) room 113) (outdoor unit)	40775.70	424700.10	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
159	Split-system air conditioner (Office building (4) room 114) (indoor unit)	40787.80	424684.90	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
160	Split-system air conditioner (Office building (4) room 114) (outdoor unit)	40787.80	424683.90	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
161	Split-system air conditioner (Office building (4) room 116) (indoor unit)	40776.10	424686.60	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
162	Split-system air conditioner (Office building (4) room 116) (outdoor unit)	40775.70	424683.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
163	Split-system air conditioner (Office building (4) room 117) (indoor unit)	40779.10	424686.60	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
164	Split-system air conditioner (Office building (4) room 117) (outdoor unit)	40778.70	424683.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
165	Split-system air conditioner (Office building (4) room 118) (indoor unit)	40782.10	424697.20	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
166	Split-system air conditioner (Office building (4) room 118) (outdoor unit)	40781.70	424700.10	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
167	Split-system air conditioner (Office building (4) room 119) (indoor unit)	40785.10	424697.20	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
168	Split-system air conditioner (Office building (4) room 119) (outdoor unit)	40784.70	424700.10	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
169	Split-system air conditioner (Office building (4) room 122) (indoor unit)	40775.10	424698.00	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
170	Split-system air conditioner (Office building (4) room 122) (outdoor unit)	40776.70	424700.10	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
171	Split-system air conditioner (Office building (4) room 205) (indoor unit)	40766.40	424697.20	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
172	Split-system air conditioner (Office building (4) room 205) (outdoor unit)	40766.80	424700.10	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
173	Split-system air conditioner (Office building (4) room 206) (indoor unit)	40760.50	424697.20	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
174	Split-system air conditioner (Office building (4) room 206) (outdoor unit)	40760.90	424700.10	6.00	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
175	Split-system air conditioner (Office building (4) room 207) (indoor unit)	40756.90	424690.90	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
176	Split-system air conditioner (Office building (4) room 207) (outdoor unit)	40754.10	424690.50	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
177	Split-system air conditioner (Office building (4) room 208) (indoor unit)	40760.50	424686.60	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
178	Split-system air conditioner (Office building (4) room 208) (outdoor unit)	40760.90	424683.80	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
179	Split-system air conditioner (Office building (4) room 209) (indoor unit)	40763.50	424686.60	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
180	Split-system air conditioner (Office building (4) room 209) (outdoor unit)	40764.00	424683.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
181	Split-system air conditioner (Office building (4) room 210) (indoor unit)	40766.50	424686.60	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
182	Split-system air conditioner (Office building (4) room 210) (outdoor unit)	40767.00	424683.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
183	Split-system air conditioner (Office building (4) room 211) (indoor unit)	40769.40	424697.60	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
184	Split-system air conditioner (Office building (4) room 211) (outdoor unit)	40769.80	424700.40	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
185	Split-system air conditioner (Office building (4) room 212) (indoor unit)	40773.25	424686.60	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
186	Split-system air conditioner (Office building (4) room 212) (outdoor unit)	40772.90	424683.80	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
187	Split-system air conditioner (Office building (4) room 213) (indoor unit)	40779.10	424686.60	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
188	Split-system air conditioner (Office building (4) room 213) (outdoor unit)	40778.80	424683.80	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
189	Split-system air conditioner (Office building (4) room 214) (indoor unit)	40785.10	424686.60	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
190	Split-system air conditioner (Office building (4) room 214) (outdoor unit)	40784.80	424683.80	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
191	Split-system air conditioner (Office building (4) room 215) (indoor unit)	40778.80	424696.50	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
192	Split-system air conditioner (Office building (4) room 215) (outdoor unit)	40778.80	424700.10	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
193	Split-system air conditioner (Office building (4) room 216) (indoor unit)	40785.10	424697.20	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
194	Split-system air conditioner (Office building (4) room 216) (outdoor unit)	40784.70	424700.10	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
195	Axial fan Kanal-VENT-125A (Guardhouse (9.1) room 112)	40687.75	424733.80	2.30	48.0	48.0	50.0	51.0	51.0	51.0	48.0	43.0	40.0	55.0	Yes
196	Axial fan Kanal-VENT-315A (Guardhouse (9.1) room 124)	40693.90	424718.45	5.80	57.0	57.0	59.0	61.0	61.0	61.0	59.0	53.0	50.0	65.0	Yes
197	Axial fan Kanal-VENT-315A (Guardhouse (9.1) room 212	40693.90	424718.45	2.30	57.0	57.0	59.0	61.0	61.0	61.0	59.0	53.0	50.0	65.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
198	Duct fan Kanal-VENT-315A (Guardhouse (9.1) room 220)	40693.70	424724.40	5.50	57.0	57.0	59.0	61.0	61.0	61.0	59.0	53.0	50.0	65.0	Yes
199	Air handling unit VRAN 6-2.8 (Guardhouse (9.1) room 221)	40692.50	424751.70	3.50	64.0	64.0	71.0	80.0	83.0	77.0	70.0	65.0	46.0	82.0	Yes
200	Air handling unit VRAN 6-2.8 (Guardhouse (9.1) room 221)	40693.20	424751.70	3.50	64.0	64.0	71.0	80.0	83.0	77.0	70.0	65.0	46.0	82.0	Yes
201	Air supply unit (Guardhouse (9.1) room 222)	40693.60	424757.60	3.70	43.1	43.1	53.1	60.1	66.1	69.1	70.1	70.1	68.1	76.2	Yes
202	Air supply unit (Guardhouse (9.1) room 222)	40691.50	424758.00	3.60	54.0	54.0	58.0	60.0	64.0	68.0	68.0	67.0	62.0	73.7	Yes
203	Split-system air conditioner (Guardhouse (9.1) room 103) (indoor unit)	40692.40	424732.20	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
204	Split-system air conditioner (Guardhouse (9.1) room 103) (outdoor unit)	40694.90	424733.20	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
205	Split-system air conditioner (Guardhouse (9.1) room 103) (indoor unit)	40693.40	424732.20	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
206	Split-system air conditioner (Guardhouse (9.1) room 103) (outdoor unit)	40694.90	424732.30	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
207	Split-system air conditioner (Guardhouse (9.1) room 104) (indoor unit)	40683.60	424726.55	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
208	Split-system air conditioner (Guardhouse (9.1) room 104) (outdoor unit)	40681.15	424726.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
209	Split-system air conditioner (Guardhouse (9.1) room 106) (indoor unit)	40683.60	424723.55	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
210	Split-system air conditioner (Guardhouse (9.1) room 106) (outdoor unit)	40681.15	424723.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
211	Split-system air conditioner (Guardhouse (9.1) room 108) (indoor unit)	40692.40	424742.00	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
212	Split-system air conditioner (Guardhouse (9.1) room 108) (outdoor unit)	40694.85	424741.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
213	Split-system air conditioner (Guardhouse (9.1) room 109) (indoor unit)	40683.60	424744.60	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
214	Split-system air conditioner (Guardhouse (9.1) room 109) (outdoor unit)	40681.15	424744.90	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
215	Split-system air conditioner (Guardhouse (9.1) room 125) (indoor unit)	40685.75	424718.80	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
216	Split-system air conditioner (Guardhouse (9.1) room 125) (outdoor unit)	40681.20	424717.30	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
217	Split-system air conditioner (Guardhouse (9.1) room 125) (indoor unit)	40685.75	424719.80	2.70	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
218	Split-system air conditioner (Guardhouse (9.1) room 125) (outdoor unit)	40681.20	424718.20	2.70	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
219	Split-system air conditioner (Guardhouse (9.1) room 126) (indoor unit)	40682.00	424719.00	2.70	27.0	27.0	30.0	33.0	35.0	37.0	35.0	32.0	26.0	41.0	Yes
220	Split-system air conditioner (Guardhouse (9.1) room 126) (outdoor unit)	40681.20	424719.90	2.70	35.0	35.0	38.0	41.0	43.0	45.0	43.0	40.0	35.0	49.0	Yes
221	Split-system air conditioner (Guardhouse (9.1) room 126) (indoor unit)	40682.00	424720.00	2.70	27.0	27.0	30.0	33.0	35.0	37.0	35.0	32.0	26.0	41.0	Yes
222	Split-system air conditioner (Guardhouse (9.1) room 126) (outdoor unit)	40681.20	424721.00	2.70	35.0	35.0	38.0	41.0	43.0	45.0	43.0	40.0	35.0	49.0	Yes
223	Split-system air conditioner (Guardhouse (9.1) room 127) (indoor unit)	40692.40	424715.45	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
224	Split-system air conditioner (Guardhouse (9.1) room 127) (outdoor unit)	40694.85	424715.40	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
225	Split-system air conditioner (Guardhouse (9.1) room 128) (indoor unit)	40692.45	424711.90	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
226	Split-system air conditioner (Guardhouse (9.1) room 128) (outdoor unit)	40694.85	424711.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
227	Split-system air conditioner (Guardhouse (9.1) room 129	40683.60	424715.20	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
228	Split-system air conditioner (Guardhouse (9.1) room 129) (outdoor unit)	40681.20	424714.90	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
229	Split-system air conditioner (Guardhouse (9.1) room 137) (indoor unit)	40692.60	424754.00	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
230	Split-system air conditioner (Guardhouse (9.1) room 137) (outdoor unit)	40694.90	424754.00	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
231	Split-system air conditioner (Guardhouse (9.1) room 138) (indoor unit)	40691.30	424759.10	2.70	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
232	Split-system air conditioner (Guardhouse (9.1) room 138) (outdoor unit)	40691.00	424760.80	2.70	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
233	Split-system air conditioner (Guardhouse (9.1) room 203) (indoor unit)	40684.40	424715.20	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes

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		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
234	Split-system air conditioner (Guardhouse (9.1) room 203) (outdoor unit)	40681.20	424714.20	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
235	Split-system air conditioner (Guardhouse (9.1) room 203) (indoor unit)	40683.40	424715.20	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
236	Split-system air conditioner (Guardhouse (9.1) room 203) (outdoor unit)	40681.20	424715.30	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
237	Split-system air conditioner (Guardhouse (9.1) room 204) (indoor unit)	40683.40	424723.40	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
238	Split-system air conditioner (Guardhouse (9.1) room 204) (outdoor unit)	40681.20	424723.30	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
239	Split-system air conditioner (Guardhouse (9.1) room 204) (indoor unit)	40684.40	424723.40	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
240	Split-system air conditioner (Guardhouse (9.1) room 204) (outdoor unit)	40681.20	424724.40	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
241	Split-system air conditioner (Guardhouse (9.1) room 205) (indoor unit)	40682.10	424726.80	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
242	Split-system air conditioner (Guardhouse (9.1) room 205) (outdoor unit)	40681.10	424726.90	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
243	Split-system air conditioner (Guardhouse (9.1) room 205) (indoor unit)	40682.10	424730.90	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
244	Split-system air conditioner (Guardhouse (9.1) room 205) (outdoor unit)	40681.10	424730.90	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
245	Split-system air conditioner (Guardhouse (9.1) room 215) (indoor unit)	40692.40	424736.20	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
246	Split-system air conditioner (Guardhouse (9.1) room 207) (indoor unit)	40683.60	424738.40	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
247	Split-system air conditioner (Guardhouse (9.1) room 207) (outdoor unit)	40681.15	424738.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
248	Split-system air conditioner (Guardhouse (9.1) room 208) (indoor unit)	40683.60	424741.40	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
249	Split-system air conditioner (Guardhouse (9.1) room 208) (outdoor unit)	40681.15	424741.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
250	Split-system air conditioner (Guardhouse (9.1) room 210) (indoor unit)	40692.45	424711.90	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
251	Split-system air conditioner (Guardhouse (9.1) room 210) (outdoor unit)	40694.80	424711.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
252	Split-system air conditioner (Guardhouse (9.1) room 211) (indoor unit)	40692.40	424715.10	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
253	Split-system air conditioner (Guardhouse (9.1) room 211) (outdoor unit)	40694.80	424714.70	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
254	Split-system air conditioner (Guardhouse (9.1) room 213) (indoor unit)	40692.40	424727.10	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
255	Split-system air conditioner (Guardhouse (9.1) room 213) (outdoor unit)	40694.80	424726.70	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
256	Split-system air conditioner (Guardhouse (9.1) room 214) (indoor unit)	40692.40	424733.10	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
257	Split-system air conditioner (Guardhouse (9.1) room 214) (outdoor unit)	40694.80	424732.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
258	Split-system air conditioner (Guardhouse (9.1) room 215) (outdoor unit)	40694.80	424736.10	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
259	Split-system air conditioner (Guardhouse (9.1) room 216) (indoor unit)	40692.40	424742.10	6.00	25.0	25.0	28.0	31.0	33.0	35.0	33.0	30.0	25.0	39.0	Yes
260	Split-system air conditioner (Guardhouse (9.1) room 216) (outdoor unit)	40694.80	424741.80	3.60	32.0	32.0	35.0	38.0	40.0	42.0	40.0	37.0	32.0	46.0	Yes
261	Split-system air conditioner (Guardhouse (9.1) room 223) (indoor unit)	40683.50	424716.90	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
262	Split-system air conditioner (Guardhouse (9.1) room 223) (outdoor unit)	40681.20	424717.20	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
263	Split-system air conditioner (Guardhouse (9.1) room 223) (indoor unit)	40685.30	424716.90	6.00	30.0	30.0	33.0	36.0	38.0	40.0	38.0	35.0	30.0	44.0	Yes
264	Split-system air conditioner (Guardhouse (9.1) room 223) (outdoor unit)	40681.20	424716.60	3.60	44.0	45.0	46.0	47.0	47.0	46.0	44.0	39.0	35.0	51.0	Yes
265	Grundfos CRE 3 4 A pump for feeding water to iron removal system	40756.50	424688.00	-4.10	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
266	Grundfos CRE 3 4 A pump for feeding water to iron removal system	40756.50	424688.00	-4.10	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
267	Grundfos CR 90-4F-F-A-E-HQQE water delivery pump	40756.00	424697.00	-4.10	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
268	Grundfos CR 90-4F-F-A-E-HQQE water delivery pump	40756.00	424697.00	-4.10	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
269	Grundfos CR 90-4A-F-A-E-HQQE fire water pump	40848.00	424761.00	-2.00	75.2	75.2	75.3	73.2	69.0	65.3	59.9	54.2	48.2	71.0	Yes

Source No.	Source Name	Source Coordinates			Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La	Included in the Estimate
		X (m)	Y (m)	Height, (m)	31.5	63	125	250	500	1000	2000	4000	8000		
270	Grundfos CR 90-4A-F-A-E-HQQE fire water pump	40848.00	424761.00	-2.00	75.2	75.2	75.3	73.2	69.0	65.3	59.9	54.2	48.2	71.0	Yes
271	Grundfos SEG 40.12.2.50B pump for feeding domestic waste water to KP Vector purification works	40884.50	424717.00	0.00	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
272	Grundfos SEG 40.12.2.50B pump for feeding domestic waste water to KP Vector purification works	40884.50	424717.00	-7.00	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
273	Grundfos SL1.50.65.22.2.50D pump for feeding polluted storm water to purification works	40832.00	424798.50	-11.50	63.2	63.2	63.3	61.2	57.0	53.3	47.9	42.2	36.2	59.0	Yes
274	Grundfos SL1.50.65.22.2.50D pump for feeding polluted storm water to purification works	40832.00	424798.50	-11.55	63.2	63.2	63.3	61.2	57.0	53.3	47.9	42.2	36.2	59.0	Yes
275	Grundfos SL1.50.65.22.2.50D pump for feeding polluted storm water to purification works	40849.00	424798.00	-11.55	63.2	63.2	63.3	61.2	57.0	53.3	47.9	42.2	36.2	59.0	Yes
276	Grundfos SL1.50.65.22.2.50D pump for feeding polluted storm water to purification works	40849.00	424798.00	-11.55	63.2	63.2	63.3	61.2	57.0	53.3	47.9	42.2	36.2	59.0	Yes
277	Grundfos Unilift AP12.50.11.A1 pump for feeding water to the bag-type filter	40833.50	424825.50	-6.75	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
278	Grundfos Unilift AP12.50.11.A1 pump for feeding water to the bag-type filter	40833.50	424841.50	-6.75	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
279	Grundfos Unilift AP12.40.08.A1 pump for feeding storm water into the clean storm water sewer from KP Vector site	40839.00	424830.50	-6.75	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
280	Grundfos Unilift AP12.40.08.A1 pump for feeding storm water into the clean storm water sewer from KP Vector site	40839.00	424846.50	-6.75	62.2	62.2	62.3	60.2	56.0	52.3	46.9	41.2	35.2	58.0	Yes
281	Grundfos SL1.50.80.30.2.50D pump for cleaned storm water	40831.00	424812.00	-2.60	67.2	67.2	67.3	65.2	61.0	57.3	51.9	46.2	40.2	63.0	Yes
282	Grundfos SL1.50.80.30.2.50D pump for cleaned storm water	40831.00	424812.00	0.00	67.2	67.2	67.3	65.2	61.0	57.3	51.9	46.2	40.2	63.0	Yes
283	Concrete plant	40879.00	424600.00	0.00	79.0	82.0	84.0	85.0	81.0	78.0	77.0	75.0	71.0	85.0	Yes

Table 4.34 – **List of Road Transport Noise Sources and Their Acoustic Characteristics**

Source No.	Source Name	Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									$L_{Амакс}$	Included in the Estimate
		31.5	63	125	250	500	1000	2000	4000	8000		
284	Transporter	105.0	105.0	104.0	98.0	92.0	88.0	83.0	79.0	75.0	95.0	Yes
285	Truck crane with load lifting capacity of 25 tonnes of KC-55713-K-4-02 type	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
286	Truck with an extensible boom platform of VS-18 type	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
287	Minibus for personnel of IVECO Bus 16+1 type	80.0	80.0	81.0	77.0	75.0	70.0	68.0	60.0	54.0	77.0	Yes
288	Sweeping truck (winter/summer) of PM-533701-1.02 type	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
289	KrAZ-6511H4-0000120-000	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
290	KrAZ-6511H4-0000120-000	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
291	KrAZ-6511H4-0000120-000	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
292	Putzmeister BSF 28	100.0	100.0	97.0	88.0	82.0	77.0	73.0	68.0	63.0	86.0	Yes
293	AMKODOR 332V	86.0	86.0	85.0	79.0	73.0	69.0	65.0	60.0	55.0	76.0	Yes

Table 4.35 – **List of Rail Transport Noise Sources and Their Acoustic Characteristics**

Source No.	Source Name	Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									$L_{Амакс}$	Included in the Estimate
		31.5	63	125	250	500	1000	2000	4000	8000		
294	TEM-2U diesel locomotive	98.0	98.0	95.1	86.3	80.1	74.7	70.5	66.0	61.5	84.0	Yes
295	TEM-18 diesel locomotive	98.0	98.0	95.1	86.3	80.1	74.7	70.5	66.0	61.5	84.0	Yes

4.2.5.4 Noise Impact of Process Equipment

The estimate incorporates layout, architectural/construction, and technical design solutions that provide for the reduction of noise from specific sources.

Noise levels have been determined according to the following formula:

$$L_{P.T.} = L_{ucm.} - 15\lg(r) + 10\lg(\Phi) - 0{,}001 \times \beta_a \times r - 10\lg(\Omega) \quad (16)$$

where $L_{ucm.}$ is the equipment sound power level, dB;

r is the distance from the noise source to the reference point, m;

Φ is the noise source directivity factor, $\Phi = 1$;

Ω is the spatial angle of the acoustic emission:

- for noise sources situated on the surface in the area or on fencing structures of the buildings: $\Omega = 2\pi$;
- for noise sources in a space: ..... $\Omega = 4\pi$

Sound damping due to shielding effect D_z, dB, has been calculated according to the following formula:

$$D_z = 10\lg\left[3 + (C_2/\lambda) \times C_3 \times z\right] \quad (17)$$

where C_2 is a constant to account for the ground reflection effect, $C_2 = 20$;

C_3 is a constant to account for the diffraction on top edges calculated as follows:

$$C_3 = \left[1 + (5\lambda/e)^2\right] / \left[(1/3) + (5\lambda/e)^2\right] \quad (18)$$

where λ is the length of an acoustic wave with a frequency equal to the central frequency of an octave band, m;

e is the distance between diffracting edges (Figure 4.6);

z is the difference between lengths of the direct sound path and the sound path via diffracting edges calculated as follows:

$$z = \left[(d_{ss} + d_{sr} + e)^2 + a^2\right]^{1/2} - d \quad (19)$$

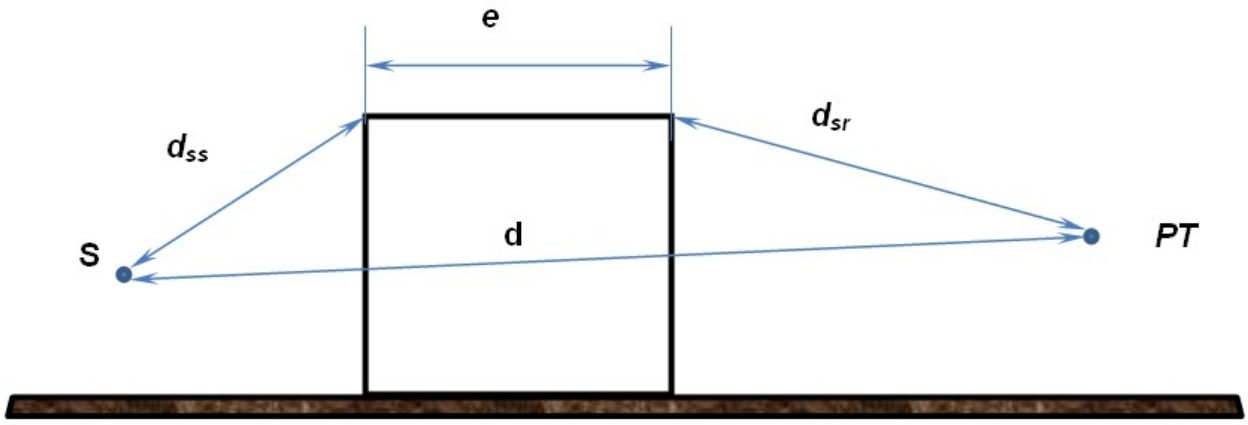

Figure 4.6 – **Geometric Values for Ascertainment of the Difference between Sound Propagation Paths in Case of the Diffraction on Two Edges**

4.2.5.5 Noise Impact of Road Transport

Given that the speed of the vehicles at the entrance and within the facility may not exceed 10 km/h, the adjusted maximum sound level is obtained from Formula [107]:

$$L_{\max 10} = L_{\max} - 30\lg(V_{60}/V_{10}) \quad (20)$$

where $L_{\max 10}$ is the maximum sound pressure level at the speed of 10 km/h at a distance of 7.5 m from the axis of motion, dBA;

V_{60} is the speed of 60 km/h;

V_{10} is the speed of 10 km/h.

The sound levels in reference points are determined by the following formula:

$$L_{P.T.} = L_{ucm.} - 20\lg(r/r_0) \quad (21)$$

where $L_{ucm.}$ is the sound level at a distance of 7.5 m from the source, dBA;
r is the distance to the reference point, m;
r_0 is the distance from the axis of the lane nearest to the reference point.

4.2.5.6 Noise Impact of Rail Transport

Rail transport noise characteristics are determined in accordance with DSTU-N B V.1.1-33:2013 [108] from the following formula:

$$L_{Амакс} = 79{,}4 + \Delta L_{Астык} + 0{,}233V \quad (22)$$

where V is the average design speed of trains, kph;
l is the actual design length of trains, m;
$\Delta L_{Астык}$ is a dBA element to take into consideration the rail track type, $\Delta L_{Астык} = 2$.
The sound levels in reference points are determined by the following formula:

$$L_{P.T.} = L_{ucm.} - 20\lg(r/r_0) \quad (23)$$

where $L_{ucm.}$ is the sound level at a distance of 25 m from the source, dBA;
r is the distance to the reference point, m;
r_0 is the distance from the axis of the lane nearest to the reference point.

4.2.5.7 Calculation of the Noise Pollution of the Atmospheric Air during Operation

Estimate of the Noise Impact of Process Equipment

Estimate Parameters

The estimation target area has been assumed to be 3000 × 3000 m large with grid spacing of 100 m. Noise calculations have been carried out in nodes of the grid of the design rectangle at h=1.5 m.

A schematic map of locations of noise sources and reference points is provided in Annex П, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Conditions

Coordinates of the target area are provided in Table 4.36.
Coordinates of reference points are provided in Table 4.37.

Table 4.36 – **Coordinates of the Target Area**

Description	Coordinates				Width (m)	Height (m)	Grid spacing (m)		Included in the estimate
	point 1		point 2						
	X (m)	Y (m)	X (m)	Y (m)			X	Y	
Target area	39250.00	424920.00	42250.00	424920.00	3000.0	1.50	100.0	100.0	Yes

Table 4.37 – **Coordinates of Reference Points**

Reference point number	Description	Reference point coordinates			Included in the estimate
		X (m)	Y (m)	Height (m)	
001	Reference point on the SPZ boundary (001)	40703.50	424458.50	1.50	Yes
002	Reference point on the SPZ boundary (002)	40546.26	424651.41	1.50	Yes
003	Reference point on the SPZ boundary (003)	40546.00	424923.91	1.50	Yes
004	Reference point on the SPZ boundary (004)	40546.00	425196.42	1.50	Yes
005	Reference point on the SPZ boundary (005)	40635.44	425421.91	1.50	Yes
006	Reference point on the SPZ boundary (006)	40878.51	425460.00	1.50	Yes
007	Reference point on the SPZ boundary (007)	40962.12	425214.56	1.50	Yes
008	Reference point on the SPZ boundary (008)	40962.44	424942.06	1.50	Yes
009	Reference point on the SPZ boundary (009)	41058.14	424689.62	1.50	Yes
010	Reference point on the SPZ boundary (010)	40975.29	424464.63	1.50	Yes
011	Reference point within the site (011)	40745.00	424710.00	1.50	Yes
012	Reference point within the site (012)	40810.00	424710.00	1.50	Yes

Results of Calculation of the Noise Impact of Process Equipment

Results of the calculation of the sound pressure in nodes of the target area are provided together with diagrammatic maps as a result of the calculation of the sound pressure level in octave bands with central frequencies in Hz, and the integral indicator are presented in Annex P in Volume 12.2 Environmental Impact Assessment. Part 2. Annexes.

Results of the sound pressure calculation in reference points on the SPZ boundary and within the site are presented in Table 4.38.

Table 4.38– **Results of the Sound Pressure Calculation in Reference Points on the SPZ Boundary and within the Site**

Reference point number	Description	Sound Pressure (Sound Power if R=0) Levels, dB, in Octave Bands with Center Frequencies, Hz									La
		31.5	63	125	250	500	1000	2000	4000	8000	
001	Reference point on the SPZ boundary (001)	42.5	41.4	42.4	38.9	33.5	28.6	23.0	15.5	5.1	35.60
002	Reference point on the SPZ boundary (002)	41.5	40.3	40.8	38	32.9	28.0	20.9	11.1	0.0	34.70
003	Reference point on the SPZ boundary (003)	44.1	42.8	42.5	40.8	36.1	32.0	25.3	17.2	4.8	37.90
004	Reference point on the SPZ boundary (004)	41.9	40.8	41.7	38.2	32.0	25.9	16.1	3.7	0.0	34.00
005	Reference point on the SPZ boundary (005)	38.3	36.8	37.1	33.2	26.5	19.7	8.9	0.0	0.0	28.70
006	Reference point on the SPZ boundary (006)	35.0	33.5	33.7	30.5	24.6	18	7.4	0.0	0.0	26.30
007	Reference point on the SPZ boundary (007)	36.8	34.7	33.8	31.5	26.3	21.7	13.3	0.0	0.0	28.10
008	Reference point on the SPZ boundary (008)	41.1	38.8	38	36	31.7	27.7	21.2	12.2	0.0	33.50
009	Reference point on the SPZ boundary (009)	36.8	34.9	35.1	33.6	29.9	26.5	22.6	16.6	7.4	32.10
010	Reference point on the SPZ boundary (010)	35.1	33.9	34.4	34	30.2	26.8	23.6	18.8	10.6	32.50
011	Reference point within the site (011)	51.2	50	51	47.3	42	36.6	29.3	20.9	10.9	43.80
012	Reference point within the site (012)	45.3	43.5	43.9	42	39.3	35.7	30.7	24.5	16.2	41.00

Estimates show that the expected levels of noise from the process equipment on the CSFSF site do not exceed an equivalent noise level of 80 dBA as prescribed by DSN DSN 3.3.6.037-99 [103]; expected levels of noise from the process equipment at the SPZ boundary do not exceed an equivalent noise level of 45 dBA as prescribed by SN No. 3077-84 [104] in all octave bands. The discomfort zone due to noise of the technological equipment does not exceed the boundaries of the SPZ and will not affect the development of the further acoustic field.

Estimate of the Noise Impact of Road Transport

Since constant flow of the road transport is not expected on the territory of the CSFSF, the noise estimate is based on the maximum noise levels of the noisiest means of transport [105-107].

$L_{Амакс} = 95{,}0\ дБА$

$L_{\max 10} = 71{,}7\ дБА$

Where $r = 100\ м$, $L_{P.T.} = 31{,}7\ дБА$

According to calculations and estimates, noise impact of the road transport on the parking lots and internal roads within the site is within the acceptable range.

Noise Impact of Rail Transport

Since constant flow of the rail transport is not expected on the territory of the CSFSF, the noise estimate is based on the maximum noise levels [105-107].

Design speeds of traffic on loading/unloading tracks is assumed to be under 5 kph ($V = 5\ км/ч$) in accordance with SNIP 2.05.07-91 [109]. In accordance with DSTU-N B V.1.1-33:2013 [108] $\Delta L_{Астык} = 2$:

$L_{Амакс} = 82{,}565\ дБА$

Where $r = 100\ м$, $L_{Р.Т.} = 42{,}6\ дБА$

The estimates show that the noise impact of the rail transport will be within the acceptable limits.

4.2.5.8 Results of Sound Pressure Level Calculations

The acoustic effects of the operation of the facility will be permanent and will accompany the activities on the site during the whole operation period.

The estimates show that the noise discomfort zone of the technological equipment does not exceed the boundaries of the SPZ and will not affect the development of the further acoustic field; the noise impact from the road transport on parking lots and internal roads, as well as from the rail transport, which provides services to the CSFSF, are within an acceptable range.

The operation of the facility is deemed acceptable from the point of view of the expected noise impact.

4.2.6 Impact of Electric and Electromagnetic Fields on Air Environment

4.2.6.1 Impact of Electric and Electromagnetic Fields

This Project does not rely on high-voltage equipment with the electric field strength in excess of 5 kV per meter. The highest voltage in the equipment used is 10 kV. If the electric field strength does not exceed 5 kV per meter, no restrictions are imposed on the time of the presence of personnel during the maintenance of the equipment in question.

The following will be the most important electromagnetic impact sources at the CSFSF site:

- the electrical equipment (transformers, generators, electrical drives, diesel generator power units);
- the radio communication and RLC antennas placed on a telecommunication tower with a modular building.

4.2.6.2 Impact of Electromagnetic Fields from Electrical Equipment

High field strengths caused by strong magnetic fields can occur in transformers, generators, electric motors, KRU-0.4 kV and KRU-10 kV switchgear cabinets shielded by the natural structural elements of these switchgears. The installation of the appropriate grounded shells and shields (i.e., structural elements operating effectively as stationary anti-magnetic shields covering live parts) is a sufficient measure of protection against the harmful biological impact of strong magnetic fields generated by heavy currents (over 1000 A) in electrical installations on human organism (operating personnel).

The personnel is protected against magnetic field impacts at the operating frequency of up to 50 Hz (in case of an unacceptable level of magnetic field strength or induction) with stationary or portable anti-magnetic shields, if required. The need for portable anti-magnetic shields is determined only on the basis of specific magnetic field strength in the place of work taking into account the permitted duration of exposure of the personnel to the magnetic field impact. Additional safety measures for the work within the impact zone of magnetic and electric fields shall be specified as Special Instructions in the work orders on the basis of specific measurements of the strengths of fields in question in places of work.

4.2.6.3 Impact of Electromagnetic Fields from Radio Communication and RLC Antennas Placed on a Telecommunication Tower with a Modular Building

Justification of Estimation Methods and Software Used

The electromagnetic impact has been calculated in accordance with DSN 239-96 [110] on the basis of the existing calculation methodologies [111, 112] using ANTENNA IMPACT CALCULATION software, version 4.2, on the basis of an opinion of the Ministry of Health of Ukraine that this software operates in conformity to state regulations on the calculation of electromagnetic fields on the environment.

Initial Input Data for the Calculation

Plans call for the accommodation of the following equipment on the telecommunication tower:

- ALCOMA APC-13-1.25 parabolic antenna: 1;
- CXL70-5C/F(Procom) antenna: 1;
- BPA 08/136.05 omnidirectional antenna: ..... 1.

The following equipment is placed in a modular structure (a container module 2.3×3.1×2.7 m in size) to be installed near the telecommunication tower:

- ALCOMA AL13F radio relay station: 1;

- JSD-300-545/DIN2 (220/48 V 5 A) power supply system with a 26 A×h accumulator battery: 1;
- a telecommunication cabinet (19" 32U): 2;
- a radio repeater of RD985S (Hytera Communication) type: 4;
- a 12 V, 55 A×h accumulator battery: 5; .....
- NKRFA07800 7/8" DRAKA cable.

Closed-type accumulator batteries will be used. No gas is emitted when charging accumulator batteries, thus no EIA calculations are required.

Places of the installation of antennas and equipment of the radio communication and RLC system are specified on Figure 4.7.

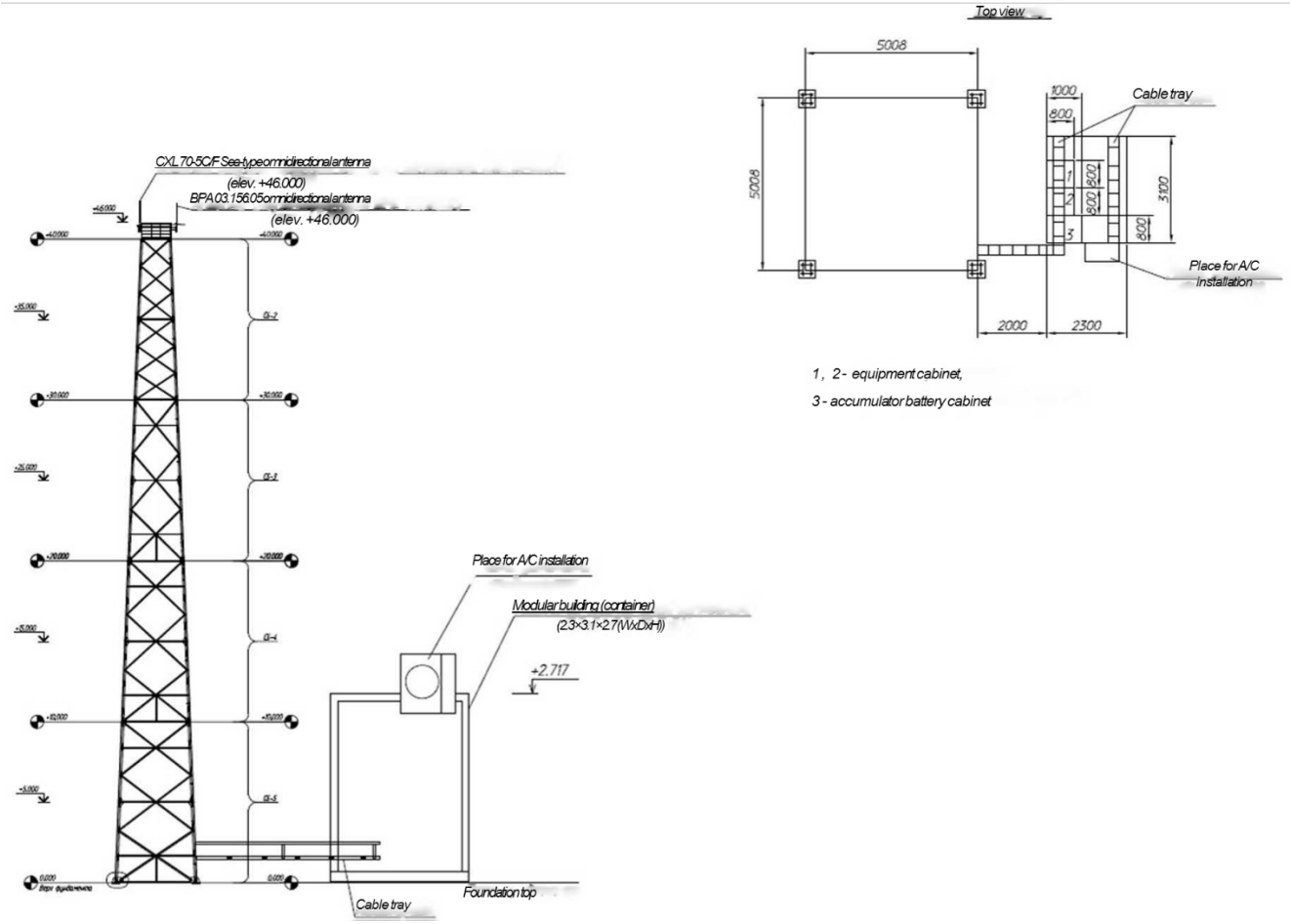

Figure 4.7 – **Places of the Installation of Antennas and Equipment of the Radio Communication and RLC System**

Estimate Parameters

The calculation of electromagnetic field levels generated by radio facilities in the area adjacent to a radio facility has been carried out in the following planes:

- ground projection of the MAL exceedence zone No. 1;
- vertical plane No. 1 (X=0 m; Y=0 m; azimuth=0 °);
- vertical plane No. 2 (X=0 m; Y=0 m; azimuth=0 °);
- vertical plane No. 3 (X=0 m; Y=0 m; 267 °).

The calculation of the electromagnetic impact during operation is presented in Annex C, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Electromagnetic Field Level Calculation Results

The analysis of calculation results has confirmed the following:

1 For the designed facility, values (S/S_{don}) at a height of 2.0 m, the maximum radius of the 2.0 uW/cm^2 fixed radiation level zone, and the height of the development restriction zone along directions of the radiation maximums of the designed antennas are specified in Table 4.39.

Table 4.39 – **Maximum Radius of the Fixed Radiation Level Zone, Minimum Height and Maximum Radius of the Development Restriction Zone (DRZ)**

Azimuth, degrees	Maximum electromagnetic field level (S/S_{don}) at a height of 2.0 m	Minimum DRZ height, m	Maximum DRZ radius, m
0 °	0.032	37.399	41.452
261 °	0.032	37.399	114.259

2. The total electromagnetic energy flux density in the surrounding area at a height of 2 m above the ground at a distance of 0-1000 meters from the transmitting antennas does not exceed 3.2 % of the MAL. The construction and the operation of the base station will not require a sanitary protection zone to be instituted.

3. The aggregate impact of transmitting antennas makes it necessary to impose a residential development restriction zone. The minimum DRZ height is at least 37.399 m. Radii of development restriction zones are listed in Table 4.39.

The existing residential buildings are located outside the restricted zone. If the established restricted zones around the radio-engineering site are observed, the electromagnetic field is safe for human health.

4. There is no need to take measures to normalize electromagnetic situation.

5. In general, conditions of the accommodation and operation of equipment of the telecommunication tower with a modular building are in accordance with DSN 239-96 [110] requirements.

4.3 Geological Environment

4.3.1 Radiation Impact on Geological Environment

No direct radiation impact on geological requirement is expected at any stage of the CSFSF operation under any operating conditions.

4.3.2 Non-radiation Impact on Geological Environment

Various unfavorable natural and natural/artificial processes and phenomena have been observed in the area of the CSFSF site. They include exogenic processes, such as:

- sheet erosion (sheet and surface washing);
- aeolian processes (sand blowing);
- swamp development.

Within the CSFSF site, no physical/geological processes and phenomena that would affect the evaluation of the area negatively have been observed [45]. The erosion of soil, gullies and landslides is absent due to the minor difference between absolute ground surface elevations (within 2.0 m). No swamp development and waterlogging of the area have been observed (underground waters occur at depths of 12.2 to 19.2 meters).

Since the surveyed area in geological terms consists of well permeable sandy soils, the design level of underground waters was assumed to be 1.0 m higher than the level recorded during the survey to account for seasonal fluctuations. Temporary water table of the perched water may form in the thick deposits on top of the impermeable layers of clay soils during periods of intensive rainfall or in case of leakage from water lines.

In terms of the complexity of soil conditions, the construction site is categorized as Category II in accordance with Annex Zh to DBN A.2.1-1-2008 [46]. No changes in geological conditions are expected in the course of construction and operation of the storage facility.

4.4 Water Environment

4.4.1 Radiation Impact on Water Environment

4.4.1.1 Radiation Impact on Surface Waters

As a result of the Chernobyl disaster and the accident fallouts all the water bodies within the 10-kilometer zone of the SSE “Chornobyl NPP” were contaminated and keep being contaminated.

Currently, the water bodies (rivers, streams, lakes, ponds, backwaters, canals and waterways) play the leading role in the redistribution of the radionuclides in the environment within the exclusion and compulsory resettlement zone. The radioactive substances soluble in the melt, rain and flood waters migrate via the runoff into the groundwater and streams, and flow into the into rivers and lakes from the surface. The main contribution to the formation of the radioactive contamination of the surface waters is made by ^{137}Cs and ^{90}Sr.

Radiation Impact under Normal Operating Conditions

The CSFSF impact on surface waters will be negligible because the additional radionuclide contamination of the closest areas, where surface water bodies are located, will be 4 to 5 orders of magnitude below (see Section 4.5.1.1) the current level under normal CSFSF operating conditions and the most conservative calculation assumptions (see Sections 4.2.1.2 and 4.2.1.5).

Radiation Impact in Case of a Maximum Design-Basis Accident and a Beyond-Design-Basis Accident

Surface water bodies are situated far away from the CSFSF (River Uzh at about 11 km, River Sahan at about 9 km, River Pripyat at 12 km).

It should be borne in mind that catchment basins of rivers being the closest to the CSFSF are relatively leveled and forested territories where no surface runoff, which is the major source of the ingress of radioactive substances from catchment areas, is present. A substantial percentage of catchment areas are swamped and act effectively as natural biogeochemical barriers preventing the dissemination of radioactive substances.

On this basis, it can be concluded that the direct transfer of radioactive substances from catchment areas in case of accidents at the CSFSF will be substantially arrested by the existing biogeochemical barriers.

On this basis, a conclusion can be drawn that the major impact on surface water bodies will be from the direct ingress of radioactive substances on the surface of water bodies.

In case of a maximum design-basis accident with the maximum radiation impacts, the additional radioactive contamination of the area (Section 4.5.1.2) at the closest distances to surface water bodies is close to n E-2 Bq/m², and amounts to several one hundredths of one percent of the existing contamination caused by the accidental discharge from Chernobyl NPP.

Thus, radiation impacts on water environment in case of a maximum design-basis accident with the maximum radiation impact will be insignificant.

When estimating the impact of a radioactive discharge from a hypothetic beyond-design-basis accident, it is assumed that the maximum radiation impact on surface waters is possible in case of the deposition of radioactive substances on the upper section of the Pripyat River estuary. This section has the water body surface width (flood plain) of approximately 1,000 m and is located 20 km to southeast from the CSFSF. In this case, according to estimated data, the maximum aggregate additional deposition of radionuclides from a discharge in case of a hypothetic beyond-design-basis accident into water of the Pripyat River will amount to 1.0E+09 Bq of aggregate activity which is by three orders of magnitude lower than the annual export of the aggregate activity with the Pripyat River flow (about n E12 Bq). Taking into account insubstantial additional aggregate activity and the low probability of this accident, the radiation impacts from a hypothetic beyond-design-basis accident on surface waters can be deemed acceptable.

4.4.1.2 Conclusions of the Assessment of the Radiation Impact of the CSFSF on Surface Waters during Operation

The risk of radioactive contamination of surface waters during normal operation of the CSFSF is minor in comparison with the existing contamination.

4.4.1.3 Radiation Impact on Underground Waters

Radiation Impact under Normal Operating Conditions

The radioactive surface contamination of neighboring areas in case of the normal operation of the CSFSF is negligible in comparison with the existing contamination (Section 4.5.1.4), and will not affect the condition of underground waters.

Radiation Impact in Case of a Maximum Design-Basis Accident and a Beyond-Design-Basis Accident

In case of accidents, the intensity of underground water contamination processes will be determined both by the depth of ground waters and the level of the additional surface contamination depending on the distance to the discharge point.

The CSFSF is located on a leveled plateau with a deep groundwater occurrence (over 18 m) without large enclosed topographic lows whose surface contamination could result in their substantial contamination with time.

Since the highest surface contamination of soils from accidents will be observed in a close vicinity of the CSFSF site and the additional soil contamination is minor, no noticeable additional contamination of underground water will occur.

4.4.1.4 Conclusions of the Assessment of the Radiation Impact of the CSFSF on Underground Waters during Operation

Additional radiation contamination of underground waters in case of the normal operation of the CSFSF is ruled out.

In case of accidents at the CSFSF, the impact on underground waters is minor due to the insignificance of the additional contamination of soils and the deep occurrence of ground water in the vicinity of the CSFSF site.

4.4.2 Non-radiation Impact on Aquatic Environment

The water consumption and disposal balance is provided in Annex T, Volume 12.2, Environmental Impact Assessment. Part 2. Annexes.

In order to monitor changes of the hydrogeological situation in the area of the CSFSF a network of monitoring wells was established.

According to the report [45], six wells have been drilled down to the first aquifer (Wells 8514, 8517, 8520/1, 8532, 8561 and 8563/1) and one well — down to the perched water (Well 8534/1).

A map of monitoring wells in the area of the CSFSF is shown in Annex У, Volume 12.2, Environmental Impact Assessment. Part 2. Annexes.

Water supply to the CSFSF is designed from existing networks at the Vector site. Drained water is disposed by the storm and melt water from the CSFSF territory to the existing purification works of Vector facility.

There is no non-radioactive impact on aquatic environment during operation of the CSFSF.

The operation of the facilities, in terms of impact on water bodies, is acceptable.

4.5 Soils

4.5.1 Radiation Impact on Soil

4.5.1.1 Radiation Impact under Normal Operating Conditions

The maximum additional surface soil contamination in the course of the regular CSFSF operation at the most conservative calculation conditions (Sections 4.2.1.2, 4.2.1.5) is specified below in Table 4.40. Values of the surface contamination have been obtained for a discharge described in Section 4.2.1.2.

Table 4.40 – **Additional Ground Surface Radionuclide Contamination along the Trail Axis Depending on the Distance (Normal CSFSF Operation Case), Bq/m^2**

Radionuclide	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
^{90}Sr	6.07E+01	3.96E+01	1.74E+01	5.81E+00	1.32E+00	2.90E-01	2.64E-01	1.21E-01
^{134}Cs	2.75E+01	1.75E+01	7.63E+00	2.59E+00	6.03E-01	1.37E-01	1.22E-01	5.57E-02
^{137}Cs	9.50E+01	6.07E+01	2.64E+01	8.98E+00	2.09E+00	4.75E-01	4.22E-01	1.93E-01

Obtained results are much lower than the existing contamination.

4.5.1.2 Radiation Impact in Case of a Maximum Design-Basis Accident

The design-basis accident with the maximum radiation consequences is considered in Section 3.6. The distribution of radioactive emission in the atmosphere in case of such an accident is considered in Section 4.2.1.3.

Calculated values of the surface contamination of soil depending on the distance from the CSFSF site are specified in Table 4.41 for two cases: with or without precipitation.

Table 4.41 – **Additional Ground Surface ^{60}Co Contamination along the Trail Axis Depending on the Distance (MDBA Case), Bq/m^2**

Weather	Distance, m							
	100	600	1000	2000	5000	12000	13000	20000
Without precipitation	6.40E+00	4.00E+00	1.80E+00	5.90E-01	1.40E-01	3.20E-02	2.70E-02	1.30E-02
With precipitation	1.48E+01	1.47E+00	6.90E-01	2.70E-01	7.80E-02	2.08E-02	1.80E-02	8.40E-03

Results of the calculation of the additional volumetric activity of ^{60}Co in the ground-level layer of the air due to the propagation of an accidental discharge for two types of weather conditions under review are presented on Figure 4.8.

Maximum levels of the ground surface contamination with ^{60}Co as a result of an accident under review will be observed in close vicinity of the CSFSF and will not exceed the level of 15 Bq/m². This impact will hardly affect the condition of the top soil due to the high initial level of the surface contamination of soils in neighboring areas (about 200 kBq/m² for radionuclides in aggregate).

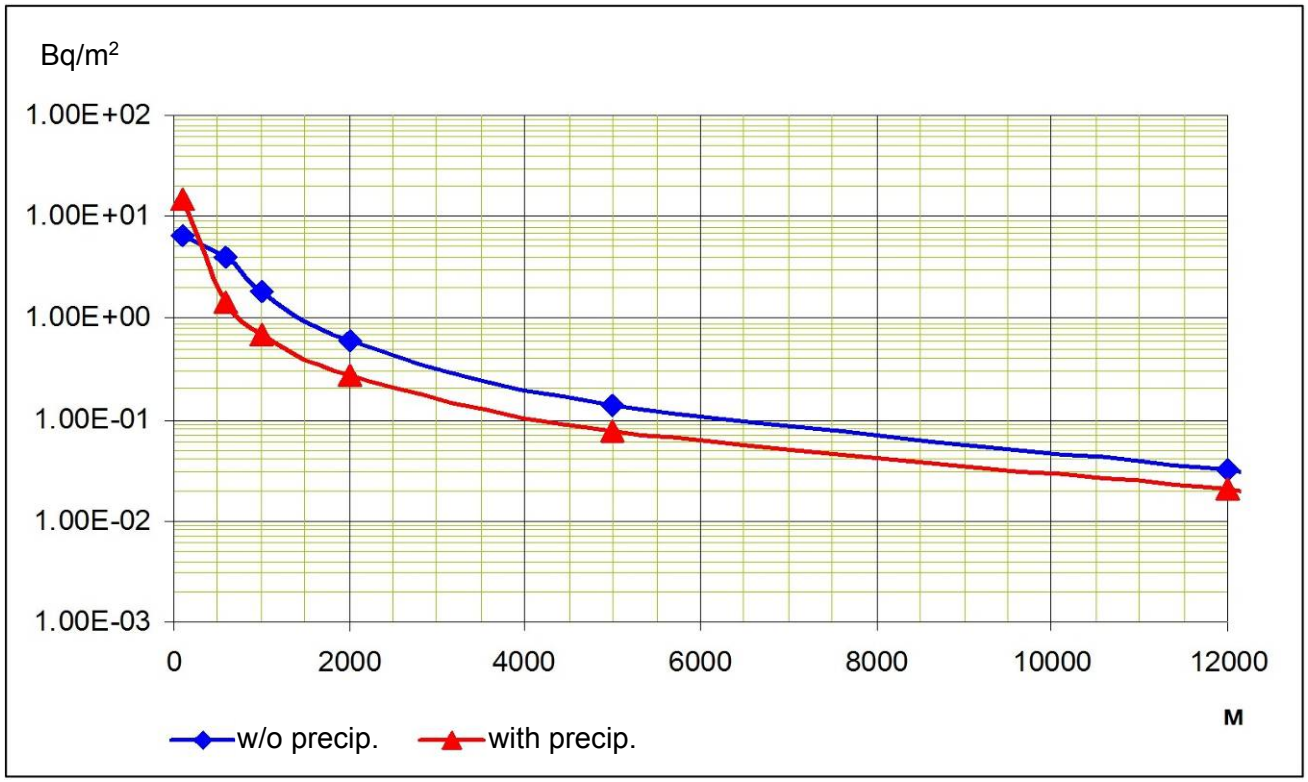

Figure 4.8 – **Dependence of Additional Ground Surface ^{60}Co Contamination along the Trail Axis on the Distance (MDBA Case), Bq/m²**

4.5.1.3 Radiation Impact in Case of a Beyond-Design-Basis Accident

The hypothetic beyond-design-basis accident is considered in Section 3.6. The distribution of radioactive emission in the atmosphere in case of such an accident is considered in Section 4.2.1.4.

Calculated values of the surface contamination of soil from the hypothetic accident under review depending on the distance from the CSFSF site are specified in Table 4.20 for two cases: with or without precipitation.

Table 4.42 – **Additional Ground Surface Radionuclide Contamination along the Trail Axis Depending on the Distance (BDBA Case), Bq/m^2**

Radionuclides	Distance, m							
	100	**600**	**1000**	**2000**	**5000**	**12000**	**13000**	**20000**
Without precipitation								
^{60}Co	3.30E+04	2.10E+04	9.60E+03	3.10E+03	7.20E+02	1.70E+02	1.40E+02	6.70E+01
^{90}Sr	2.30E+05	1.50E+05	6.60E+04	2.20E+04	5.00E+03	1.10E+03	1.00E+03	4.60E+02
^{137}Cs	3.60E+05	2.30E+05	1.00E+05	3.40E+04	7.90E+03	1.80E+03	1.60E+03	7.30E+02
TE	7.31E+04	4.66E+04	2.12E+04	6.88E+03	1.59E+03	3.70E+02	3.18E+02	1.48E+02
With precipitation								
^{60}Co	7.40E+04	7.60E+03	3.60E+03	1.40E+03	4.00E+02	1.09E+02	9.50E+01	4.39E+01
^{90}Sr	5.09E+05	5.20E+04	2.50E+04	9.60E+03	2.82E+03	7.50E+02	6.50E+02	3.05E+02
^{137}Cs	8.10E+05	8.30E+04	3.90E+04	1.52E+04	4.30E+03	1.18E+03	1.04E+03	4.76E+02
TE	1.59E+05	1.61E+04	7.95E+03	3.07E+03	8.90E+02	2.34E+02	2.05E+02	9.54E+01

Results of the calculation of the additional soil contamination due to the propagation of an accidental discharge in case of a hypothetic beyond-design-basis accident for two types of weather conditions under review are presented on Figures 4.9 to 4.12.

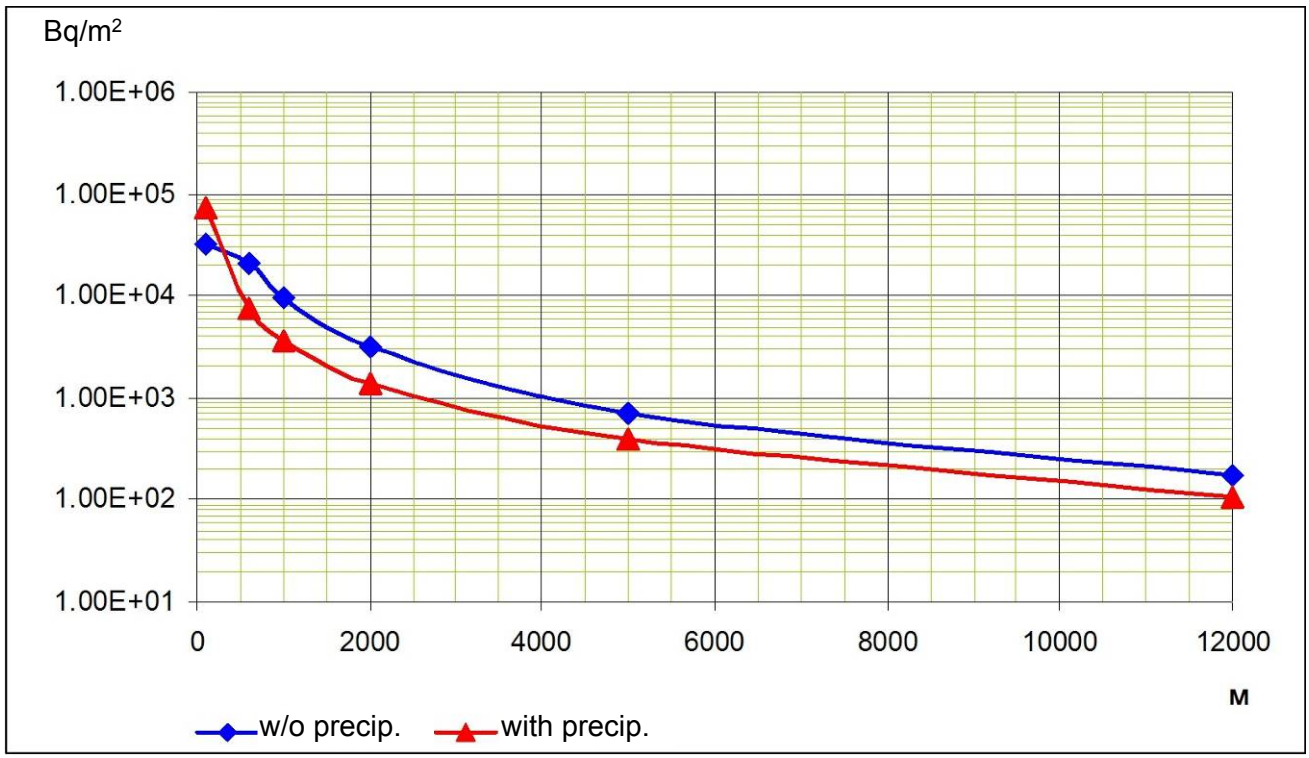

Figure 4.9 – **Additional Ground Surface ^{60}Co Contamination along the Trail Axis Depending on the Distance (BDBA Case), Bq/m^2**

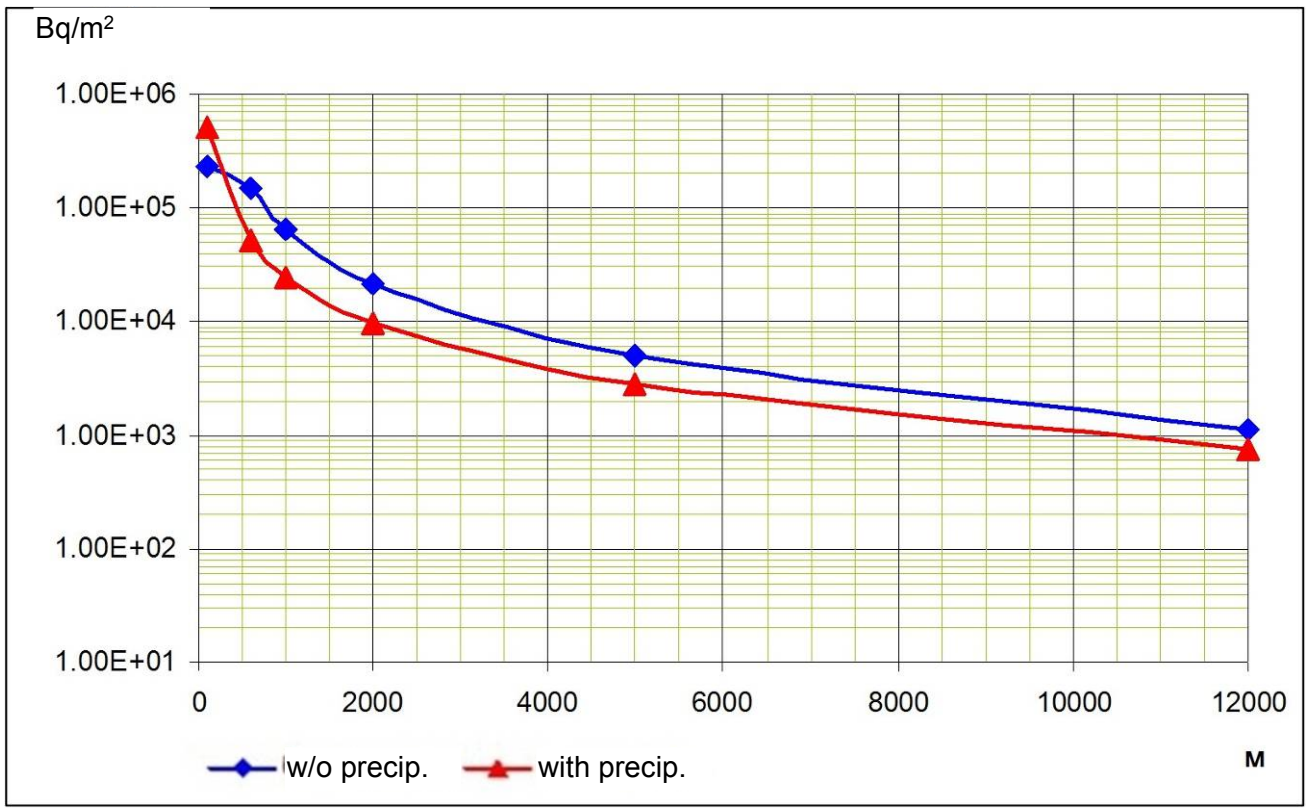

Figure 4.10 – **Additional Ground Surface ^{90}Sr Contamination along the Trail Axis Depending on the Distance (BDBA Case), Bq/m^2**

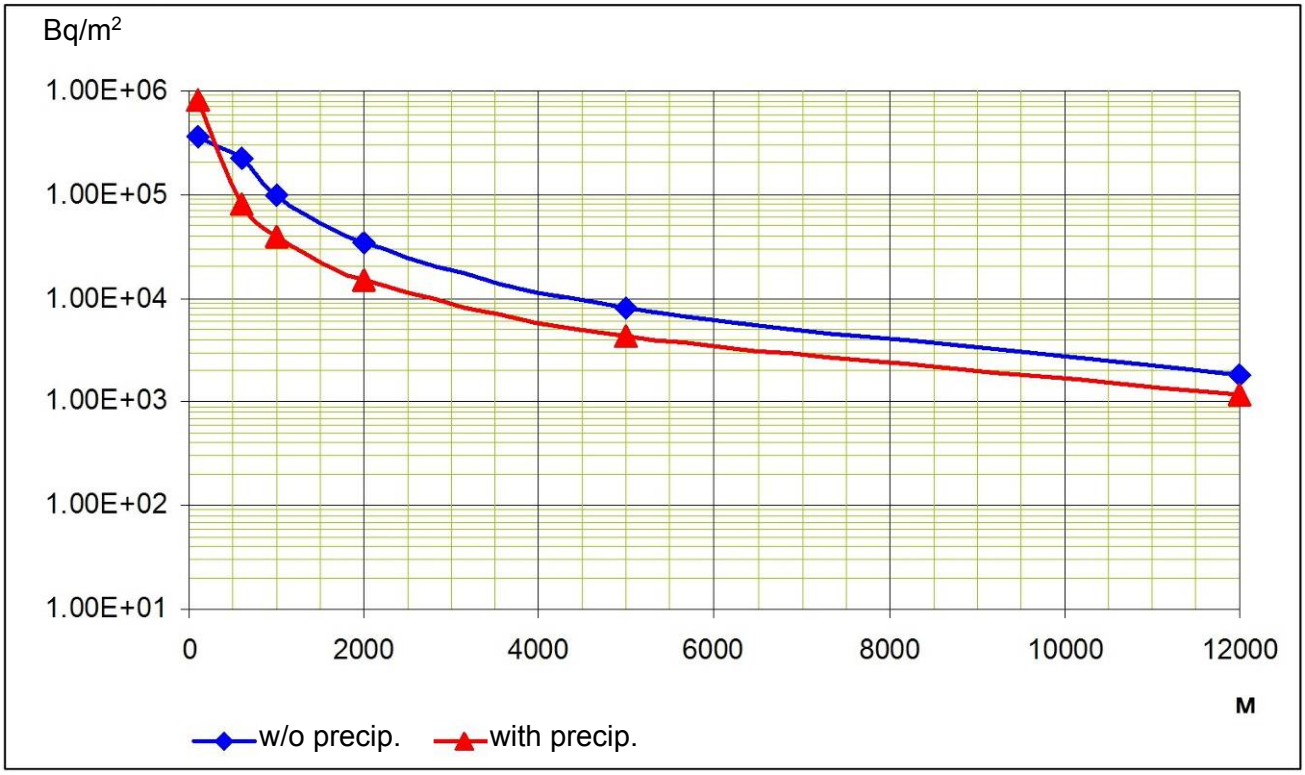

Figure 4.11 – **Additional Ground Surface ^{137}Cs Contamination along the Trail Axis Depending on the Distance (BDBA Case), Bq/m^2**

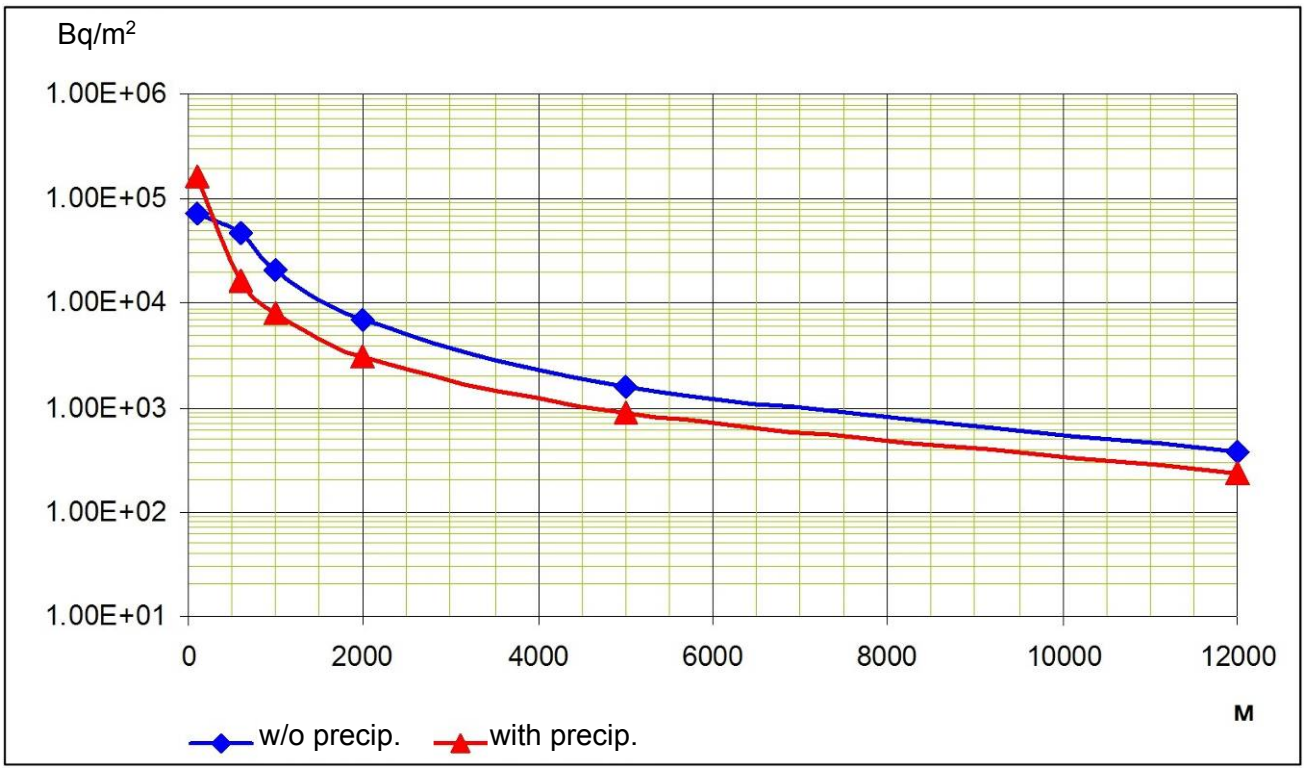

Figure 4.12 – **Additional Ground Surface Transuranium Elements Contamination along the Trail Axis Depending on the Distance (BDBA Case), Bq/m^2**

4.5.1.4 Conclusions of the Assessment of the Radiation Impact of the CSFSF on Soil during Operation

Th maximum surface contamination of the soil will be observed in close vicinity of the CSFSF site both in case of the normal operation and in case of accidents.

The existing surface contamination of the soil (Section 2.5.1.4) in the CSFSF site area ranges from dozens to hundreds of kBq/m² in case of ^{137}Cs and ^{90}Sr, and from several kBq/m² to several dozens of kBq/m² in case of transuranium elements (TE). Average β-particle flow density in the CSFSF site area ranges from 50 to 80 particles×cm^{-2}×min^{-1}.

With regular operation and in case of a design-basis accident with maximum radiation impact, the radioactive contamination of the soil is extremely negligible in comparison with the existing contamination and will not affect the condition of the top soil substantially.

In case of a hypothetic beyond-design-basis accident, an additional radioactive contamination of the soil in close vicinity of the CSFSF site can exceed the existing contamination several fold, and it will be somewhat lower than the existing contamination at distances of about 2 km. The additional contamination at the closest boundary of the exclusion and compulsory resettlement zone (12 km to southwest) will lower than the existing one by an order of magnitude.

It should be borne in mind that this contamination has been obtained along the trail axis using extremely conservative assumptions (Sections 3.6 and 4.2.1.4), and it would have been much lower than specified above in case of more realistic assumptions. A conclusion can be made on this basis, and in view of the extremely low probability of the hypothetic beyond-design-basis accident under review that the radioactive impact of the CSFSF on soil is acceptable.

4.5.2 Non-radiation Impact on Soil

During the preparatory stage, activities are planned to clear the CSFSF construction site from forests and shrubs, and to carry out grading and leveling work.

In view of the adopted grade elevation, rainfall runoff that accumulates in the neighboring area in the north will flow along the natural gradient toward the fence of the CSFSF site.

There is no non-radioactive impact on soil during operation of the CSFSF.

The operation of the facilities, in terms of impact on soil, is acceptable.

4.6 Flora and Fauna, Protected Sites

4.6.1 Radiation Impact on Flora and Fauna, Protected Sites

4.6.1.1 Radiation Impact under Normal Operating Conditions

According to the Report [47], the average dose rate in close vicinity of the CSFSF site is about 0.4 uSv/year or 3.5 mSv/year, and is determined by the existing radioactive contamination of the environment. In some areas, the dose rate is several times as high as the average dose rate. It has been shown in Section 3.7 that the additional dose rate during normal operation of the CSFSF (in case of the maximum utilization of the storage area) will not exceed 0.7 mSv/year at a distance of 100 m and further from the site boundaries and will amount to about 20% of the existing average.

In addition, it bears mentioning that biocenoses in the CSFSF site area exist and develop successfully under conditions of the substantial density of the contamination of soil and vegetation with the aggregate activity rising to 7.4×10^{10} – 14.8×10^{10} Bq/km² in some sections of neighboring territories.

It can be concluded on this basis that the radiation impact of the normal CSFSF operation on flora and fauna is negligible.

4.6.1.2 Radiation Impact in Case of a Maximum Design-Basis Accident and a Beyond-Design-Basis Accident

As shown in Sections 3.6, 4.2.1.2, 4.2.1.3, and 4.2.1.4, accidents under review will not result in a substantial contamination of vegetation and topsoil, air, and aquatic environment at distances of more than 2 km from the CSFSF. No substantial radiation impacts on flora and fauna are expected due to the above.

4.6.1.3 Radiation Impact in Case of a Beyond-Design-Basis Accident

A beyond-design-basis (hypothetic) accident will not result in substantial contamination of vegetation and topsoil, air, and aquatic environment. No substantial radiation impacts on flora and fauna are expected due to the above.

4.6.1.4 Conclusions as a Result of Assessment of the Radiation Impact of the CSFSF on Flora and Fauna, Protected Sites during Operation

Therefore, radiation impacts on flora and fauna resulting from a BDBA shall be deemed acceptable.

4.6.2 Non-radiation Impact on Flora and Fauna, Protected Sites

Non-radiation factors, especially, natural succession processes dominate the development of biocenoses. For this reason, one should not expect any changes in the structures of natural populations as a result of radioactive discharges from the CSFSF equivalent to several tenths of a percent of the existing area contamination density. Clearing of the forest on the construction site (at an area of 8.6 hectares) and during the railroad construction (at an area of 7 hectares) to the storage facility is the major flora and fauna impact factor at normal conditions of the CSFSF construction.

Forest sections to be cleared are low-yield artificial pine plantations planted in 1960s on low-fertility dry sandy soils unsuitable for crop husbandry. In terms of forest growth conditions, these forests are categorized as dry coniferous forests with the lowest quality class among forests within the exclusion and compulsory resettlement zone. Dry coniferous forests within the exclusion and compulsory resettlement zone usually consist of low-value coniferous species and offer a meager fodder base for wildlife. In connection with this, felling the above-mentioned forest sections will have no significant impact on the species diversity of the phytocenoses and, accordingly, the faunal complexes of the surrounding areas.

The design calls for the compensation for forestry losses and the damage caused to the forest user in the total amount of UAH 2,835,873. (A copy of Letter of the State Agency of Ukraine for the Exclusion Zone Management No. 01-2043/1.4.2 of July 22, 2014, “Calculation of Forestry Losses” is provided in Annex A to Volume 16 Preparatory Works Design.

Felling of the forest for the construction of a 6.4 km long railway track can substantially restrict the movement of wild ungulate animals by disturbing their traditional migration routes. However, no substantial damage to the number and the species diversity of animals is expected due to the substantial number of animals in the local population, the elevated forest coverage percentage of the neighboring areas and the effectively natural-reserve conditions in the area.

The wildlife disturbance caused by the presence of people and equipment during construction and operation of the facility cannot have a substantial impact on the flora and fauna of the surrounding area, because harmful effects are limited to the site boundaries.

Since the impact of chemical air pollution, the acoustic impact, the impact of electric and electromagnetic fields is confined to site boundaries, they cannot affect the flora and fauna of the surrounding area and the NRF sites located at a considerable distance from the CSFSF site significantly.

The operation of the facilities, in terms of impact on flora, fauna, and protected sites, is acceptable.

4.7 Assessment of the Waste Impact During Operation

During operation of the CSFSF, radioactive and non-radioactive waste is produced. The waste is managed in the course of the CSFSF operation in accordance with Volume 3 Process, Part 2. Waste Management During Operation (571402.201.003-TH02).

4.7.1 Radioactive Waste (RW)

No high-level waste production is expected during operation of the CSFSF.

The amount and composition of the generated radioactive waste, and methods of managing the same have been considered in Sections 2, 3, and 4 of Volume 3.2 Process. Part 2. Waste Management During Operation.

The maximum single receipt of the LRW into the drain water tanks in case of the simultaneous receipt of the shower water and wash water from decontamination of the facilities is 3,774 dm³.

Water from the decontamination of rooms affected by an accident is the source of the generation of the liquid radioactive waste.

The estimated amount of SRW generated as a result of the CSFSF operation is 3.9 t/year. Ten KT-0.2a casks will be required to ship this amount of SRW for treatment.

4.7.2 Non-radioactive Waste

Production waste and consumption waste are the sources of non-radioactive waste during operation of the CSFSF.

The range, volumes, hazard classes of non-radioactive waste are set out in Annex Φ Φ, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The total amount of industrial waste produced during operation of the CSFSF is ~183.3 t, including:

- Hazard Class 1 ..... 0.06625 tonnes per year;
- Hazard Class 2 ..... 0.460 tonnes per year;
- Hazard Class 3 ..... 19.228 tonnes per year;
- Hazard Class 4 ..... 163.500 tonnes per year;

Ten MGBR-240 plastic waste containers will be used to collect solid non-radioactive waste within the area of buildings and structures.

Two KRL 1-90 containers will be used for the collection of spent mercury-filled lamps.

The waste will be handed over to third parties for processing or recycling as it accumulates; thus, all the technical solutions concerning the operation of the CSFSF rule out the potential of excess waste impact on all components of the environment.

5 ESTIMATED SOCIAL IMPACT OF THE PROJECTED ACTIVITY

5.1 Characteristics Of The Social Environment

Territory of the exclusion and compulsory resettlement zone is characterized by the radioactive contamination as a result of the Chernobyl accident in 1986, which made the land unusable for agricultural purposes and settlement [21].

In order to improve the radiation safety of the personnel and to prevent the spread of contamination [12], the exclusion and compulsory resettlement zone is divided into three radiation-regime zone [19], namely:

Zone I (the 10-kilometer zone) — the area within a 10-km radius around the Chernobyl Nuclear Power Plant. In this area, the radiation-hazardous works are carried out on the basis of programs agreed with the regulatory authorities in accordance with the requirements of the current normative-legal acts on radiation safety in Ukraine. If necessary, based on the results of radiation monitoring, the especially hazardous operations are carried out according to the special regulations as to the dosimetry. The radiation control is continuous.

Zone II (the buffer zone) — the territory from the border of the 10-kilometer zone to the outer edge of the exclusion zone (except the city of Chernobyl which is in Zone III). The works in this zone are carried out in accordance with the monthly schedules. The radiation control is continuous.

Zone III (the residential zone) — this zone comprises a part of the territory of Chernobyl where there are dormitories and administrative buildings, the public catering facilities and retail outlets, the social, cultural, health-care institutions, and the access roads.

The CSFSF production site is located within Zone I.

The location of the radiation regime zones is shown in Figure 5.1.

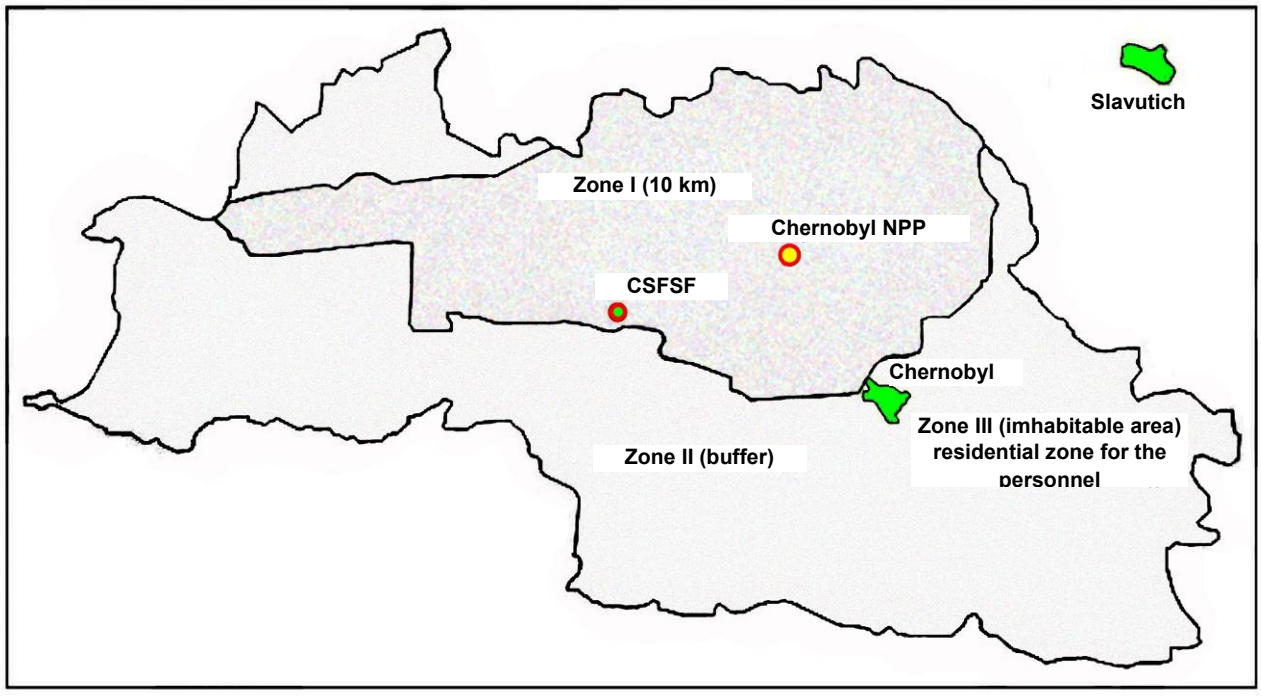

Figure 5.1. **The Boundaries Of The Radiation-Regime Zones Within The Exclusion And Compulsory Resettlement Zone**

5.2 The Radiation Impact On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone

5.2.1 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone

The radiation doses for the personnel and the public during normal operation of the CSFSF in the exclusion and compulsory resettlement zone can be achieved as a result of internal and external (by inhalation) exposure to the emission and external radiation from the SNF casks.

The annual dose from emissions during the normal operation of the CSFSF (emissions considered in Section 4.2.1.2) at a distance of 100 m from the site (the SZZ boundary) is 1.8 uSv/year. This value is based on the assumption that the exposure takes place in three ways — externally from the radioactive cloud, externally from the contaminated land surface, and internally by inhalation, because local foods are not to be used in the exclusion and compulsory resettlement zone.

It should be noted that the calculated dose from the emissions during normal operation of the CSFSF is based on the extremely conservative assumptions described in Sections 4.2.1.1 and 4.2.1.5, and in case of more realistic assumptions, the value will be by several orders of magnitude lower than the indicated above.

In order to assess the individual effective doses the calculation was performed according to the dose rate from the storage facilities completely filled with HI-STORM casks (project number is 458 pieces).

The dependence of the maximum possible (with regard for the actual location of the HI-STORM casks on the CSFSF site) individual effective dose (mSv/year), the distance from the CSFSF production site border is shown in Figure 5.2.

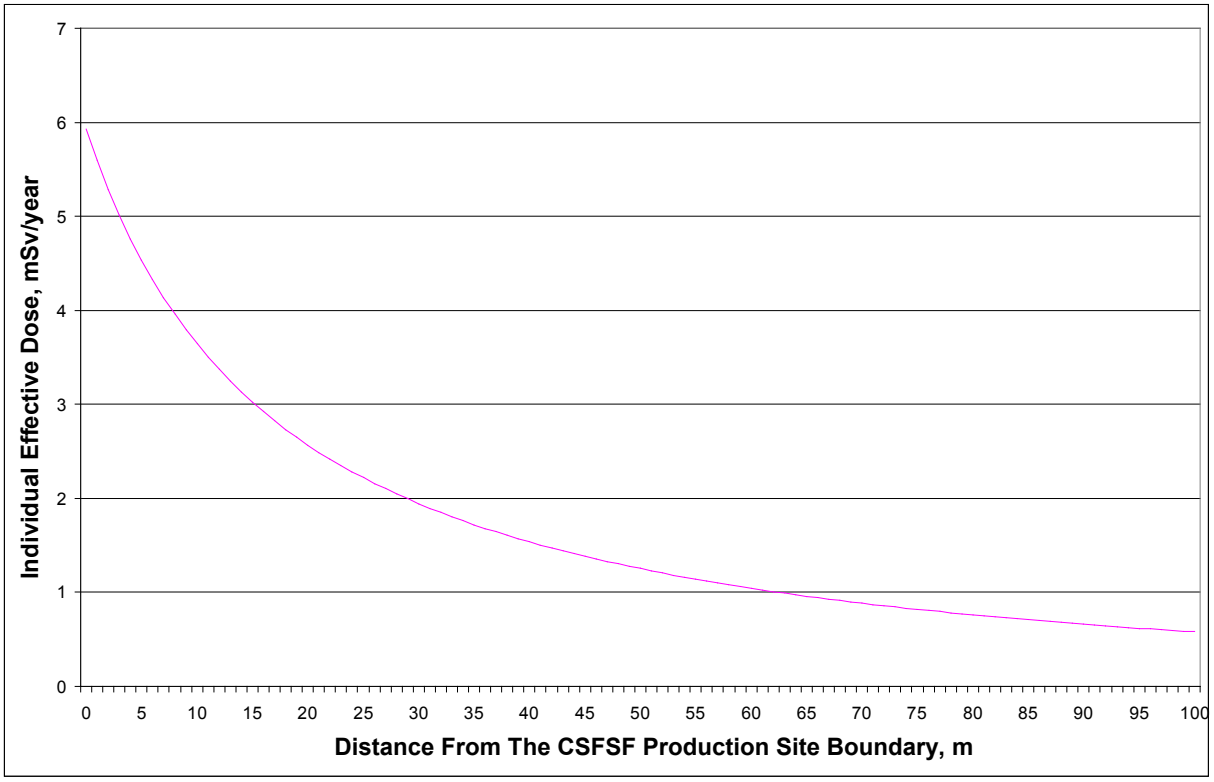

Figure STYLEREF 1 \s 5.2. **The Dependence Of The Individual Effective Dose (mSv/year) On The Distance From The CSFSF Production Site Boundary (m)**

Thus, under normal operating conditions of the CSFSF, the border, where the individual effective dose does not exceed 1 mSv/year, is the distance of about 70 m from the CSFSF border.

The radiation impact of the CSFSF on the population during normal operation is impossible due to the significant distance from the site to the possible deployment of the personnel.

The additional dose rates during normal operation of the CSFSF will not exceed 0.7 mSv/year at a distance of 100 m and further from the site boundaries. The said dose rate will be achieved after 50 yearsof operation of the CSFSF, if the maximum design storage capacity is 458 casks.

Thus, given that the design border of the SZZ CSFSF is located 100 m from the CSFSF site border, the radiation impact of the CSFSF in normal operation mode does not contradict the requirements of the existing NTD of Ukraine on radiation safety.

It should be noted that according to the report [47], the average dose rate from the external exposure in the immediate vicinity of the CSFSF production site is about 3.5 mSv/year.

In this case the reference level of external exposure of the personnel who may be exposed to radiation from the CSFSF in normal operation, in accordance with the control level [19], is 11 mSv/year.

According to the assessment, during normal operation, the radiation impact of the CSFSF on the personnel and the population of the exclusion and compulsory resettlement zone is acceptable.

5.2.2 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone With Maximum Consequences

The design accident with the maximum radiation consequences is considered in Section 3.6. The distribution of radioactive emission in the atmosphere at such an accident is considered in Section 4.2.1.3.

Table 5.1 and Figure 5.3 below contain the doses achieved in the accident at various distances from the CSFSF site for two types of weather conditions — with precipitation and without.

The values in Table 5.1 and in Figure 5.3are based on the assumption that the exposure takes place in three ways — externally from the radioactive cloud, externally from the contaminated land surface, and internally by inhalation, because local foods are not to be used in the exclusion and compulsory resettlement zone.

In addition, Table 5.2 contains a dose for the distance of 12 km distance (at the nearest border of the exclusion and compulsory resettlement zone), which is based on the assumption of local foods consumption.

Table 5.1. **Individual Effective Dose Without Regard For The Consumption Of Local Foods (at MDBA), Sv**

Weather	Distance m							
	100	600	1,000	2,000	5,000	12,000	13,000	20,000
Without precipitations	2.95E-07	1.82E-07	8.36E-08	2.73E-08	6.30E-09	1.44E-09	1.26E-09	5.79E-10
With precipitation	6.61E-07	6.70E-08	3.16E-08	1.23E-08	3.55E-09	9.55E-10	8.41E-10	3.85E-10

Table 5.2. **The Individual Effective Dose With Regard To All The Paths Of Exposure (at MDBA), Sv**

Weather	Distance m

	100	600	1,000	2,000	5,000	12,000	13,000	20,000
Without precipitations	3.12E-07	1.91E-07	8.85E-08	2.92E-08	6.64E-09	1.51E-09	1.31E-09	6.14E-10
With precipitation	7.02E-07	7.12E-08	3.31E-08	1.30E-08	3.81E-09	1.00E-09	9.01E-10	4.10E-10

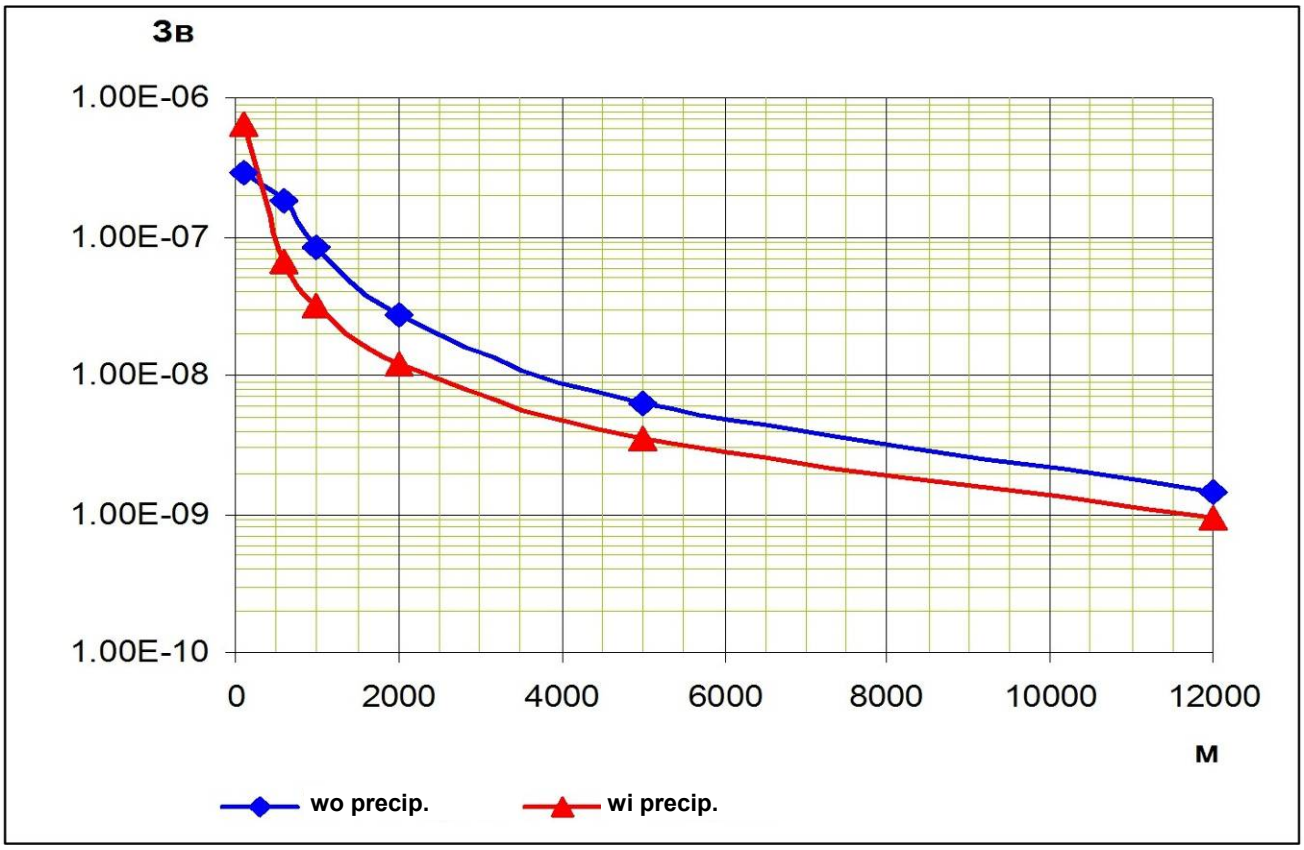

Figure 5.3. **The Dependence Of The Individual Effective Dose On The Distance Without Regard For The Local Food Consumption (at MDBA)**

As follows from the results, the possible radiation exposure as a result of the accident in question is well below the acceptable levels presented in DGN 6.6.1-6.5.001-98 [14] and the reference level [19], which implies that the radiation exposure of the personnel and the population in the exclusion and compulsory resettlement zone as a result of the accident is not significant.

5.2.3 The Radiation Load On The Personnel And The Population Within The Exclusion And Compulsory Resettlement Zone In Case Of Accident Beyond The Design Basis

The hypothetical accident beyond the design basis is considered in Section 3.6. The distribution of radioactive emission in the atmosphere at such an accident is considered in Section 4.2.1.4.

Table 5.3 and Figure 5.4 below contain the doses achieved in the accident at various distances from the CSFSF site for two cases — with precipitation and without.

As in the previous section, the exposure was assumed in three paths — from the radioactive cloud, the contaminated land surface (external), and internally through inhalation.

In addition, Table 5.4 contains a dose, which is based on the assumption of local foods consumption.

Table 5.3. **Individual Effective Dose Without Regard For The Consumption Of Local Foods (at BDBA), Sv**

Weather	Distance m							
	100	600	1,000	2,000	5,000	12,000	13,000	20,000
Without precipitations	1.15E-02	7.35E-03	3.34E-03	1.08E-03	2.51E-04	5.78E-05	5.02E-05	2.32E-05
With precipitation	2.38E-02	2.38E-03	1.11E-03	4.25E-04	1.19E-04	3.19E-05	2.77E-05	1.27E-05

Table 5.4. **The Individual Effective Dose With Regard To All The Paths Of Exposure (at BDBA), Sv**

Weather	Distance m							
	100	600	1,000	2,000	5,000	12,000	13,000	20,000
Without precipitations	2.12E-02	1.34E-02	6.23E-03	2.00E-03	4.67E-04	1.08E-04	9.34E-05	4.34E-05
With precipitation	4.69E-02	4.84E-03	2.30E-03	8.91E-04	2.56E-04	6.92E-05	6.10E-05	2.74E-05

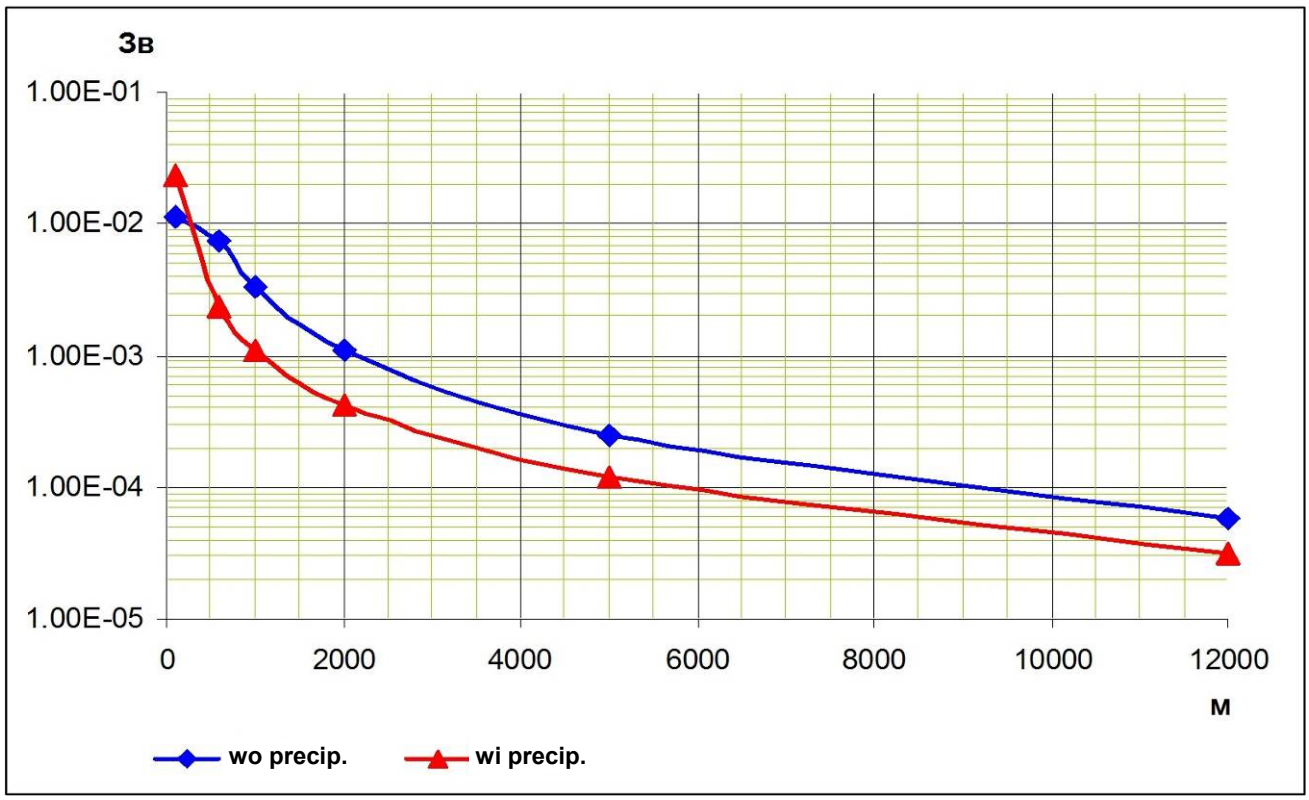

Figure 5.4. **The Dependence Of The Individual Effective Dose On The Distance Without Regard For The Local Food Consumption (at BDBA)**

The dose load, achieved as a result of a hypothetical accident, was compared to the levels of intervention/activities stipulated in DGN 6.6.1-6.5.001-98 [14].

From the conservative point of view, the minimum limit of 1 mSv within 14 days implying “restrictions on the outdoor stay for children” and the maximum limit of 50 mSv per year implying “evacuation” were used as justifying criteria.

As seen in Tables 5.3 and 5.4, the exposure load on the population as a result of the considered hypothetical accident will not exceed the established criteria beyond the inner boundary of the 10-km special radiation hazard area (2 km from the CSFSF), which means that the radiation impact on the population as a result of the accident is acceptable and does not require any countermeasures.

5.3 The Radiation Impact On The Social Environment Outside The Exclusion And Compulsory Resettlement Zone

During normal operation of the CSFSF, the release of radioactive substances is impossible due to the tightness of the MSC. The radiation doses outside the CSFSF area are determined by the dose rate of the external radiation from the spent fuel casks.

The radiation impact of the CSFSF outside the exclusion and compulsory resettlement zone during normal operation is negligible due to the significant distance from the site.

The values of additional radiation effects on the personnel working on the territory of the exclusion and compulsory resettlement zone and the population living on the adjacent territories are shown in Table 5.5.

Table 5.5. **Additional Dose Load On The Personnel And The Population Outside The Exclusion And Compulsory Resettlement Zone During Operation Of The CSFSF**

Site	Distance from the CSFSF km	The Limit Doses Of Radiation For The Population [14], mSv/year	Additional dose load during operation of the CSFSF	
			MDBA*, mSv	BDBA, mSv
The border of the exclusion and unconditional (obligatory) resettlement zone	13	1	1.51E-06	9.34E-02
Chernobyl	20	1 (“squatters”)	6.14E-07	4.34E-02

* The doses are calculated taking into account all the exposure pathways.

The analysis presented in Section 5.2 of this document as well as the data in Table 5.5 show that the radiation impact on the social environment during normal operation and in case of possible accident in the CSFSF will not lead to the violation of the the national standards for radiation safety.

5.4 Estimated Social Consequences Of Non-radiation Impact On The Air

Due to sufficient distance from the site to the the territories with the controlled levels of living environment, the pollutant emissions will not have negative impact on the health and lifestyle of the population of the surrounding areas and will not lead to adverse social consequences associated with the impact of the projected facilities on the air.

In terms of air pollution, the operation of the site is permissible.

5.5 Social Impact Assessment Related To Noise Exposure

The acoustic effects of the operation of the facility will be permanent and will accompany the activities on the site during the whole operation period.

Due to a large enough distance from the territories with the controlled quality of the environment, the site operation will not result in exceeding the sanitary and hygienic standards, and will have no adverse social impacts associated with noise exposure.

The estimates show that the noise discomfort zone of the technological equipment does not exceed the boundaries of the SPZ and will not affect the formation of further sound field. The noise emissions from the road transport on the parking lots and internal roads within the site as well as the rail transport servicing the CSFSF, is within the acceptable range.

The operation of the facilities, in terms of expected noise, is acceptable.

5.6 The Assessment Of The Social Impact Of The Electric And Electromagnetic Fields

The impact of electric and electromagnetic fields during operation of the facility will be permanent during the whole operation period.

Due to a large enough distance from the territories with the controlled quality of the environment, the site operation will not result in exceeding the sanitary and hygienic standards, and will have no adverse social impacts associated with the electric and electromagnetic fields.

The existing residential buildings are located outside the restricted zone. If the established restricted zones around the radio-engineering site are observed, the electromagnetic field is safe for human health.

The operation of the facilities, in terms of electric and electromagnetic impact, is acceptable.

5.7 Assessment Of Social Consequences Related To The Impact On Water Bodies

There is no non-radioactive impact on the aquatic environment during operation of the CSFSF.

The operation of the facilities, in terms of impact on water bodies, is acceptable.

5.8 Assessment Of Social Consequences Related To The Impact On Soils

There is no non-radioactive impact on the soils during operation of the CSFSF.

The operation of the facilities, in terms of impact on soils, is acceptable.

5.9 Assessment Of Social Consequences Related To The Impact On Flora, Fauna, And Reserved Sites

The impact of chemical air pollution, acoustic impact, the impact of electric and magnetic fields may not significantly affect the flora and fauna of the surrounding area, because the harmful effects are limited to the boundaries of the production site and the the NRF sites located at a considerable distance from the CSFSF site.

6 OPERATION OF THE FACILITIES, IN TERMS OF IMPACT ON FLORA, FAUNA, AND RESERVED SITES, IS ACCEPTABLE.ESTIMATED IMPACT OF THE PROJECTED ACTIVITY ON THE MAN-MADE ENVIRONMENT

A distinctive feature of the man-made environment in the exclusion and compulsory resettlement zone is the relative radiation impact of the adjacent sites on each other. This impact is mainly in the form of additional radioactive contamination of the air, infrastructure surfaces, workplaces, working clothes of the personnel of the neighboring enterprises, which can lead to additional exposure, including the possibility of exceeding the regulatory levels [19].

At present, on the territory of the exclusion and compulsory resettlement zone, there are more than 30 permanent enterprises, organizations and institutions of different departmental subordination, which are the objects of the man-made environment. The key objects of the man-made environment in the area under the impact of the proposed activity are listed in Figure 6.1.

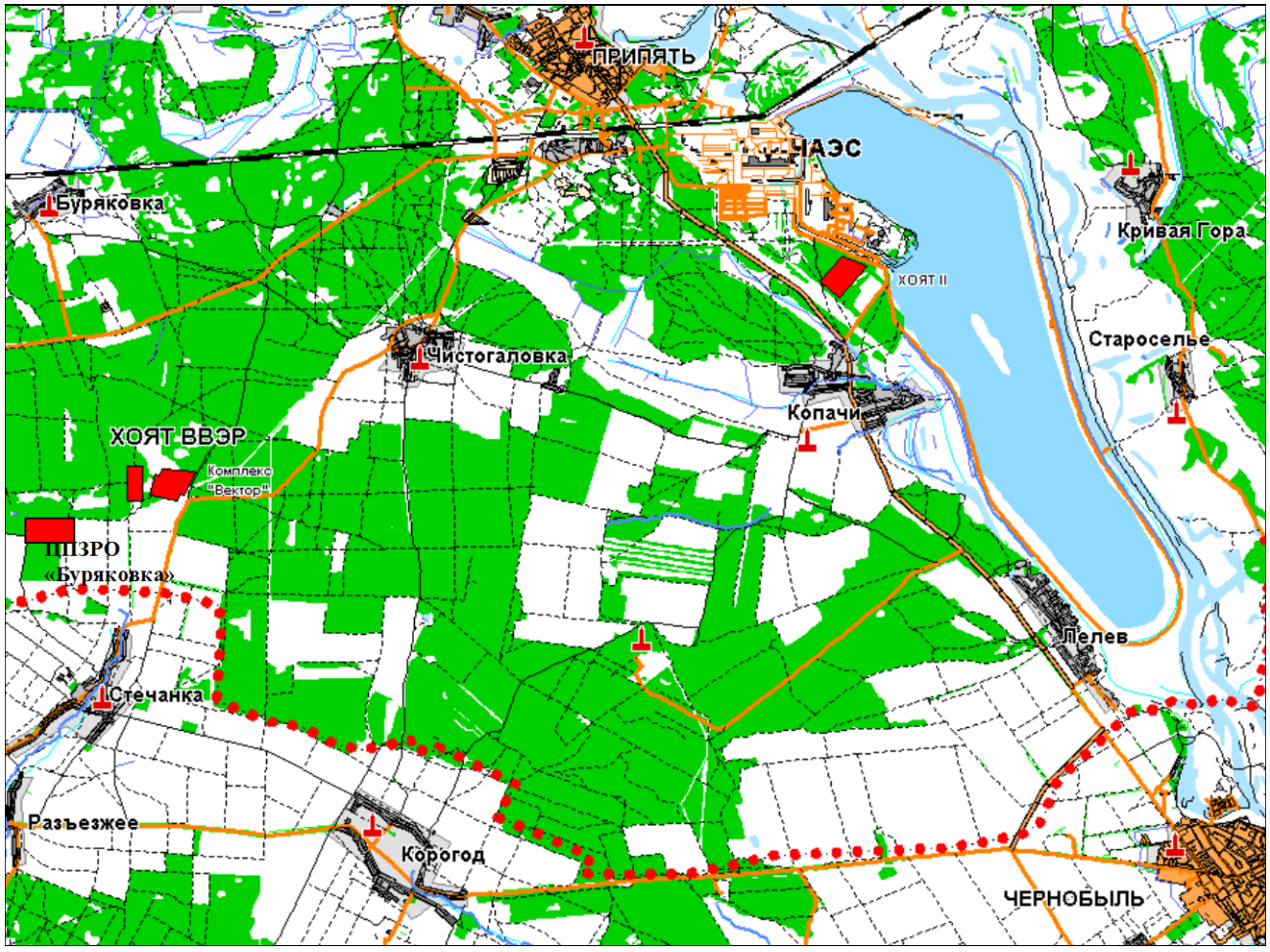

Figure 6.1. **The Map Of The Man-Made Objects In The Vicinity Of The CSFSF Site**

According to The State Agency of Ukraine For The Exclusion Zone Management (Letter № 01-2429/1.4.2 of 04.11.2015) the sites listed below are located within the 30 -kilometer radius of the CSFSF construction site.

1 The sources of fire hazard and accidents:

- the production and heating boiler-jouse SSE “Chornobyl NPP” (basic fuel — natural gas, backup fuel — fuel oil, 2 tanks 5,000 tons each);
- the transport department garage of SE “Department for Supply of the ChNPP Facilities”(gasoline tank of 33 t, diesel oil tank of 8 t);

- the garage of GSP “Chernobyl Special Plant” (hereinafter — GSP EIC) in the Chernobyl;
- the garage (convoy of specialized equipment) GSP EIC in Pripyat;
- Gas Station SSE EIC in Chernobyl (fuels storage capacity — 200 t);
- the central regional boiler-house of SSE EIC in Chernobyl (main fuel — natural gas, backup fuel — diesel oil, capacity of 2,000 t).

2 The sources of explosion hazard and accidents:

- “Vector” production facilities.

3 The roads that can be used to transport explosive materials being the sources of fire and explosion safety:

3.1 Motorway “Chernobyl — Kyiv”:

- transportation of petroleum products (1,500 t per year, 120–150 t per month);
- transportation of flammable and explosive mixtures of gases (oxygen, methane, propane, acetylene, etc.) — 18 t per year, up to 2 t per month.

3.2 Motorway “Chernobyl — ChNPP — Pripyat”:

- transportation of petroleum products, gas mixtures and other dangerous goods for production needs of SSE “Chornobyl NPP”, SE “UZFO Chernobyl”, SSE EIC, SSE TSPPRV and their subcontractors.

3.3 Motorway “ChNPP — NWBF Buryakovka”:

- transportation of radioactive waste (30–40 m³/day).

3.4 Motorway “KPP Lelev — KV Vector” (transportation of radioactive waste and sources of ionizing radiation).

3.5 Motorways in the exclusion zone used for the delivery of petroleum products to forestries VLG “Chernobyl Pushcha” and SSE FSC (up to 10 t per month).

On the territory adjacent to the CSFSF, there are no acting valid housing, communal, social and cultural facilities, as well as monuments of architecture, history and culture, protected by the state. In the areas of possible impact, there are no recreational areas and cultural landscapes.

The operation of the CSFSF will not change the existing conditions of operation of the enterprises, located nearby (Vector, ChNPP, etc.). The only factor of impact is the infrastructure of Vector complex and CheNPP, as well as the increasing of the radiation load on the personnel involved in the operation of the CSFSF (Table 6.1).

During normal operation of the CSFSF, the radiation impact is expected only to the personnel of "Vector", which is located in close proximity to the CSFSF production area. The maximum additional radiation doses for the personnel of "Vector" will not exceed 0.2 mSv/year, which does not exceed the reference levels even if put together with the existing dose. The radiation impact to the personnel of other enterprises listed in Table 6.1, is negligible due to the large distances from the CSFSF.

Table 6.1. **The Dose Loads On The Personnel Of The Enterprises In The Exclusion And Compulsory Resettlement Zone During Operation And Accidents At The CSFSF**

Enterprises and their subdivisions	Distance from the CSFSF, km	Reference levels [19], mSv/year	Existing radiation doses, mSv/year	Additional radiation doses,	
				MDBA*, mSv	BDBA*, mSv
Phase 1 and Phase 2 of GSP “Chernobyl”	12.7	14	3.01	1.26E-06	5.02E-02
LRWTP	13	14	3.01	1.26E-06	5.02E-02
SFSF-2	13.3	14	3.01	1.26E-06	5.02E-02

Enterprises and their subdivisions	Distance from the CSFSF, km	Reference levels [19], mSv/year	Existing radiation doses, mSv/year	Additional radiation doses,	
				MDBA*, mSv	BDBA*, mSv
NWBF “Vector” (enterprise under construction)	0.2	14	3.5	6,61E-04	10.00
Companies in Chernobyl	21	14	0.1–3.9	5.79E-07	2.32E-02
NWBF “Buryakovka”	1.1	14	1.64	8.36E-05	3.34

Since the planned activities will ensure safe operation of the CSFSF technological equipment, additional radiation exposure for the personnel in the exclusion and compulsory resettlement zone, caused by possible accidents at the CSSNF, will not result in exceeding the specified limit values for the exposure of personnel of the listed enterprises.

7 COMPREHENSIVE MEASURES TO ENSURING THE COMPLIANT ENVIRONMENT AND ITS SAFETY

7.1 Resource-Saving Activities

The following resource-saving activities are planned:

- non-utilization of the artesian water to regulate the room temperature — electric heating will be used instead;
- non-utilization of clean water for territory irrigation — the clarified rainwater will be used instead;
- the use of equipment (cranes, fans, pumps) consuming minimal electric power at the same technical specifications;
- the use of technology, which provides for placing the maximum number of SFAs in one MPC, which reduces the specific consumption of resources per SFA;
- the chosen altitude of the CSFSF (139 m) is expected to minimize the amount of excavation;
- the thermal protection of the buildings and structures in order to minimize heat losses.

7.2 Protective Measures

The construction of the CSFSF will include the measures to prevent or limit the impact on the geological environment (the impact of anthropogenic factors on the development of adverse natural processes):

- to improve the properties of the geological environment to compensate for the effects of exogenous processes;
- to prevent the deterioration of soils (reduction of compressibility and strength) in the base foundation structures;
- to prevent local flooding.

To prevent or limit the impacts of the anthropogenic factors on the geological environment during operation of the CSFSF, the following measures will be implemented during the construction:

- the area will be planned, paved and landscaped to fully eliminate erosion and aeolian processes;
- the bulk soils, if any, will be removed and replaced with stratified compacted soils;
- the drainage and surface runoff diversion.

To reduce the impact of geological factors on the CSFSF operation, the CSFSF will be designed with due regard to the seismic characteristics of the site.

To prevent the loss of control of spent nuclear fuel and the technological process in case of full loss of power supply to the CSFSF it is planned to develop a system of reliable power supply to the radiation monitoring, nuclear materials control and accounting, physical protection and fire alarm systems.

Besides:

- to reduce the likelihood and/or to eliminate the impact of the CSFSF on the environment in the initiating external circumstances, characteristic of this site, it is planned to erect reception facilities in accordance with the requirements of the PiN AE 5.6 [113] regarding the buildings of Category 1, in terms of loads and effects caused by the NPP according to their input in the nuclear and radiation safety;
- to protect the CSFSF structures from possible external fires, it is planned to build firebreaks along the CSFSF perimeter;

- to reduce/eliminate the environmental impact of accidents involving plane crashes on the CSFSF site, it is planned to use HI-STORM casks designed for the impact during plane crashes and, therefore, the accident would not lead to the release of radioactive substances into the environment.

Taking into account the ongoing activities, the development of adverse natural and man-made processes at the CSFSF site is not expected.

7.3 Rehabilitation Measures

The following rehabilitation measures are planned:

- removal of the radioactive contaminated soil from the NWBF “Buryakovka”;
- planning activities to improve the existing terrain and to reduce the exogenous processes in the area of the CSFSF;
- landscaping with planting shrubs;
- asphalting of roads and internal area in the restricted zone to reduce and/or prevent the penetration of radioactive substances into the soil;
- creation of the system of rainwater drainage on the production site with control and further treatment;
- decontamination of 18.2 ha in the exclusion zone during construction.

The CSFSF site landscaping map is shown in Annex X, Volume 12.2, Environmental Impact Assessment. Part 2. Annexes.

7.4 Compensatory Measures

These include as follows:

- the allocation of a part (3 %) of the investment in the construction of the CSFSF to the development of social facilities;
- the estimated operating costs of the CSFSF include the bonuses, allowances and rewards in addition to the tariff salaries in accordance with the current legislation of Ukraine;
- the construction cost estimate provides for additional funds for remuneration for the work on a rotational basis under the conditions of the Chernobyl exclusion zone, as regulated by the existing legislation;
- to compensate for the possible influence on the infrastructure of “Vector” facilities, it is planned to provide for additional artesian wells and reconstruction of Substation “Buryakovka”.

In addition, under the current legislation:

- the personnel of the CSFSF have the right to social and economic compensation for the adverse influence of ionizing radiation on their health;
- the citizens, whose health and property was damaged as a result of adverse impact of the ionizing radiation during the use of nuclear energy, are eligible for reimbursement in full;
- the personnel of nuclear units is subject to compulsory insurance against the risk of adverse effects of ionizing radiation at the expense of the licensee.

7.5 Security Measures

The security measures implied in the project include monitoring of the CSFSF production site and its zones of influence using the technological instrumentation and control systems.

7.5.1 Security Features Of The Instrumentation And Control System

The following design criteria were used as the basis for the instrumentation and control system:

- reliability (to be achieved through the use of high-reliability components and optimal system structure, and hardware-based fault detection capabilities);
- openness of the system (to be achieved by means of additional components and subsystems as well as by means of integration with other information systems).
- The instrumentation and control system will consists of the following local systems:
- transport and technological equipment monitoring and control, including the control of incoming casks;
- accounting and control of the fissile materials;
- storage process monitoring and control;
- radiation monitoring;
- heating and ventilation monitoring and control;
- special sewage monitoring and control;
- pressurised air monitoring and control;
- water supply monitoring and control;
- shower water monitoring and control;
- rain runoff monitoring and control;
- electricity supply monitoring and control;
- fire safety monitoring and control;
- communication.
- automated threat/emergency early detection and warning system (ASRVO).

The package design parameters control system, including the non-destructive monitoring of the metal and welded joints, is not a part of the monitoring and control system and is carried out at MPC and HI-STORM manufacturing facilities.

The non-destructive testing of welds in the MPC covers is carried out at the power unit before dispatch to the CSFSF and is beyond the scope of the monitoring and control system.

The monitoring of the properties of concrete during manufacture of HI-STORM casks at the CSFSF is also beyond the scope of the monitoring and control system and is carried out in the laboratory on the concrete factory.

The control and management of the transport and technological facilities are carried out independently in the place of production activities.

The technological solutions related to the monitoring and control system are set out in detail in Sections 3, 4, 5 of Volume 6 (571402, 201.006-AT), and the basic functions of the local monitoring and control systems for electricity supply and communication are described in further volumes (571402.201.005-ETR).

The monitoring and control system is a distributed information management system that consists of two levels of hierarchy:

- the upper level — the technical means of the man-machine interface (workstations with monitors, control server, archiving and documentation server, printers);
- the lower level — the technical means for data receiving and processing, remote control and interlocking, modular stations of the distributed IO systems, the analog and digital sensors, electric drives of stop and control valves and other mechanisms.

7.5.2 Control And Monitoring Systems Of The Transport And Technological Equipment

In the course of technological operations connected with the reception of HI-STAR shipping casks, the following procedures are planned:

- monitoring of the surface contamination of the transport casks;

- cask surface gamma and neutron radiation dose rate monitoring throughout the entire process chain.

The surface gamma and neutron radiation dose rate monitoring will be carried out using portable dosimeter-radiometers.

The information about the incoming transport casks and SFAs will be entered into the database of the fissile materials monitoring and control system.

The HI-STAR and HI-STORM casks preparation operations as well as the technological operations during MPC movement are performed partially by the main crane, partially manually. The main crane is operated locally by radio (from the central room of the reception facilities).

The HI-STORM storage casks are moved to the storage area using a vertical conveyor. The conveyor is controlled from the built-in control panel.

7.5.3 The Fissile Materials Control And Accounting System

The nuclear materials (NM) are subject to national and international control (IAEA) and inspections. Accounting and control of the nuclear materials is carried out according to the requirements of NP 306.7.122-2006 [114] with regard to specific procedures of receiving, preparation and storage of fuel, implemented on the site.

The nuclear power plant that supplies the spent fuel will provide data on the inventory and history of all the fuel assemblies (the degree of burnout, the holding time, the amount of fissile material, etc.). After loading and sealing the MPCs no other material reorganization is done at the reactor site.

The spent fuel assemblies are subjected to the measurement procedure in the key measurement point during loading into multipurpose casks before they arrive at the CSFSF.

Each MPC containing certain amount of spent nuclear fuel assemblies is a batch of nuclear material (MPC-31 comprises 31 assemblies of the VVER-1000 reactors, MPC-85 comprises 85 assemblies of the VVER-440 reactors). Before the MPCs leave the reception building, each of them is assigned a unique identification number. The nuclear material, leaving the reception building, will be under constant supervision. The inventory of nuclear material contained in the MPC is held at the entrance to the reception building.

The nuclear materials entering the storage facility will be counted using the computerized database for the nuclear fuel management.

The system includes a set of technical and organizational measures to ensure the continuous monitoring of the available nuclear materials (including record keeping, identification, and inventory of the incoming SFAs and HI-STORMs, archiving of the information). The data on incoming nuclear material are entered into the system through the CSFSF monitoring and control system. The central control and management board provides for a separate workspace for the control and accounting of the nuclear materials.

7.5.4 Storage Process Monitoring System

When storing the spent nuclear fuel in HI-STORM casks, the following procedures are performed:

- periodic HI-STORM surface temperature monitoring;
- continuous monitoring of the heat sink process during storage of the spent nuclear fuel in the HI-STORM casks in terms of the cooling air temperature at the outlet of each HI-STORM cask;
- periodic monitoring of the integrity of the containment and protective barriers;
- continuous monitoring of the radiation situation in the storage facility.

The information about the temperature and radiation status of the casks and the radiation situation in the storage facility is sent to the monitoring and control system remotely using radio

equipment installed on each HI-STORM cask. This information is displayed on the automatic process control workstation on the central control panel.

7.5.5 Radiation Monitoring System

The Radiation Monitoring System (RMS) is a subsystem of the monitoring and control system. The detailed description of the radiation monitoring system is given in Section 4, Volume 6, Monitoring And Control System (571402.201.006-SCU), namely:

- the RMS belongs to the system, it is important for security.
- The CSFSF RMS contains the following components:
- process radiation monitoring (PRM);
- radiation dosimetric monitoring (RDM);
- individual dosimetric monitoring (IDM);
- environmental radiation monitoring (ERM);
- radiation monitoring to prevent the spread of radioactive contamination.

TheERM subsystem monitors the sources of possible radioactive environmental pollution.

The following parameters are monitored:

- the activity and radionuclide composition of the gas-aerosol emissions into the atmosphere through the vent stack;
- the radiation situation at the CSFSF production site;
- the activity and radionuclide composition of the wastewater;
- the activity and radionuclide composition of the water monitoring wells.
- The activity of the emissions into the atmosphere is monitored by the alpha- and beta-aerosols.

The radiation situation in the production area of the CSFSF is carried out by the following means:

- the ARMS channels using the stationary gamma-radiation dose rate detecting units installed on the storage site;
- the permanently installed emergency aerosols volumetric activity detection units;
- portable devices;
- sampling for laboratory analysis.

The information characterizing the radiation situation at the CSFSF is transmitted to the existing automated radiation monitoring system (ARMS) of the exclusion zone. Location of the ARMS control stations is shown in Figure 7.1.

The ARMS is designed for continuous monitoring of the radiation situation in the area under control in all the operating modes, including the design basis (DBA) and beyond design basis (BDBA) accidents, as well as during decommissioning.

In the normal operation, the ARMS is designed to receive and process the information about the radiation situation in the area under monitoring for the development of operational conclusions on the conformity of the radiation situation with regulatory requirements.

In case of design basis or beyond design basis accident, the ARMS receives and processes the information on the changes in the radiation situation in the area under control to make recommendations on elimination of the consequences of the radiation accident.

To monitoring of the meteorological parameters is done using the meteorological mast installed in the storage area. Information on the measured meteorological parameters is also used by other systems (temperature control in the storage area, ASRVO system).

The radiation monitoring of the activity and radionuclide composition of the water discharged into the river (rainwater drainage) and the water discharged to the site KP “Vector” (industrial and

domestic sewage) is carried out by the laboratory in the course of routine sampling and objective assessment.

To control the leakage of radioactive liquids into the soil and to prevent penetration into the groundwater, the monitoring is done using the groundwater monitoring wells located along the CSFSF perimeter. The monitoring is carried out by sampling followed by analysis in the radiation control laboratory.

7.5.6 Radioactive Drain Monitoring And Control

The system provides for the monitoring and control of the technological radioactive sewage system equipment located in the reception building. The monitoring and control is both local and fro the Central Control Board.

The sewage water activity in terms of gamma-radiation dose rate is monitored using the stationary sensors and sampling procedure followed by analysis in the laboratory before the ware leaves the facility.

7.5.7 Shower Water Monitoring And Control

The system provides for the monitoring and control of the technological shower water system equipment located in the reception building. The monitoring and control is both local and fro the Central Control Board.

The shower water activity in terms of dose rate is monitored in the test tanks using the sampling procedure followed by analysis in the laboratory.

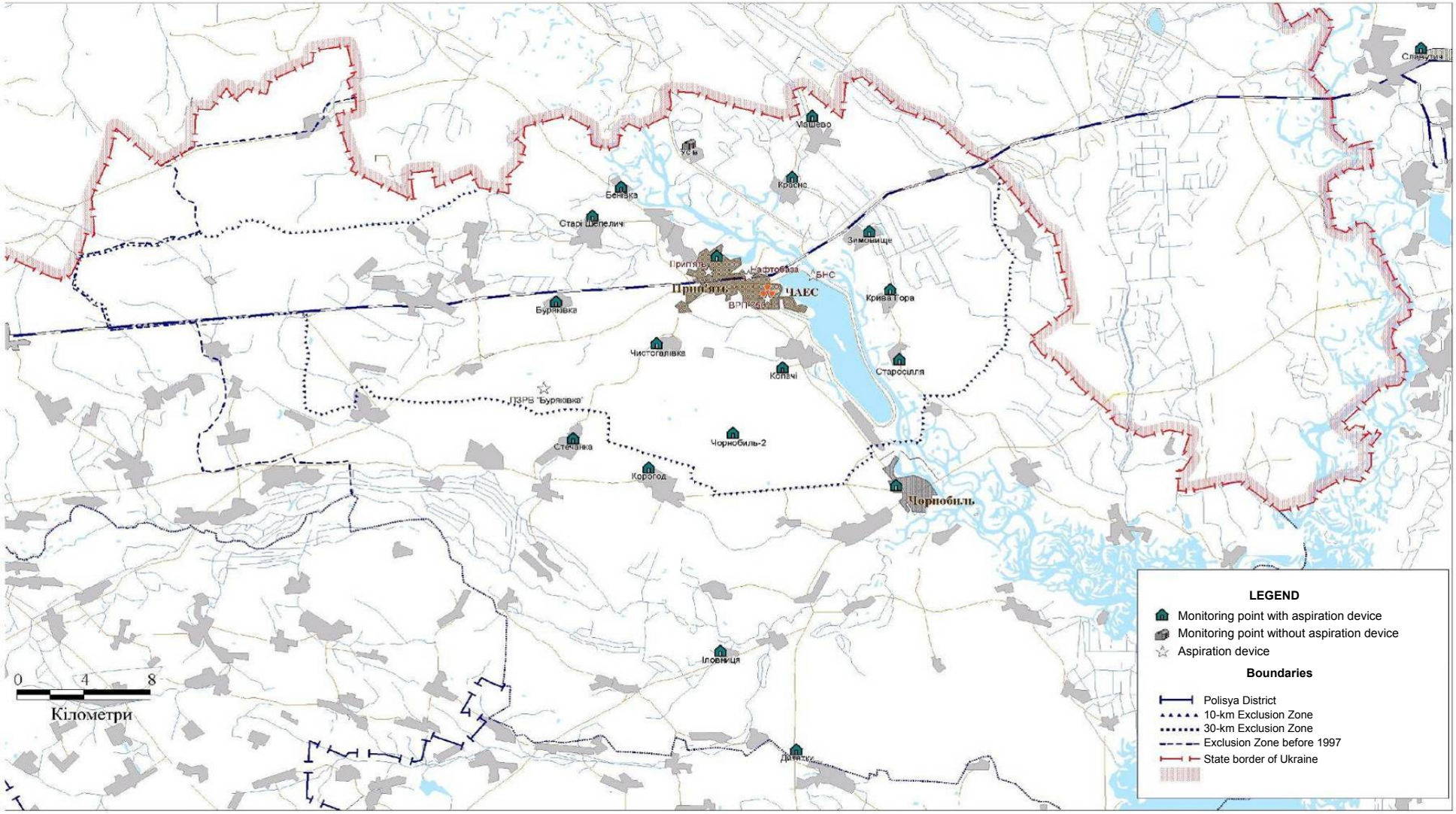

Figure 7.1. **Location Of The ARMS Radiation-ecological Monitoring Stations In The Exclusion And Compulsory Resettlement Zone**

7.5.8 Heating, Ventilation And Air Conditioning Control and Monitoring Systems

The required climatic conditions in the premises of the zone of strict and free regimes of the reception building and auxiliary structures is maintained automatically.

The heating and ventilation monitoring and control systems are installed in the following buildings:

- the reception building;
- the technical maintenance building with the MPC warehouse;
- the administrative building;
- the electrical equipment building;
- the garage;
- the guard building;
- Checkpoint-1;
- Checkpoint-2;
- fire water pump-house.

The ventilation units are controlled from:

- the local control boards, supplied with the main ventilation equipment and located in the immediate vicinity of the units;
- the central monitoring and control board.

The heating systems are controlled locally depending on the air temperature in the premises where the electric heaters are installed.

The equipment in the local HVAC control boards performs the following functions:

- air temperature control in the premises;
- air flow management;
- heating to prevent freezing;
- filter control.

7.5.9 Pressurised Air Monitoring And Control System

The system automatically monitors and controls the supply of the compressed air by compressors. The unit is controlled from the local control board supplied with the compressor. The central control board outputs signals “System Operating” and the generalized “Fault” signal.

7.5.10 Fire Safety Monitoring And Control System

The fire safety system provides for:

- gas fire suppression;
- water fire extinguishing.

The monitoring and control system outputs the following signals to the central control board:

- the signal on the operation of the fire pump (on, off, fault);
- the water level in the fire reservoirs (maximum level and refill level).

7.5.11 The System Of Monitoring Wells

In order to monitor changes of the hydrogeological situation in the area of the CSFSF a network of monitoring wells was established.

According to the report [45], six wells have been drilled down to the first aquifer (Wells 8514, 8517, 8520/1, 8532, 8561 and 8563/1) and one well — down to the vadose water (Well 8534/1).

The map of monitoring wells in the area of the CSFSF is shown in Annex У, Volume 12.2, Environmental Impact Assessment. Part 2. Annexes.

7.5.12 Automated Threat/Emergency Early Detection And Warning System

The CSFSF design implies the use of the automated threat/emergency early detection and warning system (ASRVO).

The automated threat/emergency early detection and warning system (ASRVO) performs the following functions in case of emergency or threat:

- automatic informing of decision-makers (personnel in charge of actions to prevent the emergency situations or minimize the adverse effects in case of their occurrence);
- on command from the operator, the system notifies the regional central warning system and send the warning identifier (formal accident codes) of the expected emergency situation scenario, and in the absence of the operator response, the automatic transmission of the identifier of the worst-case scenario;
- on command of the operator (if there is no response from the operator, automatically), warns the employees about the threat or emergency using the local alarm system.

The main component of the ASRVO is the ASRVO Control Board, which is located in the premises of the CSFSF central control post and manages the terminal systems, the reception and processing of the information from the CSFSF control system and the fire alarm system PPKP SPS with automatic transmission of the preset thresholds to the central monitoring server (on the side of the centralized regional warning system).

The ASRVO control board activates the alarm, alerts the plant personnel, the officials, and the population about the emergency. All incoming and outgoing information and the operator's actions are displayed on the screen in the event log.

The detailed description of the automated threat/emergency early detection and warning system (ASRVO) is set out in Section 5 of Volume 6 (571402.201.006-SCU).

7.6 Summary Of The Monitoring And Post-Project Analysis Programmes

The organization and performance of the environmental monitoring within the exclusion and compulsory resettlement zone using a combination of influence factors is entrusted to the State Agency of Ukraine for the Exclusion Zone Management.

In terms of geography, the supervised area of the CSFSF (600-m radius), including the SPZ (within 100 m around the CSSNF production site) and the production area itself belong to Radiation Regime Zone 1 of the exclusion and compulsory resettlement zone (the territory within 10-km radius around the Chernobyl NPP).

In this area, the radiation-hazardous works are carried out on the basis of programs agreed with the regulatory authorities in accordance with the requirements of the current normative-legal acts on radiation safety in Ukraine. The strict radiation monitoring procedures are implemented in this zone.

The production monitoring program implemented within the CSFSF production site and its SPZ are shown in Table 7.1.

A consolidated list of project activities in environmental protection is set out in Table 7.2.

Table 7.1. **The CSFSF Production Monitoring Program**

The environmental factor (recipient, monitoring object) under the impact	Production process, works, source of exposure	The object of environmental monitoring	Methods of control	Monitoring point	Frequency	Number of samples / measurements
Atmospheric air	Atmospheric air	The radioactive substances content in the air during the CSFSF operational. Aerosols, RN content	Instruction 38E-CRB, portable aspiration unit DC, ACPA-РСП-20ДР1,8-30 filter, at the height of 1 m above the ground surface, and using other gas analysers also when required by the specific laboratory according to its capabilities. Beta-activity is determined in the laboratory of CRZ ChNPP using the radiometer KRK-1, detection module BDIB-01.	Design points on the boundary of the SPZ Points coordinates: No. / X (m) / Y (m) (001) 40703.50 424458.50 (002) 40546.26 424651.41 (003) 40546.00 424923.91 (004) 40546.00 425196.42 (005) 40635.44 425421.91 (006) 40878.51 425460.00 (007) 40962.12 425214.56 (008) 40962.44 424942.06 (009) 41058.14 424689.62 (010) 40975.29 424464.63	In accordance with the approved procedures	According to the agreed schedule
Atmospheric air	Atmospheric air	The contaminating substances content in the air during the CSFSF operational. nitrogen dioxide (NO_2); sulfur dioxide (SO_2); carbon oxides (CO); benz(a)pyrene; suspended solids, undifferentiated composition.	To be established by the laboratory performing the measurement of contaminating substances in the air.	Design points on the boundary of the SPZ Points coordinates: No. / X (m) / Y (m) (001) 40703.50 424458.50 (002) 40546.26 424651.41 (003) 40546.00 424923.91 (004) 40546.00 425196.42 (005) 40635.44 425421.91 (006) 40878.51 425460.00 (007) 40962.12 425214.56 (008) 40962.44 424942.06 (009) 41058.14 424689.62 (010) 40975.29 424464.63	In accordance with the approved procedures	According to the agreed schedule
Atmospheric air	Atmospheric air	Noise level monitoring	Noise level monitoring in the recommended reference points using two parameters: • the sound pressure levels in the octave bands with the average compound frequencies of 31.5–8000 Hz; • the equivalent sound level (sound level), adjusted for scale “A”.	Design points on the boundary of the SPZ Points coordinates: No. / X (m) / Y (m) (001) 40703.50 424458.50 (002) 40546.26 424651.41 (003) 40546.00 424923.91 (004) 40546.00 425196.42 (005) 40635.44 425421.91 (006) 40878.51 425460.00 (007) 40962.12 425214.56 (008) 40962.44 424942.06 (009) 41058.14 424689.62 (010) 40975.29 424464.63	In accordance with the approved procedures	According to the agreed schedule
Surface boundary layer of the atmosphere	Surface boundary layer of the atmosphere	Ambient dose equivalent rate (DER) of the gamma radiation	Dosimeter-radiometer MKS-07 with the gamma radiation detecting unit installed at the height of 1 m and 0.03–0.1 m, the travel speed under 2 km/h.	The territory of the CSFSF production site	In accordance with the approved procedures	The frequency of measurement is established by “The Regulations Of Radiation Monitoring During Operation Of The CSFSF”
Surface boundary layer of the atmosphere	Surface boundary layer of the atmosphere	Flux surface density of the beta radiation particles	Dosimeter-radiometer MKS-07 with the beta radiation detecting unit installed at the height of 0.01–0.03 m above the ground surface with open and closed beta detector window.	The territory of the CSFSF production site	In accordance with the approved procedures	The frequency of measurement is established by “The Regulations Of Radiation Monitoring During Operation Of The CSFSF”

The environmental factor (recipient, monitoring object) under the impact	Production process, works, source of exposure	The object of environmental monitoring	Methods of control	Monitoring point	Frequency	Number of samples / measurements
Surface boundary layer of the atmosphere	Surface boundary layer of the atmosphere	The content of inorganic dust during the operation of the concrete plant	To be established by the laboratory performing the measurement of contaminating substances in the air.	Border between the CSFSF SPZ and the CE “Vector”, twenty silo heights	During silo loading and taking into account the concrete plant operation mode	According to the frequency of silo loading
Water environment, personnel	Water environment, personnel	LRW activity (decontamination water of the central room, ventilation systems, waters after the motor transport washing)	Sampling from the LRW receiving tank with the subsequent monitoring of the activity and composition of the samples in the radiochemical laboratory (Room 107) according to the licensed methods	The LRW receiving tank with the special sampling port	As the LRW tanks are filled	The number of samples is determined by the chosen method
Water environment, personnel	Water environment, personnel	The radiological pollution, the exceeding of the MPC (technological effluents in the strict regime zone, rainwater)	Sampling with subsequent determination of the activity using the licensed laboratory procedures	The monitoring tanks installed in Room 110, rainwater tank	As the tanks are filled	Before the discharge of the wastewater into the external sewage system or rainwater discharge channel to the River Marianivka
The water environment during the CSFSF operation	The water environment during the CSFSF operation	The contamination of the effluents with the petroleum products (rain runoff from the refueling sites and railway embankments)	Manual sampling through the WWTP service chambers with subsequent determination of the composition of the samples in the radiochemical laboratory using the licensed methods	WWTP service chamber	Every six months (when filling the storage tanks)	Before discharge of the effluents into the external channel network
The water environment during the concrete plant operation	The water environment during the concrete plant operation	The degree of pollution of the wash water in the recycling unit before the discharge into the storm sewer	The parameters of the wash water must meet the following requirements: • suspended substances — 500 mg/l; • salt content — 250 mg/l; • oil products — 10 mg/l; • COD of the filtered sample — 100 mg/l; • BOD of the filtered sample — 20 mg/l; • pH — 6.5–8.5; specific complexes — no.	Before the discharged into storm alarm system well	Depending on the recycling unit performance	According to the approved schedule

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Table 7.2. **Consolidated List Of Project Activities In Environmental Protection**

Production process, works, source of exposure	Anthropogenic factors of significant effect	The environmental factor (recipient, protected object) under the impact	Project activities in environmental protection	Section of Project Documentation, providing for the activities
1. Site preparation, construction of the CSFSF, sources of pollutant emissions, distribution during earthworks, and secondary dusting during the MPC management using HI-STORMs	Chemical contamination of the air	Population, vegetation, fauna	The ban on burning of waste and debris on the construction site and the adjacent area. The ban on dumping of waste and debris from floors of buildings and structures without enclosed chutes and receiving bins.	Volume 11 (571402.201.011-POS) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
			Compliance of the construction and road machines with the regulatory requirements as to the content of pollutants in the exhaust gases (equipment that does not meet the level of emission is not allowed). Monitoring technical condition of the road and construction machinery. When choosing the contractors for the construction, the companies using the machinery and equipment that meets the standards for emission of pollutants, adopted by the EU, US and Japan should be preferred.	
			Loading and unloading of vehicles should be carried out on-site with the engine off.	
			The maximum contamination rate for the railway platform is 190 Bq/year — this activity will not increase the radiation impact on the environment.	Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
2. Preparation of the CSFSF construction site, earthworks,	exogenous processes, reduced compressibility and durability, local flooding	The geological environment, soil	The measures to minimize the influence of the technogenic factors on the development of adverse natural processes	Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
3. Preparation of the CSFSF construction site	Chemical contamination of the air	Air, soil, vegetation	The vehicles used to carry goods in bulk (natural stone, sand, sand-and-gravel micture, pebbles, gravel, crushed stone, concrete blocks, soil, construction and demolition waste, household waste, garbage, etc.) must be equipped with tented bodies to prevent spillage and dusting during transportation. In order to avoid dusting in dry days, the soil in the places of excavations and earthworks should be watered daily 15–30 minutes prior to the beginning of works, as well as after their completion.	Volume 16.1 (571402.201.016-PPR01)
4. Site preparation, construction of the CSFSF	Chemical pollution of the air, RN emission	Water environment, vegetation, soil	Obtaining permits for emissions of pollutants during the construction phase. Registration of the construction contractors as payers for the adverse environmental impact. Payments for the air pollution.	Volume 11 (571402.201.011-POS)
5. Site preparation, construction of the CSFSF	Noise pollution	social environment, personnel	Performance of works in the areas allocated by the master plan. Monitoring the technical condition of the engines and exhaust systems of vehicles, bulldozers and excavators in order to prevent the operation of non-compliant machinery producing high noise. The ban on the operation of the automotive and construction machinery with open bonnets. The ban on parking vehicles and automobiles, as well as bulldozers and excavators with running engines when not in use.	Volume 11 (571402.201.011-POS)
6. Site preparation, construction of the CSFSF, noise sources	Noise pollution	Social environment, personnel	Maintaining the roads and entrances within the construction site to provide for the passage of automotive and construction equipment without excess load on the engines, as well as without vibrations of bodies and goods. Organization of construction in strict accordance with the planned technological and technical decisions of the project. Carrying out works in accordance with good practice, compliance with the rules of work, engagement of the personnel with the necessary qualifications. When choosing the contractors for the construction, the companies using the machinery and equipment that meets the emission standards adopted by the EU, US and Japan should be preferred.	Volume 11 (571402.201.011-POS)
7. Operation of the CSFSF, noise sources	Noise pollution	Social environment, personnel	Installation of noisy equipment (pumps, compressors, fans, transformers, etc.) in separate buildings and technical rooms. Using the enclosing structures and technical rooms with good sound-insulating properties — at least 20 dBA. The use of intermediate ventilation chambers in the ventilation air supply systems. Installation of flexible connections between fans and ducts. Installation of technological and ventilation equipment on vibration isolators and plates.	Volume 4.1 (571402.201.004-AS01) Volume 4.2 (571402.201.004-AS02) Volume 5 (571402.201.005-ERT) Volume 6 (571402.201.006-SKU) Volume 7 (571402.201.007-OV) Volume 8 (571402.201.008-VK) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)

Production process, works, source of exposure	Anthropogenic factors of significant effect	The environmental factor (recipient, protected object) under the impact	Project activities in environmental protection	Section of Project Documentation, providing for the activities
8. Site preparation, CSFSF, water supply to the construction site	The quality of water resources	Personnel	Ensuring compliance with SanPiN 2.2.1.1312-03 during the delivery of water to the site of construction	Volume 8 (571402.201.008-VK) Volume 11 (571402.201.011-POS)
9. Operation of the CSFSF, production and accumulation of waste	Environmental pollution associated with the accumulation of waste on the site	Atmospheric air, surface and ground water, soil	Organization and arrangement of waste storage sites in accordance with the applicable environmental, sanitary, and fire norms.	Volume 3.2 (571402.201.003-TH02) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
10. Operation of the CSFSF, production and accumulation of hazardous waste	Health hazards in case of improper handling of hazardous waste	Personnel, animals, birds	Equipment of the waste storage sites with lockable containers, including the containers that provide protection from animals and birds. Restricting the access of the personnel to the hazardous waste and raising awareness of the dangers posed by the waste. Training under specially developed programs, including the handling of hazardous waste, waste collection and sorting. Arrangements for production control in the field of waste management, including regular briefings with the responsible persons. Keeping the “Waste Movement Logs” in accordance with the actual movement of waste.	Volume 3.2 (571402.201.003-TH02) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
11. Operation of the CSFSF, waste production and disposal on the external sites	Alienation of land resources and environmental pollution related to unauthorized disposal of waste	The land, as a spatial resource, the atmospheric air, the surface and underground waters, soil	Concluding contracts with the specialized organizations holding valid licenses for hazardous waste management and disposal in accordance with these contracts. Procurement of the “waste disposal limits” in accordance with the law. Payment for the waste disposal at the landfill.	Volume 3.2 (571402.201.003-TH02) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
12. Operation of the CSFSF, water supply	Quality and consumption of the water resources	Water resources, personnel	Planned measures: • non-utilization of the artesian water to regulate the room temperature — electric heating will be used instead; • non-utilization of clean water for territory irrigation — the clarified rainwater will be used instead;	Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
13. Site preparation, construction of the CSFSF, area cleaning, area layout	Rehabilitation of the soil properties, landscaping	Land as a spatial resource, soil, geological environment, surface waters, personnel	Planned measures: • removal of the radioactive contaminated soil from the NWBF “Buryakovka”; • planning activities to improve the existing terrain and to reduce the exogenous processes in the area of the CSFSF; • landscaping with planting shrubs; • asphalting of roads and internal area in the restricted zone to reduce and/or prevent the penetration of radioactive substances into the soil; • creation of the system of rainwater drainage on the production site with control and further treatment; • decontamination of 18.2 ha in the exclusion zone during construction.	Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
14. Operation of the CSFSF, technological operations, sources of radiation	The dose rate of the gamma and neutrino emission	Air environment, personnel	In the course of technological operations connected with the reception of HI-STAR shipping casks, the following procedures are planned: • monitoring of the surface contamination of the transport casks; • cask surface gamma and neutron radiation dose rate monitoring throughout the entire process chain.	Volume 6 (571402.201.006-SKU) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
15. Operation of the CSFSF, spent fuel storage, HI-STORM surface	The radiation situation in the storage facility	Air environment, personnel	When storing the spent nuclear fuel in HI-STORM casks, the following procedures are performed: • periodic HI-STORM surface temperature monitoring; • continuous monitoring of the heat sink process during storage of the spent nuclear fuel in the HI-STORM casks in terms of the cooling air temperature at the outlet of each HI-STORM cask; • periodic monitoring of the integrity of the containment and protective barriers; • continuous monitoring of the radiation situation in the storage facility.	Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
16. Operation of the CSFSF, petrol station	Gasoline and diesel fuel vapours	Air environment, personnel	At the petrol station, the following measurements are carried out: • concentrations of explosive substances in the air and gasoline and diesel fuel blends; • levels of gasoline and diesel fuel in the tanks; • pressure in the tanks;	Volume 6 (571402.201.006-SKU) Volume 12.1 (571402.201.012-OVOS01)

Production process, works, source of exposure	Anthropogenic factors of significant effect	The environmental factor (recipient, protected object) under the impact	Project activities in environmental protection	Section of Project Documentation, providing for the activities
			• temperature of gasoline and diesel fuel in the tanks. The measurement data is transmitted to the following recipients: • the control room of the petrol station operator, located in the reception building; • the automated threat/emergency early detection and warning system (ASRVO) and further transmission to the separate workstation in central control room.	Volume 12.2 (571402.201.012-OVOS02)
17. Operation of the CSFSF, ASRVO system, emergencies	Emergency	Environment, personnel	The CSFSF design implies the use of the automated threat/emergency early detection and warning system (ASRVO). The automated threat/emergency early detection and warning system (ASRVO) performs the following functions in case of emergency or threat: • automatic informing of decision-makers (personnel in charge of actions to prevent the emergency situations or minimize the adverse effects in case of their occurrence); • on command from the operator, the system notifies the regional central warning system and send the warning identifier (formal accident codes) of the expected emergency situation scenario, and in the absence of the operator response, the automatic transmission of the identifier of the worst-case scenario; • on command of the operator (if there is no response from the operator, automatically), warns the employees about the threat or emergency using the local alarm system.	Volume 6 (571402.201.006-SKU) Volume 12.1 (571402.201.012-OVOS01) Volume 12.2 (571402.201.012-OVOS02)
18. Operation of the CSFSF, collection and transportation of LRW (decontamination water)	LRW activity	Water environment, personnel	Collection and transportation of LRW at the CSFSF is performed as described below. During the works performance, the decontamination water drains by gravity to the drainage pits located in the central room (Room 114) and in the tanks control rooms (110), the drain water tanks (109), and the “dirty” workshop (104). The drainage channels and pits are lined with stainless steel. The decontamination water after washing of the vehicles are pumped from Room 110 by the pipeline with the diameter of 57x3 нж, laid in the channel, to the inspection pit sump located in Room 103 of the garage. The drainage sumps are equipped with the submersible drainage pumps with floating switches. They pump the liquid radioactive waste into one of the drain water tanks. For the removal of decontamination water, at Point 11,100 in the exhaust ventilation systems room (402), there is a sump connected by pipelines to the drain water tanks. In order to assess the activity of the LRW accumulated in the reception tank, there is a sampling port for sampling and analysis of the drain water in the radiochemical laboratory (Room 107). The laboratory analyses the samples of drain water sent for recycling for the isotopic composition, activity, and chemical composition. The results are use as the basis for the LRW batch passport. Then, and caused the the LRW is transported to the Chernobyl NPP.	Volume 3.2 (571402.201.003-TH02)

7.7 Estimated Environmental Impact Of The Projected Activity

The environmental risk is the risk of adverse changes in the environment or the effects of such changes, resulting from the negative human impact on the environment.

7.7.1 Radiation Contamination Risk Assessment

The analysis made in the previous sections of this EIA, showed that:

- the impact of the CSFSF on the natural, technological and social environment consists mainly in the radiation exposure;
- the impact on the environment will not exceed the current state of the environment and can be considered acceptable (according to Reference Levels [19]);
- under normal conditions of construction and operation of the CSFSF, the impact on the man-made environment will not exceed the hygienic standards established for the exclusion and compulsory resettlement zone;
- under normal conditions of construction and operation of the CSFSF, the impact on the social environment will not exceed the hygienic standards established by DGN 6.6.1-6.5.001-98 [14].

DGN 6.6.1-6.5.061-2000 [15] provides for the concept of “acceptable risk”, which means the amount of risk inherent in the dose limits for the personnel established by DGN 6.6.1-6.5.001-98 [14], as well as the dose limits (in terms of practice) and threshold dose levels for cessation of intervention for the population.

DGN 6.6.1-6.5.061-2000 [15] provides for the following normalized values of acceptable risk:

- for personnel ..... 2×10^{-4} year^{-1};
- for population ..... 5×10^{-5} year^{-1}.

The negligible risk, as provided for in DGN 6.6.1-6.5.061-2000 [15], is the risk of 5×10^{-7} year^{-1}.

As a result of the foregoing, it can be assumed that in compliance with the normative values of impact of the CSFSF under normal operating conditions, the risk to the environment and human health is acceptable.

The analysis of the impact in case of accidents at the CSFSF with maximum effects showed that during the operation:

- the impact on the environment in case of the maximum design-basis accident and beyond design-basis accident will not exceed the current state of the environment;
- the impact on the technological environment in case of the maximum design-basis accident and beyond design-basis accident will not exceed the current hygienic norms established by DGN 6.6.1-6.5.001-98 [14];
- the impact on the social environment in case of the maximum design-basis accident and beyond design-basis accident will not exceed the current hygienic norms established by DGN 6.6.1-6.5.001-98 [14].

According to DGN 6.6.1-6.5.061-2000 [15], in order to measures the harm to the public health, the notion of “generalized risk” is established, which is defined as the product of probability of potential exposure per year and the probability of radiation-related stochastic effects (cancerous diseases).

The maximum values of probability of cancerous diseases and lethal cases among the personnel and the public as a result of exposure in case the hypothetical beyond design basis accident depending on the distance, obtained using Genii 2.10 software, are presented in Table 7.3.

Table 7.3. **The Probability Of Cancer And Lethal Cases As A Result Of Exposure (BDBA)**

Accident	Distance, m

	100	600	1,000	2,000	5,000	12,000	13,000	20,000
Cases of cancer	3.1E-03	2.0E-03	9.0E-04	2.9E-04	6.8E-05	1.6E-05	1.4E-05	6.3E-06
Including lethal cases	2.0E-03	1.3E-03	5.9E-04	1.9E-04	4.5E-05	1.0E-05	9.0E-06	4.1E-06

As shown in Table 7.3, the probability of cancer and lethal cases at the border of the exclusion and compulsory resettlement zone is 1.6E-05 and 1.0E-05, respectively; on the border of the 10-km special radiation hazard area (2 km from the CSFSF) — 2.9E-04 and 1.9E-04 respectively. Thus, even if the likelihood of BDBA is 1 per year, the public risk on the border of the exclusion zone will be acceptable.

Considering the fact that, according to HOLTEC reports [85, 88], the BDBA accident with 100 % loss of sealing in the TFE and the leakage at the rate of 1.05×10^{-3} cm^3/s as a result of MPC's welded joint failure is not probable, the health risk to workers and the public from radiation caused by the BDBA accident can be neglected.

7.7.2 Assessment Of The Human Health Risk From Air Pollution By Chemicals

The calculation of the risk of impact of the proposed activity on the environment as done using "Risk Indicator" software utility, which is a part of the of "EOL 2000" software package listed among the programs recommended by the Ministry of Environmental Protection [99]. The calculation utility modules implement the risk assessment in accordance with Amendment 1 to DBN 2.2-1-2003 [10], taking into account the Methodological Recommendations of MR 2.2.12-142-2007 of Ministry of Health of Ukraine [116]. The assessment of the risk of impact of the planned activity of the public health is based on the estimated average concentration value.

7.7.2.1 Evaluation Of Non-carcinogenic Risk Of The Planned Activities

Justification Of The Estimation Methods Used

The risk of non-carcinogenic effects is determined by calculation of the hazard index (HI) according to the following formula:

The risk of non-carcinogenic effects is determined by calculation of the hazard index (HI) according to the following formula:

$$HI = \sum HQ_i \tag{24}$$

where HQ_i — the hazard ratios for individual substances are determined according to the following formula:

$$HQ_i = \frac{C_i}{R_f \times C_i} \tag{25}$$

where C_i — the estimated average annual concentration of i substance on the border of the settlement area, mg/m^3;

$R_f \times C_i$ — the reference (safe) concentration of the i substance, mg/m^3;

$HQ_i = 1$ — the maximum acceptable risk.

The evaluation of non-carcinogenic risk is based on the criteria set out in Table 7.4.

Table7.4. **Non-carcinogenic Risk Criteria**

Risk Specification	Hazard Ratio (HQ)
The risk of harmful effects is extremely low	< 1
The limiting value of acceptable risk	1
The likelihood of adverse effects increases in proportion as HQ increases	> 1

Calculated Non-carcinogenic Risk Of The Planned Activities

The calculated non-carcinogenic risk of the planned activities is shown in Table 7.5.

Table 7.5. **Calculated Non-carcinogenic Risk Of The Planned Activities**

CAS code (group code*)	Substance name (combined action group)	The annual average concentration, mg/m³	Background concentrations, mg/m³	Reference (safe) concentration, mg/m³	Hazard ratio (hazard index*)
10102-44-0	Nitrogen dioxide	0.15016209	0.00799999	0.0400	3.75405216
7783-06-4	Hydrogen sulfide	0.00320003	0.00320000	0.0010	3.20003414
7446-09-5	Sulphurous anhydride	0.09075899	0.01999996	0.0800	1.13448739
630-08-0	Carbon monoxide	0.75543207	0.39999986	3.0000	0.2518107
	Overall risk	–	–	–	**8.34038448**
*100	Group affecting the respiratory organs (10102-44-0,7446-09-5,7783-064)	–	–	–	*8,08857369
*33	Summation group No. 33 (10102 44-0,630-08-0,7446-09-5)	–	–	–	*5.14035025
*31	Summation group No. 31 (10102-44-0,7446-09-5)	–	–	–	*4.88853955
*25	Summation group No. 25 (1010244-0,630-08-0)	–	–	–	*4.00586286

The non-carcinogenic risk estimate of the planned activities is shown in Table 7.6.

Table 7.6. **Non-carcinogenic Risk Assessment Of The Planned Activities**

No.	Risk Specification	Contaminant (combined action group)	Hazard ratio (hazard index*)
1	The likelihood of adverse effects increases in proportion as HQ increases	100 Group affecting the respiratory organs	8.08857369
		33: Summation group No. 33	5.14035025
		31: Summation group No. 31	4.88853955
		25: Summation group No. 25	4.00586286
		1010244-0: Nitrogen dioxide	3.75405216
		7783-06-4: Hydrogen sulfide	3.20003414
		7446-09-5: Sulphurous anhydride	1.13448739
2	The risk of harmful effects is extremely low	630-08-0: Carbon monoxide	0.2518107

According to the calculations, the risk of non-carcinogenic effects is extremely low, the likelihood of adverse effects increases in proportion as HQ increases.

7.7.2.2 Evaluation Of Carcinogenic Risk Of The Planned Activities

Justification Of The Estimation Methods Used

The risk of individual carcinogenic effects ICR_i of the substances, characterized by the inherent carcinogenic effect, is calculated using the following formula:

$$ICR_i = C_i \times UR_i \quad (26)$$

where C_i — the estimated average annual concentration of i substance on the border of the settlement area, mg/m^3;

UR_i — single carcinogenic risk of the i substance, mg/g.

The carcinogenic risk of the combined effect of several carcinogenic contaminants is determined by the following formula:

$$CR_a = \sum IRC_i \quad (27)$$

ICR_i — the carcinogenic risk of the i-th substance.

The evaluation of carcinogenic risk of the planned activity is based on classification of the carcinogenic risk levels set out in Table 7.7.

Table 7.7. **Classification Of The Carcinogenic Risk Levels**

Risk level	Lifetime risk
Unacceptable for personnel and the population	> 10^{-3}
Acceptable for personnel, but unacceptable for the population	10^{-3}... 10^{-4}
Conditionally acceptable	10^{-4}... 10^{-5}
Acceptable	< 10^{-6}

Calculated Carcinogenic Risk Of The Planned Activities

The calculated carcinogenic risk of the planned activities is shown in Table 7.8.

Table 7.8. **Calculated Carcinogenic Risk Of The Planned Activities**

CAS code (group code*)	Substance name (combined action group)	The annual average concentration, mg/m³	Background concentrations, mg/m³	Carcinogenic potential factor (SF (mg/(kg*day))	Single risk (UR) (m³/mg)	Individual carcinogenic risk (carcinogenic risk of combined action)
50-32-8	Benz(a)pyrene	0.00000153	0.00000040	3.1000	0.88571423	0.00000136

The carcinogenic risk estimate of the planned activities is shown in Table 7.9.

Table 7.9. **Carcinogenic Risk Assessment Of The Planned Activities**

Risk level	Contaminant (combined action group)	Lifetime risk
Conditionally acceptable	50-32-8: Benz(a)pyrene	0.00000136

According to the calculations, the risk of carcinogenic effects is conditionally acceptable.

7.7.2.3 Evaluation Of Social Risk Of The Planned Activities

Justification Of The Estimation Methods Used

The risk of the proposed activity is defined as the risk for the group of people, which may be affected by the economic activity, with regard for the characteristics of natural and man-made systems.

The estimated value of social risk (R_S) is determined using the following formula:

$$R_S = CR_a \cdot V_u \cdot \frac{N}{T} \cdot \left(1 - N_p\right), \quad (28)$$

where CR_a — the social risk, persons/year;

V_a — the vulnerability of the territory due to the air pollution is determined by the ratio of the area allocated for the object of economic activity to the area of the sanitary protection zone in fraction of the unit;

N — the population size:

а) according to the data on the residential district, if any, in the locality;

б) according to the data on the whole locality, if there are no districts and the locality is city-forming;

в) according to the data on the settlements located in the zone of influence of the design object, if it is on their border, number of people.

T — the average life expectancy (as determined for the given region, otherwise assumed 70);

N_a — the coefficient derived using the formula:

- during the reconstruction of the object:

$$N_p = \frac{\Delta N_p}{N_{rm}}, \quad (29)$$

- if the number of jobs does not changes:

$$N_p = 0, \quad (30)$$

where ΔN_p — the number of additional jobs (negative value, if decreases);

N_{rm} — previous jobs number.

The evaluation of social risk of the planned activity is based on classification of the social risk levels set out in Table 7.10.

Table 7.10. **Classification Of The Social Risk Levels**

Risk level	Lifetime risk
Unacceptable for personnel and the population	$> 10^{-3}$
Acceptable for personnel, but unacceptable for the population	$10^{-3}... 10^{-4}$
Conditionally acceptable	$10^{-4}... 10^{-5}$
Acceptable	$< 10^{-6}$

Social Risk Calculation Results

The social risk calculation results of the planned activities are set out in Table 7.11.

Table 7.11. **Social Risk Calculation Results**

The vulnerability of the territory due to the air pollution	0.5143
The area allotted for the object (km²)	0.18
The area allotted for the object with SZZ (km²)	0.35
Population (people)	607
Life expectancy (years)	70
The new object/reconstruction	yes/no
The number of additional jobs (pcs)	0
Allowance for the possible carcinogenic activity groups	Implemented
Method of carcinogenic risk assessment:	Normative ($CRa = 0{,}000001$)

Evaluation of social risk of the planned activities is given in the Table 7.12.

Table 7.12. **Evaluation Of Social Risk Of The Planned Activities**

Risk Specification	Harmful substances (combined action group)	Carcinogenic risk	Lifetime risk
Conditionally acceptable	–	0.000001	0.00000446

The Results Of The Assessment Of The Risks Of Influence The Planned Activities On The Environment

The results of the assessment of the risks of influence the planned activities on the environment:

- the risk of non-carcinogenic effects is extremely low, the likelihood of adverse effects increases in proportion as HQ increases.
- the risk of carcinogenic effects is conditionally acceptable.
- the social risk of the planned activities is conditionally acceptable.

According to the calculations, the risks of public health from air pollution with chemicals and the risks of impact of the the planned activities on the environment are assumed acceptable.

7.8 Identification Of The Potentially Dangerous Object

Identification of the potentially dangerous object is performed using the Method [117].

According to the results of identification, the CSFSF is a potentially dangerous object defined by Paragraph 17 of Methods [117].

7.9 The List And Description Of The Residual Impacts

The consolidated list of residual impact of the CSFSF is made for normal operating conditions and failures during operation, as shown in Table 7.13.

The information is based on the data on the impact sources listed in Sections 3 and 4 of the EIA, and the estimates set out in Sections 4 to 6 of the EIA, with regard for the measures provided for by the project to ensure environmental safety, as set out in Section 7 of the EIA.

Table 7.13. **List Of Residual Impacts Of The CSFSF**

Types And Sources Of Impact	The Parameters Of Emissions And Discharges	Characteristics Of The Impact On The Components Of The Environment					
		Air Environment	Water Environment	Soils	Flora, Fauna, And The NRF Sites	Man-made Environment	Social Environment
Construction							
The radiation impact due to raising of dust during the site preparation and construction	The total of 2.1 E06 Bq of radioactive substances will be emitted to the air, including: • ^{137}Cs — 1.4 E6 Bq; • ^{90}Sr — 6.5 E5 Bq; • α-emitting TUE — 3.0 E4 Bq	The calculated average annual concentrations below the maximum allowable levels: • ^{137}Cs — values of Order 10^5 Bq; • ^{90}Sr — values of Order 10^6 Bq; • α-emitting TUE — values of Order 10^2 Bq.	The volumetric concentration of the RS in the water bodies (River Uzh — 6–8 km, River Sahan — about 7 km, River Pripyat — 12 km) due to the CSFSF operation CSSNF will be below the detection level.	The value of maximum additional soil contamination in the vicinity of places of work will amount to 0.2-0.3 % of the existing soil contamination rate. On the border of the 10-km zone of Chernobyl, the additional pollution levels will not exceed 0.01 % of the existing pollution rate.	No significant impact on the species diversity of the phytocenoses and, accordingly, the faunal complexes of the surrounding areas as well as the number and species diversity of animals is not expected.	The maximum additional exposure dose for the personnel of "Vector" is 0.3 mSv/year, which does not exceed 3 % of the reference level.	The dose load on the population outside the exclusion zone will not exceed 0.001 % of the limit established by NRBU-97 (1 mSv/year).
The emissions from the construction equipment	Total emission: • iron oxide (Fe_2O_3): 0.049 t/year; • manganese and its compounds (MnO_2): 0.007 t/year; • nitrogen dioxide (NO_2): 3.77 t/year; • soot: 1.461 t/year; • sulfur dioxide (SO_2): 1.885 t/year; • carbon monoxide (CO): 9.425 t/year; • benz(a)pyrene: 3.02E-05 t/year; • NMVOC: 2.828 t/year; • suspended solids: 8.635 t/year.	The analysis of the results of calculations of the ground-level concentrations of pollutants shows that the extent of CSFSF emissions effect on the air during construction will be local.	The impact on the water environment during the construction of the CSFSF is not expected.	The impact on the soils during the construction of the CSFSF is not expected.	The impact of chemical air pollution may not significantly affect the flora and fauna of the surrounding area, because the harmful effects are limited to the boundaries of the production site and the the NRF sites located at a considerable distance from the CSFSF site.	The construction of the CSFSF will not change the existing conditions of operation of the enterprises, located nearby (Vector, ChNPP, etc.).	Due to sufficient distance from the site to the the territories with the controlled levels of living environment, the pollutant emissions will not have negative impact on the health and lifestyle of the population of the surrounding areas and will not lead to adverse social consequences associated with the impact of the projected facilities on the air.
Acoustic impact of the construction equipment.	Acoustic impact during construction will be limited to the boundaries of the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.	During construction, the noise will not reach the residential areas and will be limited to the construction site.
Waste production	During construction of the CSFSF, non-radioactive waste is produced.	The total amount of waste produced during construction of the CSFSF is ~125,596 t.					
Final evaluation of the residual impacts during construction		**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**

Types And Sources Of Impact	The Parameters Of Emissions And Discharges	Characteristics Of The Impact On The Components Of The Environment					
		Air Environment	Water Environment	Soils	Flora, Fauna, And The NRF Sites	Man-made Environment	Social Environment
Operation							
Normal Operating Conditions							
Radiation Impact	Maximum activity: • ^{85}Kr — 2.16 E09 Bq/year • ^{90}Sr — 1.35 E07 Bq/year • ^{134}Cs — 6.14 E06 Bq/year • ^{137}Cs — 2ю12 E07 Bq/year	The maximum design values of the additional concentrations in the boundary air layer at the SPZ boundary are at the level of the existing average concentrations. On the nearest border of the exclusion and compulsory resettlement zone, the values are by a factor of 2 to 3 lower than the average values.	The water pollution is negligible if compared to the existing rates.	The additional pollution does not exceed 0.1 % of the current level of soil contamination rate.	Due to the negligible additional pollution of the soil and vegetation, the impact on flora and fauna is not significant.	The maximum additional radiation doses for the personnel of "Vector" will be about 0.2 mSv/year, which does not exceed the reference levels even if put together with the existing dose.	The dose load on the population outside the exclusion zone will not exceed 0.001 % of the limit established by NRBU-97 (1 mSv/year).
The contaminants emissions from the CSFSF infrastructure	Total emission: • nitrogen dioxide (NO_2): 1.146 t/year; • soot: 0.442 t/year; • sulfur dioxide (SO_2): 0.571 t/year; • sulfur dioxide ($H2_S$): 0.000 t/year; • carbon monoxide (CO): 2.852 t/year; • benz(a)pyrene: 9.12E-06 t/year; • NMVOC: 0.855 t/year; • suspended solids: 0.094 t/year; • inorganic dust (containing 70-20 % ща silicon dioxide): 0.008 t/year.	The analysis of the results of calculations of the ground-level concentrations of pollutants shows that the extent of CSFSF emissions effect on the air during operation will be local.	The impact on the water environment during operation of the CSFSF is not expected.	The impact on the soils during the operation of the CSFSF is not expected.	The impact of chemical air pollution may not significantly affect the flora and fauna of the surrounding area, because the harmful effects are limited to the boundaries of the production site and the the NRF sites located at a considerable distance from the CSFSF site.	The operation of the CSFSF will not change the existing conditions of operation of the enterprises, located nearby (Vector, ChNPP, etc.).	Due to sufficient distance from the site to the the territories with the controlled levels of living environment, the pollutant emissions will not have negative impact on the health and lifestyle of the population of the surrounding areas and will not lead to adverse social consequences associated with the impact of the projected facilities on the air.
Acoustic impact of the CSFSF infrastructure.	The acoustic effects of the operation of the facility will be permanent and will accompany the activities on the site during the whole operation period.	The estimates show that the noise discomfort zone of the technological equipment does not exceed the boundaries of the SPZ and will not affect the formation of further sound field.	The acoustic impact on the water environment during operation of the CSFSF is not expected.	The acoustic impact on the soils during the operation of the CSFSF is not expected.	The acoustic impact may not significantly affect the flora and fauna of the surrounding area, because the harmful effects are limited to the boundaries of the production site and the the NRF sites located at a considerable distance from the CSFSF site.	The operation of the CSFSF will not change the existing conditions of operation of the enterprises, located nearby (Vector, ChNPP, etc.).	Due to a large enough distance from the territories with the controlled quality of the environment, the site operation will not result in exceeding the sanitary and hygienic standards, and will have no adverse social impacts associated with noise exposure.
The impact of the electric and electromagnetic fields of the communication antennas.	The total electromagnetic energy flux density in the surrounding area at the height of 2 m above the ground at the distance of 0-1000 meters from the transmitting antennas does not exceed 3.2 % of the MAL.	Due to a large enough distance from the territories with the controlled quality of the environment, the site operation will not result in exceeding the sanitary and hygienic standards.	The impact of the electric and electromagnetic fields of the communication antennas during the operation of the CSFSF is not expected.	The impact of the electric and electromagnetic fields of the communication antennas on the soil during the operation of the CSFSF is not expected.	The impact of the electric and electromagnetic fields may not significantly affect the flora and fauna of the surrounding area, because the harmful effects are limited to the boundaries of the production site and the the NRF sites located at a considerable distance from the CSFSF site.	The operation of the CSFSF will not change the existing conditions of operation of the enterprises, located nearby (Vector, ChNPP, etc.). The only factor of impact is the infrastructure of Vector complex and CheNPP, as well as the increasing of the radiation load on the personnel involved in the operation of the CSFSF.	The existing residential buildings are located outside the restricted zone. If the established restricted zones around the radio-engineering site are observed, the electromagnetic field is safe for human health.
Waste production	During operation of the CSFSF, radioactive and non-radioactive waste is produced.	High level waste production is not expected during operation of the CSFSF. The maximum single receipt of the LRW into the drain water tanks at the simultaneous receipt of the shower water and wash water from decontamination of the facilities is 3,774 dm³. The estimated amount of SRW generated as a result of the CSFSF operation is 3.9 t/year. The total amount of industrial waste produced during operation of the CSFSF is ~183.3 t.					
Final Evaluation Of The Residual Impacts During Normal Operation	**–**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**	**The effects will not exceed the permissible levels**
Emergency Conditions In Operation							
Radiation Exposure							

Types And Sources Of Impact	The Parameters Of Emissions And Discharges	Characteristics Of The Impact On The Components Of The Environment					
		Air Environment	Water Environment	Soils	Flora, Fauna, And The NRF Sites	Man-made Environment	Social Environment
The design accident with the maximum consequences (MDBA).	Expected release activity: • ^{60}Co — 1.45 E06 Bq	The maximum value of the average annual concentration in the air: • on the SPZ border: 5.75 E-05 Bq/m³; • on the border of the 10-km zone: 3.83 E-06 Bq/m³; • on the Exclusion zone border: 2.11 E-07 Bq/m³.	The water pollution is negligible if compared to the existing rates.	Additional pollution will not exceed the following levels: • on the SPZ border: 15 Bq/m^2; • on the border of the 10-km zone: 0.6 Bq/m^2; • on the Exclusion zone border: 0.032 Bq/m^2. All the values do not exceed 0.1 % of the current level of soil contamination rate.	Due to the negligible additional pollution of the soil and vegetation, the impact on flora and fauna is not significant.	The maximum additional radiation doses for the personnel of "Vector" will be about 0.3 mSv, which does not exceed the reference levels even if put together with the existing dose.	The total effective radiation dose (mSv/year) die to all the sources of ^{60}Co • on the border of the 10-km zone: 3.0 E-05 mSv/year; • on the Exclusion zone border: 1.5 E-06 mSv/year. This is well below the limit set for the population by NRBU-97.
Beyond design basis accidents (BDBA)	Total activity of the emissions in case of hypothetical beyond design basis accident is estimated at 2.0E11 Bq.	The maximum annual average volumetric concentration at the distance of 100 meters from the failed HI-STORM does not exceed the value of Order 10 Bq/m³. On the nearest border of the exclusion and compulsory resettlement zone, the volumetric activity will not exceed 0.005 Bq/m³.	The total number of radionuclides deposited in the most dangerous area (20 km south-east) of River Pripyat will not exceed 4.3 E09 Bq, which is by three orders of magnitude less than the activity of the annual runoff of River Pripyat (up to 10^{120} Bq).	The additional surface contamination (ASC) at the distance of 100 meters from the failed HI-STORM will not exceed the following values: • ^{137}Cs — 810 kBq/m²; • ^{90}Sr — 509 kBq/m²; • α-emitting TUE — 159 kBq/m², which is comparable to the existing contamination rates. On the border of the exclusion and compulsory resettlement zone, the ASC will not exceed the following values: • ^{137}Cs — 1.8 kBq/m²; • ^{90}Sr — 1.1 kBq/m²; • α-emitting TUE — 0.37 kBq/m². which is not significant and does not exceed 10 % of the current level of soil contamination rate.	Given the fact that significant radiation impact on the air, soil and surface waters is not expected, the impact on the flora and fauna is considered acceptable.	The additional doses of radiation will not result in exceeding the RLs for the personnel of the enterprises located in the exclusion and compulsory resettlement zone.	On the border of the exclusion and compulsory resettlement zone, the annual individual effective dose is not more than 0.1 mSv, which is less than the annual dose limit for the population set by NRBU-97 (1 mSv/year).
Final Evaluation Of The Residual Impacts In Case Of Emergency		**Acceptable Impac**	**Acceptable Impac**	**Given the likelihood of BDBA, the impact is acceptable**	**Acceptable Impac**	**Acceptable Impac**	**Acceptable Impac**

8 EVALUATION OF ENVIRONMENTAL IMPACT DURING CONSTRUCTION

8.1 Impact Sources

The sources of environmental impact during construction of the CSFSF are as follows:

- construction machinery and mechanisms;
- welding works;
- excavation.

The characteristics of the potential environmental impact sources of the proposed activity are as follows:

- radiation impact;
- contaminants emissions;
- acoustical impact;
- generation of waste.

8.2 Radiation Impact During Construction

The radiation exposure during construction is estimated as the total emission of radionuclides due to the raising of dust under normal conditions of construction during preparation of the construction sites for the main structures. This explained by the fact that in the accidents involving construction equipment failures or falling, the raised dust will be local and the emission value will be much lower.

During the mentions works [Investment Feasibility Study for the Construction of the Central Spent Fuel Storage Facility for VVER Nuclear Power Plants of Ukraine, OAO KIEP, 2008], the following values are expected:

- ^{137}Cs..... 1.4 E6 Bq;
- ^{90}Sr..... 6.5 E5 Bq;
- TUE..... 3.0 E4 Bq.

The results set out below were obtained under the assumption that the emission is terrestrial, the atmospheric stability category is D, the wind speed is $V = 3\ м/с$.

8.2.1 Air Pollution

The maximum concentrations of radionuclides in the release under consideration will occur in the immediate vicinity of the excavation.

The additional average annual concentration in the air at the boundary of the SPZ (100 m from the site) will be, according to IFS [24]:

- ^{137}Cs ..... 1.8 E-4 Bq/m^3;
- ^{90}Sr ..... 4.7 E-5 Bq/m^3;
- TUE ..... 1.8 E-6 Bq/m^3.

The additional average annual volumetric activity on the border of the 10-kilometer zone of the Chernobyl Nuclear Power Plant, which is located at the distance of 2 km south from the CSFSF, complies with the IFS [24]:

- ^{137}Cs..... 5.9 E-7 Bq/m^3;
- ^{90}Sr..... 1.2 E-7 Bq/m^3;
- TUE..... 9 E-9 Bq/m^3.

The additional average annual volumetric air pollution at the border of the exclusion and compulsory resettlement zone (12 km) due to the CSFSF site preparation will comply with the IFS [24]:

- ^{137}Cs..... 3 E-8 Bq/m^3;
- ^{90}Sr..... 5.9 E-9 Bq/m^3;
- TUE..... 3.5 E-10 Bq/m^3.

The reference levels of air pollution (the average volumetric activity) for the site of “Vector” (located in the immediate vicinity of the CSFSF production area) [19] are as follows:

- ^{137}Cs..... 6.0 E-4 Bq/m^3;
- ^{90}Sr..... 5.0 E-4 Bq/m^3;
- TUE..... 4.0 E-4 Bq/m^3.

The average level of contamination of the boundary air layer (Section 2.5.1.1) in the area round the CSFSF site of the order of magnitude of $n\times10^{-4}$ Bq/m^3 in terms of ^{137}Cs.

The comparison of these values shows that the additional air pollution near the site will not bring significant changes to the existing air pollution. And at the distance of two kilometers and further from the CSFSF construction site, the impact is negligible.

8.2.2 Contamination Of The Soil Surface

The results of calculation of the impact on the soil, according to the IFS [24], suggest that, under these conditions, the impact will be negligible compared to the existing pollution rates. Thus, the maximum surface contamination of soil with the Cs isotopes in the immediate vicinity of the production works will not exceed 7 kBq/m², which is about 0.1 % of the current radioactive contamination rate.

On the border of the 10-km zone of the Chernobyl Nuclear Power Plant (2 km to the south), the surface contamination with the isotopes of Cs is ~4 Bq/m², which corresponds to 0.002 % of the current soil contamination rate.

The maximum surface contamination of soil with ^{90}Sr in the immediate vicinity of the production works will not exceed 1,5 kBq/m², which is about 0.04 % of the current contamination rate.

On the border of the 10-km zone of the Chernobyl Nuclear Power Plant, the contamination with ^{90}Sr is 0.8 Bq/m², which corresponds to 0.0001 % of the current contamination rate.

The density of the additional soil contamination with the alpha-emitting TUE, the maximum of which will occur in the immediate vicinity of the construction site, will not exceed the value of 70 Bq/m^2, which is 3 % of the current contamination rate (2.2 kBq/m²). On the border of the 10-km zone of the Chernobyl NPP, the surface contamination with the alpha-emitting TUE will be ~0.04 Bq/m^2, which corresponds to 0.01 % of the current soil contamination rate.

On the nearest border of the exclusion and compulsory resettlement (12 km southwest), the surface contamination with $^{134+137}Cs$, ^{90}Sr and alpha-emitting TUE will be 0.2 Bq/m², 0.04 Bq/m² and 0,002 Bq/m² respectively, which is within fraction of a percent of the current contamination rates on the territory due to the accident of 1986.

Based on the above results, the additional soil contamination during construction of the CSFSF can be neglected.

8.2.3 Additional Exposure Of The Personnel And The Population

The additional individual effective doses caused by the construction [Investment Feasibility Study for the Construction of the Central Spent Fuel Storage Facility for VVER Nuclear Power Plants of Ukraine, OAO KIEP, 2008] are as follows:

- about 0.3 mSv — on the border of the SPZ (100 m from the site);
- about 1.0 E-3 mSv — on the border of the 10-kilometer zone of the Chernobyl NPP;
- about 4.0 E-5 mSv — on the nearest border of the exclusion and compulsory resettlement zone (12 km southwest).

According to the Report [47], the average dose rate in the vicinity of the CSFSF production site is about 3.5 mSv/year, which means that the expected additional exposure during construction on the border of the SPZ will not be significant.

The additional doses on the border of the 10-kilometer zone of the Chernobyl NPP, where the the population may live in the foreseeable future, as well as on the nearest border of the exclusion and compulsory resettlement zone, will not exceed one percent of the dose limit established for the population by DGN 6.6.1-6.5.001-98 [14].

In view of the above, the impact on the personnel and the public during the construction of the CSFSF acceptable.

8.3 Non-radiation Impact During Construction

The non-radiation impact during construction includes the emissions of contaminants into the atmosphere from the construction equipment, during welding and excavation works, the acoustic impact of the construction equipment, and the waste.

8.3.1 Assessment Of The Impact Of Contaminant Emissions During Operation Of The Construction Equipment

8.3.1.1 Justification Of The Estimation Methods Used

The calculation of the pollution from the construction equipment was based on the Methods [94, 95].

In order to calculate the maximum single mass of emission, the weight of emission in g/km was converted to g/s using the following formula:

$$g.V\ (г/с) = g\ (г/км) \times V\ (км/ч)/3600\ (с) \quad (31)$$

The amount of emission from the internal combustion engines was estimated using the formula from the Resource Manual [97]:

$$M_i = K_i^t \times B^t \quad (32)$$

where M_i — the amount of contaminants, g, t;

K_i^t — the specific emissions of the i substances during combustion, g/g, t/t;

B^t — the volume of fuel consumed g, t;

The coefficient K_i^t values for various fuels is shown in Table 8.1.

Table 8.1. **The Value Of The Coefficient K_i^t For Different Types Of Fuel**

Contaminant Code And Name		MAC mg/m³	Specific Emission	
			Diesel	Gasoline
301	Nitrogen dioxide (NO_2)	0.2	0.04	0.04
328	Soot	0.15	0.0155	0.0158
330	Sulfur dioxide (SO_2)	0.5	0.02	0.002
337	Carbon oxides (CO)	5.0	0.1	0.6

703	Benz(a)pyrene	1×E-5	0.00000032	0.00000023
2,754	Non-methane volatile organic compounds	1.0	0.03	0.1

8.3.1.2 Source Data For The Assessment Of The Contaminants Emission To The Atmosphere During Operation Of The Construction Equipment

Duration of work on the CSFSF construction site — 12 months (251 days).
Data on the number of simultaneously operating machines are shown in Table 8.2.

Table 8.2. **Data On The Number Of Simultaneously Operating Machines**

Name	Number of simultaneously operating machines	Service hours per shift, h
Crawler Crane DEK-251	5	6.3
Truck Crane KTA-25	1	4.6
Truck Crane KTA-18	3	4.6
Concrete Mixer Truck KrAZ-612R4	1	3.3
High Sided Truck KAMAZ-43118, cargo 10 t	1	3

The impact on the atmosphere as a whole will be determined by the more powerful sources of emissions.

All the vehicles operating on site are equipped with diesel internal combustion engines. The number of units, the speed, the time of operation, and the amount of fuel consumed are set out in Table 8.3.

Table 8.3. **The Characteristics And Cost Of Fuel For The Construction Machinery And Road Vehicles**

Name	Quantity	Speed km/h	Working hours, h	Fuel Consumption				
				l/h	kg/h	g/km	g/s	t/year
Crawler Crane DEK-251	5	1	1581.3	7.3	30.113	6022.500	1.67291667	47.617
Truck Crane KTA-25	1	20	1154.6	8.80	7.260	72.600	0.40333333	8.382
Truck Crane KTA-18	3	20	1154.6	8.80	21.780	217.800	1.21000000	25.147
Concrete Mixer Truck KrAZ-612R4	1	20	828.3	5.00	4.125	41.250	0.22916667	3.417
High Sided Truck KAMAZ-43118, cargo	1	20	753	19.80	16.335	163.350	0.90750000	12.300
TOTAL	**11**				**77.963**	**779.625**	**6.45906250**	**94.254**
Note: standard diesel fuel density is 0.825 kg/l.								

8.3.1.3 The Calculation Of The Contaminants And Greenhouse Gases Emissions Into The Atmosphere From The Construction Equipment

$M_{NOx}^{сек} = 6,45906250 \times 0,04 = 0,17691667\ г/с$

$M_{NOx}^{год} = 94,254 \times 0,04 = 3,875\ т/год$

$M_{Сажа}^{сек} = 6,45906250 \times 0,0155 = 0,06855521\ г/с$

$M_{Сажа}^{год} = 94,254 \times 0,0155 = 1,501\ т/год$

$M_{SO_2}^{сек} = 6,45906250 \times 0,02 = 0,08845833\ г/с$

$M_{SO_2}^{год} = 94,254 \times 0,02 = 1,937\ т/год$

$M_{CO}^{сек} = 6,45906250 \times 0,1 = 0,44229167\ г/с$

$M_{CO}^{год} = 94,254 \times 0,1 = 9,686\ т/год$

$M_{Бенз(а)пирен}^{сек} = 6,45906250 \times 0,00000032 = 0,00000142\ г/с$

$M_{Бенз(а)пирен}^{год} = 94,254 \times 0,00000032 = 0,00003100\ т/год$

$M_{НМЛОС}^{сек} = 6,45906250 \times 0,03 = 0,13268750\ г/с$

$M_{НМЛОС}^{год} = 94,254 \times 0,03 = 2,906\ т/год$

The amount of contaminants emission from the construction equipment into the atmosphere is set out in Table 8.4.

Table 8.4. **The Amount Of Contaminants Emission From The Construction Equipment Into The Atmosphere**

Contaminant Code And Name		MAC mg/m³	Specific Emission	
			g/s	t/year
301	Nitrogen dioxide (NO_2)	0.2	0.25836250	3.770
328	Soot	0.15	0.10011547	1.461
330	Sulfur dioxide (SO_2)	0.5	0.12918125	1.885
337	Carbon oxides (CO)	5.0	0.64590625	9.425
703	Benz(a)pyrene	1×E-5	0.00000207	0.00003016
2,754	Non-methane volatile organic compounds	1.0	0.19377188	2.828

The total amount of emissions is set out in Table 8.10.

8.3.2 Evaluation Of The Impact Of Polluting Substances Emissions During Welding

8.3.2.1 Justification Of The Estimation Methods Used

The calculation of the pollution from the earthworks was based on the Methods [94].

The emissions of contaminants into the air from welding are taken from Compendium [118] and make as follows (g/kg):

- Dust 12.53;

- Manganese and its compounds ..... 1.87.

8.3.2.2 The Source Data For The Calculation Of The Emissions During Welding

E-42 (ANO-5) electrodes in the amount of 0.390 t/year will be used for welding works on the CSFSF construction site. Working hours: 26 days (260 hours).

8.3.2.3 The Calculated Emissions During Welding

The emissions of contaminants into the air from welding at the CSFSF construction site are assumed at 0,390 t/year (0.00041667 kg/s):

- Dust (iron oxide (in terms of iron) (Fe_2O_3)) $12{,}53\ г/кг \times 0{,}00041667\ кг/с = 0{,}00522083\ г/с$;
- Manganese and compounds (in terms of manganese dioxide) (MnO_2)) $1{,}87\ г/кг \times 0{,}00041667\ кг/с = 0{,}00077917\ г/с$.

The duration of welding on the CSFSF site: 26 days (260 hours), gross emissions:

- Dust (iron oxide (in terms of iron) (Fe_2O_3)) $0{,}00522083\ г/с \times 0{,}0036 \times 260\ ч/год = 0{,}0049\ т/год$;
- Manganese and compounds (in terms of manganese dioxide) (MnO_2)) $0{,}00077917\ г/с \times 0{,}0036 \times 260\ ч/год = 0{,}007\ т/год$.

The amount of emissions during welding are set out in Table 8.5.

Table 8.5. **The Amount Of Emission Into The Air During Welding**

Substance code and name		Specific contaminant emission	
		The sludge dewatering plant area	
		g/s	t/year
123	Dust (iron oxide (in terms of iron) (Fe_2O_3))	0.00522083	0.049
143	Manganese and compounds (in terms of manganese dioxide) (MnO_2))	0.00077917	0.007

The total amount of emissions is set out in Table 8.10.

8.3.3 Assessment Of The Impact Of Emissions During Earthworks

8.3.3.1 Justification Of The Estimation Methods Used

The calculation of the pollution from the earthworks was based on the Methods [94].

The dust emission calculation for the earthworks was done according to the following formula:

$$q = A = \frac{k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_7 \cdot G \cdot 10^6 \cdot B'}{3600}, \quad (33)$$

where A — the emissions during material recycling (dumping, transshipment, moving), g/s;

k_1 — the particle weight fraction of the dust in the material — determined by washing and sifting the average sample with the release of dust fraction of 0–200 um;

k_2 — the dust fraction (of the total mass of the dust) turning into aerosol;

k_3 — the coefficient to adjust for the local weather conditions;

k_4 — the coefficient to adjust for the local weather conditions, the degree of site protection from external impact, the dust generation conditions;

k_5 — the coefficient to adjust for the moisture content;

k_7 — the coefficient to adjust for the size of the material;

G — the total amount of material to be processed, t/h;

B' — the coefficient to adjust for the dumping height.

8.3.3.2 The Source Data For The Calculation Of The Emissions Of Contaminants During The Earthworks

The amounts of earthworks are shown in Table 8.6.

Table 8.6. **The Amounts Of Earthworks**

No.	Works	Unit	Quantity
	Earthworks on the CSFSF site		
1	Excavation during construction of the CSFSF	m^3	219,809.7
	Site preparation		
2	Sand	m^3	6,080.9
3	Road metal	m^3	8,076.1
4	Sand and gravel	m^3	22,683.4
	Construction of roads and sidewalks		
5	Crushed stone	m^3	1,300

Table 8.7. **The Amounts of Materials Moved**

Name	Substance code	Volume of the material m^3	Volume of the material t	Volume of the material %	Volume of the material %/t	Volume of the material t/h
Crushed stone	2,902	8,076.1	21,966.99	3.11	4.75	8.14
Crushed stone	2,902	3,010	8,187.20	1.16	1.77	3.03
Sand	2,907	219,809.7	382,468.88	84.65	82.67	141.66
Sand	2,907	6,080.9	10,580.77	2.34	2.29	3.92
Sand	2,907	22,683.4	39,469.12	8.74	8.53	14.62
Suspended materials		**94,047**	**462,672.95**	**100**	**100**	**171.36**
Note: according to Methods [94], the emissions for sand with the moisture content over 3 % are not considered.						

The volume of transported material: ~96.17 m^3/h; ~171.36 t/h

8.3.3.3 The Calculated Emissions During Earthworks

The calculation of emissions from dusting during earthworks is shown in Table 8.8.

Table 8.8. **The Calculation Of Emissions From Dusting During Earthworks Is Shown**

Name	Substance code	k_1	k_2	k_3	k_4	k_5	k_7	G	B'	q=A g/s	q=A t/year
Crushed stone	2,902	0.4	0.02	1.2	1	0.8	0.8	8.14	0.5	**0.694**	**6.848**
Crushed stone	2,902	0.4	0.02	1.2	1	0.8	0.6	3.03	0.5	**0.194**	**1.886**
Amount										**0.888**	**8.635**

Table 8.9. **The Calculated Emission Of Contaminants Into The Air During Earthworks On The Sludge Storage Site**

Substance code and name		Specific emission of the contaminants	
		g/s	t/year
2,902	Suspended materials, unidentified composition	0.888	8.635

The total amount of emissions is set out in Table 8.10.

8.3.4 The Total Volume Of Emissions During Construction Works

Table 8.10. **Total Emission of Contaminants Into The Air During Earthworks**

Substance code and name		MAC	On the CSFSF site					
			Machinery		*Welding*		*Earthworks*	
			g/s	t/year	g/s	t/year	g/s	t/year
123	Dust (iron oxide (in terms of iron) (Fe_2O_3))	0.4	–	–	0.00522083	0.049	–	–
143	Manganese and compounds (in terms of manganese dioxide) (MnO_2))	0.01	–	–	0.00077917	0.007	–	–
301	Nitrogen dioxide (NO_2)	0.2	0.25836250	3.770	–	–	–	–
328	Soot	0.15	0.10011547	1.461	–	–	–	–
330	Sulfur dioxide (SO_2)	0.5	0.12918125	1.885	–	–	–	–
337	Carbon oxides (CO)	5.0	0.64590625	9.425	–	–	–	–
703	Benz(a)pyrene	1E-5	0.00000207	0.00003016	–	–	–	–
2,754	Non-methane volatile organic compounds	1.0	0.19377188	2.828	–	–	–	–
2,902	Suspended solids, undifferentiated composition.	0.5	–	–	–	–	0.888	8.635

8.3.5 Estimated Concentration Of Contaminants In The Lowest Atmospheric Layer During Construction

8.3.5.1 Justification Of The Estimation Methods And Software Used

The calculation of the concentration of contaminants in the lowest atmospheric layer are based on the currently used method (OND-86) [98] using “EOL 2000” software package listed among the programs recommended by the Ministry of Environmental Protection [99].

Permissible exposure levels are taken in accordance with DSP-201-97 [100].

8.3.5.2 Source Data

The meteorological characteristics are taken from the Reference by The Central Geophysical Observatory (CGO) № 16-13/-82/05-06 of 15.01.2015 provided as input data in Letter from OP "Atomproektinzhiniring” № 03-46/76 dated 22.01.2015 and presented in Annex Ж, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The data on background air pollution in the area of the project activity, in terms of contaminants, are taken from Reference by Department of Ecology And Natural Resources Of Kyiv Province № 061-11/4689 of 23.12.2014 provided as input data in Letter from OP "Atomproektinzhiniring” № 03-46/76 dated 22.01.2015 and presented in Annex Ж, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes on other contaminants are based on Regulation [101], the values of the background concentrations are assumed at 0.4 MAC.

The amounts of emissions of contaminants into the air during operation is assumed at the rates indicated in Table 8.10.

8.3.5.3 Calculated Concentration Of Contaminants In The Lowest Atmospheric Layer During Construction

The concentrations of contaminants in the lowest atmospheric layer during operation were calculated for the area of 3,000x3,000 m with the grid spacing of 100 m using “EOL 2000” software package.

The calculation of ground-level concentrations of contaminants during operation is presented in Annex Ч, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The concentrations of contaminants in the reference points on the boundary of the SPZ during construction, excluding the background, are shown in Table 8.11.

The concentrations of contaminants in the reference points on the boundary of the SPZ during construction, with regard for the background, are shown in Table 8.12.

The calculated concentrations of contaminants in the lowest atmospheric layer during construction are shown in Table 8.13.

Table 8.11. **The Concentrations Of Contaminants In The Reference Points On The Boundary Of The SPZ During Construction (Excluding The Background)**

Substance code and name		MAC mg/m³	The concentration in the reference points on the boundary of the SPZ (with regard for the background) (Fractions of MAC)									
			001	002	003	004	005	006	007	008	009	010
123	Dust (iron oxide (in terms of iron) (Fe_2O_3))	0.4	The calculation for these substances was not performed due to inexpediency as provided for in Cl. 5.21 of OND-86 [98].									
143	Manganese and compounds (in terms of manganese dioxide) (MnO_2))	0.01										
301	Nitrogen dioxide (NO_2)	0.2	0.2662	0.3113	0.2938	0.3028	0.3563	0.3028	0.2948	0.2827	0.2263	0.2146
328	Soot	0.15	0.1375	0.1608	0.1518	0.1564	0.1841	0.1565	0.1523	0.1461	0.1169	0.1109
330	Sulfur dioxide (SO_2)	0.5	0.0532	0.0623	0.0588	0.0606	0.0713	0.0606	0.0590	0.0565	0.0453	0.0429
337	Carbon oxides (CO)	5.0	0.0266	0.0311	0.0294	0.0303	0.0356	0.0303	0.0295	0.0283	0.0226	0.0215
703	Benz(a)pyrene	0.00001	0.0427	0.0499	0.0471	0.0485	0.0571	0.0485	0.0472	0.0453	0.0363	0.0344
2,754	Non-methane volatile organic compounds	1.0	0.0399	0.0467	0.0441	0.0454	0.0535	0.0454	0.0442	0.0424	0.0340	0.0322
2,902	Suspended solids, undifferentiated composition	0.5	0.5745	0.4474	0.3981	0.4364	0.0599	0.4671	0.4273	0.3824	0.3319	0.4006
	Summation group No. 31	–	0.3195	0.3735	0.3526	0.3633	0.4276	0.3634	0.3537	0.3392	0.2716	0.2575

Table 8.12. **The Concentrations Of Contaminants In The Reference Points On The Boundary Of The SPZ During Construction (Excluding The Background)**

Substance code and name		MAC mg/m³	The concentration in the reference points on the boundary of the SPZ (with regard for the background) (Fractions of MAC)									
			001	002	003	004	005	006	007	008	009	010
123	Dust (iron oxide (in terms of iron) (Fe_2O_3))	0.4	The calculation for these substances was not performed due to inexpediency as provided for in Cl. 5.21 of OND-86 [98].									
143	Manganese and compounds (in terms of manganese dioxide) (MnO_2))	0.01										
301	Nitrogen dioxide (NO_2)	0.2	0.3062	0.3513	0.3338	0.3428	0.3963	0.3428	0.3348	0.3227	0.2663	0.2546
328	Soot	0.15	0.5375	0.5608	0.5518	0.5564	0.5841	0.5565	0.5523	0.5461	0.5169	0.5109
330	Sulfur dioxide (SO_2)	0.5	0.0932	0.1023	0.0988	0.1006	0.1113	0.1006	0.0990	0.0965	0.0853	0.0829
337	Carbon oxides (CO)	5.0	0.1066	0.1111	0.1094	0.1103	0.1156	0.1103	0.1095	0.1083	0.1026	0.1015
703	Benz(a)pyrene	0.00001	0.0827	0.0899	0.0871	0.0885	0.0971	0.0885	0.0872	0.0853	0.0763	0.0744
2,754	Non-methane volatile organic compounds	1.0	0.4399	0.4467	0.4441	0.4454	0.4535	0.4454	0.4442	0.4424	0.4340	0.4322
2,902	Suspended solids, undifferentiated composition	0.5	0.6745	0.5474	0.4981	0.5364	0.1599	0.5671	0.5273	0.4824	0.4319	0.5006
	Summation group No. 31		0.3995	0.4535	0.4326	0.4433	0.5076	0.4434	0.4337	0.4192	0.3516	0.3375

Table 8.13. **Calculated Concentration Of Contaminants In The Lowest Atmospheric Layer During Construction**

Substance code and name		MAC mg/m³	Source contribution (fractions of MAC)
123	Dust (iron oxide (in terms of iron) (Fe_2O_3))	0.4	The calculation for these substances was not performed due to inexpediency as provided for in Cl. 5.21 of OND-86 [98]
143	Manganese and compounds (in terms of manganese dioxide) (MnO_2))	0.01	
301	Nitrogen dioxide (NO_2)	0.2	0.7840
328	Soot	0.15	0.4051
330	Sulfur dioxide (SO_2)	0.5	0.1568
337	Carbon oxides (CO)	5	0.0784
703	Benz(a)pyrene	1×E-5	1.1256
2,754	Non-methane volatile organic compounds	1	0.1176
2,902	Suspended solids, undifferentiated composition	0.5	1.1742
	Summation group No. 31	–	0.9409

8.3.5.4 Conclusions On The Impact Of The CSFSF's Emissions On Air During Construction

The analysis of the results of calculations of the ground-level concentrations of contaminants shows that the extent of CSFSF emissions effect on the air during operation will be local.

The chemical air pollution zone will not exceed the recommended sanitary standards for the spatial gap between the industrial and residential areas.

On the border of the sanitary protection zone (100 m), the hygienic requirements as to each specific contaminant are complied with.

Thus, on the strength of all the above data, the projected environmental impact in the form of emission of contaminants into the atmosphere, is acceptable.

8.3.6 Noise Air Pollution During Construction

It is planned to provide the noise control regime to meet the requirements of sanitary standards established by DBN V.1.1-31:2013 [102]. The criteria for evaluation of the noise discomfort zones on the designed facilities are based on the acceptable levels of human exposure.

8.3.6.1 Sources Of Noise Pollution

The noise impact of the facility as a whole will be determined by the most powerful sources of intermittent noise: the cranes, the concrete mixers, and the trucks.

8.3.6.2 Justification Of The Estimation Methods Used

The permissible noise levels are taken in accordance with DSN 3.3.6.037-99 [103] and SN № 3077-84 [104]. The area of noise impact is assumed as the area on the border of which the sources of the projected enterprise create the noise levels that differ from the background noise levels.

For the purpose of estimation, the most significant areas were selected in terms of noise impact of the on-site sources that determine the size of the impacting factor footprint. Due to the fact that, according to the formula used, in case of sound level difference of over 20 dB additional 0 dB is added to the higher lever, the low-level noise sources are not considered.

As a criterion for evaluating the noise generated during operation of the facility, the equivalent sound level LA_{eq} (dB) and the maximum sound level LA_{max} (dB) in the residential areas in the direction of the reference point are accepted. Since the operation regime of the facility is non-stop, but with some types of works carried out only during the day, the evaluation and regulation of the noise exposure should be carried out according to the norms for the day and for the night. The permissible noise levels are shown in Table 8.14.

Given that the speed of the vehicles at the entrance and within the facility may not exceed 10 km/h, the adjusted maximum sound level is obtained from Formula [107]:

$$L_{\max 10} = L_{\max} - 30\lg(V_{60}/V_{10}) \quad (34)$$

where $L_{\max 10}$ — the maximum sound pressure level at the speed of 10 km/h at the distance of 7.5 m from the axis of motion, dBA;

V_{60} — the speed of 60 km/h;

V_{10} — the speed of 10 km/h.

The sound levels in the reference points are determined by the following formula:

$$L_{P.T.} = L_{ucm.} - 20\lg(r/r_0) \quad (35)$$

where $L_{ucm.}$ — the sound level at the distance of 7.5 m from the source, dBA;

r — the distance to the calculated point, m;

r_0 — the distance from the axis of the lane nearest to the reference point.

Table 8.14. **Permissible Noise Levels In Reference Points**

Scope of regulation	Sound Pressure Levels, dB, In The Octave Bands With The Centre Frequencies, Hz									Sound Level $La_{экв}$, dBA (equivalent sound level), dBA
	31.5	63	125	250	500	1,000	2,000	4,000	8,000	
Performing all types of works on permanent workplaces in the production premises and on the territories of the enterprises (DSN 3.3.6.037-99 [103])	107	95	87	82	78	75	73	71	69	80
Recreation areas on the territory of districts and residential houses groups, rest houses, boarding houses, boarding houses for the elderly and disabled, kindergartens' playgrounds, schools and other educational institutions (SN № 3077-84 [104])	67	67	57	49	44	40	37	35	33	45

8.3.6.3 Source Data

On the construction sites, the most significant noise impact will be caused by the simultaneous operation of 11 machinery units.

The noise levels from the construction machinery and the construction works are shown in Table 8.15.

Table 8.15. **The List Of Noise Sources Related To The Construction Machinery And Their Acoustic Characteristics**

Source No.	Source Name	Sound Pressure Levels (Volume When R=0), dB, In The Octave Bands With The Centre Frequencies, Hz									$L_{Амакс}$	Included in the Estimate
		31.5	63	125	250	500	1,000	2,000	4,000	8,000		
	Crawler Crane DEK-251	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
	Truck Crane KTA-25	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
	Truck Crane KTA-18	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes
	Concrete Mixer Truck KrAZ-612R4	100.0	100.0	97.0	88.0	82.0	77.0	73.0	68.0	63.0	86.0	Yes
	High Sided Truck KAMAZ-43118, cargo 10 t	101.0	101.0	95.0	91.0	88.0	88.0	83.0	75.0	69.0	92.0	Yes

8.3.6.4 Estimate of the Acoustic Impact Of The Construction Equipment

Since constant flow of the road transport is not expected on the territory of the CSFSF, the noise estimate is based on the maximum noise levels of the most noisy transport means [105-107].

$L_{Амакс} = 92{,}0\ дБА$

$L_{\max 10} = 68{,}7\ дБА$

Where $r = 100\ м$, $L_{Р.Т.} = 28{,}7\ дБА$

The estimates show that the noise impact of the road transport during construction will be within the acceptable limits.

During construction, the noise will not reach the residential areas and will be limited to the construction site.

8.4 Assessment Of The Waste Impact In The Course Of Construction Activities

The amount of waste produced during construction is shown in Volume 11. Organization Of Construction, 571412.201.011-POS. The calculation of waste was made in accordance with Annex B to DSTU-NBD.2.2-48: 2012 [119] Norms Of Losses And Waste Of Materials During Construction And Installation.

The information on the waste generated in the course of installation and construction is shown in Table 8.16.

Table 8.16. **The Waste Generated During Construction**

Name	Code	Hazard Class	Quantity, t
Material waste from painting (rags, abrasives, etc.)	3410.2.9.02	3	2.02
Total for Class 3			**2.02**
Electrodes	2820.2.1.20	4	0.039
Insulated wires and sub-standard cables	3110.3.1.01	4	0.324
Gravel, crushed stone, sand, dolomite shorts, aggregates, gypsum cement, waterproofing mastic, bound, spoiled, contaminated or unidentified substances and their residues, which can not be used for other purposes	4510.1.1.01	4	0.125
Organic bound, spoiled, contaminated or unidentified substances and their residues, which can not be used for other purposes	4510.1.2.02	4	11.501
Broken tiles, roofing and other ceramic products	4510.1.3.03	4	1.805
Plastic bound, spoiled, contaminated or unidentified substances, which can not be used for other purposes	4510.1.3.08	4	0.545

Name	Code	Hazard Class	Quantity, t
Construction insulation materials and products, including spoiled, contaminated or unidentified cardboard, cloths, mats, panels and their residues, which can not be used for other purposes	4510.1.3.10	4	6.639
Remains of asphalt and asphalt mixture without tar content	4510.2.9.04	4	100.77
Spoiled (damaged) or unidentified reinforced-concrete and metal structures, and iron and steel parts	4510.2.9.06	4	1.477
Mixed waste from construction and erection of buildings and structures	4510.2.9.09	4	0.028
Total for Class 4			123.576
Total:			**125.596**

The range, volumes, hazard classes of non-radioactive waste are set out in Annex Ф Ф, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

Almost all the volumes of waste will be transferred to third parties for processing or recycling, thus, all the technical decisions concerning the operation of the CSFSF do not imply the possibility of excess waste impact on the components of the environment.

9 LIST OF GAPS AND UNCERTAINTIES

At the feasibility study stage the gaps and uncertainties have been identified, which are important for the development of the project, including in particular:

- the study of the initial situation;
- the expected impacts of the parameters;
- the projected state of the environment components and the possible consequences;

and proposals, which implementation in the course of the development of EIA materials as part of the project made it possible to eliminate all uncertainties.

Table 9.1 contains a list of uncertainties identified at the feasibility study stage and the results achieved in elimination of such uncertainties.

Repl. Inv. No
Signature. Date
Orig. Inv. No.

Table 9.1. **The List Of Gaps And Uncertainties**

Significant Environmental Aspects Of The Activities	Uncertainties Identified For This Phase Of The EIA			Analysis Of Available IDs	Corrective Results
	Uncertainty of the study of the initial situation (site identification, inventory data, baseline data on the state of environmental components)	Uncertainty of the expected parameters of the effects (right amount of raw data, including the design solutions, availability of computational, analytical, and analog effects parameter estimation methods)	Uncertainty of the projected state of the environment components and the possible consequences (availability of computational, analytical, and analog consequences estimation methods)		
Regulatory documents	Reissue of, and introduction of changes to, the documents, according to which the feasibility study has been developed	Necessity for development of the EIA section with consideration of the requirements of the normative-legal acts in the field of environmental protection, which became effective following the submission of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study (26.08.2008)	–	–	The EIA section as part of the project has been developed with consideration of the requirements of the normative-legal acts in the field of environmental protection, which became effective following the submission of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study (26.08.2008)
Legal aspects	Lack of the Planning requirements and existence of the land plot restrictions	Lack of final architectural solutions	Impediment of applying the exposure sources without final architectural solutions	No Planning requirements and restrictions of the land plot are provided	The Planning requirements and restrictions of the land plot was received from ATOMPROEKTINZHINIRING Separated Unit with Letter No. 03-46/1023 dated 10 July 2015
Legal aspects	Absence of the agreed Assignment for the development of the EIA as part of the project	According to Par. 1.6 of the Ukrainian State Building Standard DBN A.2.2-1-2003, the procedure of execution and preparation of EIA materials must meet the general process flow of the construction investment process. The structure of the EIA includes the Assignment for the development of EIA materials	Absence of the agreed Assignment for the development of the EIA as part of the project	Assignment for the development of the EIA materials as part of the Project was submitted with the KIEP PAO's letter no. 571402.202.007.KR-P dated 10 August 2015	The agreed Assignment for the development of the specific EIA materials as part of the project was received from ATOMPROEKTINZHINIRING Separated Unit with Letter No. 03-46/431 dated 16 March 2016
Meteorological characteristics of the environment in the area of projected activity	Lack of meteorological characteristics of the environment in the area of projected activity	Difficulty in estimating the concentrations of harmful substances in the surface layer of the atmosphere	Difficulty in performing the calculations on dispersion of harmful substances in the surface layer of the atmosphere	Request for the metrological characteristics in the area of projected activity was sent with the KIEP PAO's Letter No. 571402.202.004. KR-F dated 12 February 2014	Copy of letter № 16-13/-82-05-06 dated 15 January 2015 drafted by the State Emergency Service of Ukraine and the Central Geophysical Observatory with the climate parameters (metrological characteristics) was received from ATOMPROEKTINZHINIRING Separated Unit with Letter No. 03-46/76 of 22 January 2015

Significant Environmental Aspects Of The Activities	Uncertainties Identified For This Phase Of The EIA			Analysis Of Available IDs	Corrective Results
	Uncertainty of the study of the initial situation (site identification, inventory data, baseline data on the state of environmental components)	Uncertainty of the expected parameters of the effects (right amount of raw data, including the design solutions, availability of computational, analytical, and analog effects parameter estimation methods)	Uncertainty of the projected state of the environment components and the possible consequences (availability of computational, analytical, and analog consequences estimation methods)		
Data on background air pollution in the area of projected activity location	Lack of data on background air pollution in the area of projected activity location	Difficulty in estimating the concentrations of harmful substances in the surface layer of the atmosphere	Difficulty in performing the calculations on dispersion of harmful substances in the surface layer of the atmosphere	Request for provision of data on background air pollution in the area of projected activity location was sent with the KIEP PAO's Letter No. 571402.202.004. KR-F dated 02 December 2014	Copy of the letter of Kyiv Regional State Administration, Department for Ecology and Natural Resources, under 06.1-11/4689 of 23 December 2014, with data on background air pollution in the area of projected activity location, was received from ATOMPROEKTINZHINIRING Separated Unit with Letter No. 03-46/76 of 22 January 2015
Contamination of the atmosphere	–	Lack of final technology solutions based on completeness of equipment, development prospects, and procurement requirements. Absence of final decisions on the project of construction organization.	Difficulty in quantifying the facilities/objects impacts on the air, justifying their admissibility or the need to adjust the design decisions	Lack of data on emissions from diesel power plants, road and rail transport. Lack of data on emissions from construction machinery	Data on emissions from diesel power plants, road and rail transport is adopted from index sheets. Assessment of the facilities/objects impacts on the air and justification of their admissibility have been carried out
Physical effects of acoustic effects	Lack of data on background noise levels in the areas of the proposed facilities/objects location	Lack of final technology solutions based on completeness of equipment, development prospects, and uncertainty of the selection of noise characteristics.	Difficulty in quantifying the facilities/objects noise impact, justifying its admissibility or the need to adjust the design decisions	Lack of information on the noise from technological equipment, ventilation equipment, road and rail transport. Lack of information on the noise from the construction machinery.	Data on noise characteristics of technological equipment, ventilation equipment, road and rail transport is adopted from index sheets. Assessment of the acoustic impact and justification of its admissibility have been carried out
Physical effects of electromagnetic radiation	–	Lack of data for calculation of a GSM 900/1200 tower EMR	Necessity to calculate the GSM 900/1200 tower EMR	Lack of data on the EMR impact of a cellular communication antenna	Data on the EMR impact of a cellular communication antenna is adopted from index sheets. Assessment of the GSM 900/1200 tower EMR impact and justification of its admissibility have been carried out
Land plot use, removal and transformation of soil		Lack of chemical and radiological analysis on the earth masses lifted in the course of construction.	Lack of information about indirect impact of solid pollutants, emitted into the atmosphere, on the soil cover		

Significant Environmental Aspects Of The Activities	Uncertainties Identified For This Phase Of The EIA			Analysis Of Available IDs	Corrective Results
	Uncertainty of the study of the initial situation (site identification, inventory data, baseline data on the state of environmental components)	Uncertainty of the expected parameters of the effects (right amount of raw data, including the design solutions, availability of computational, analytical, and analog effects parameter estimation methods)	Uncertainty of the projected state of the environment components and the possible consequences (availability of computational, analytical, and analog consequences estimation methods)		
Generation of polluted wastewaters		Lack of final decisions on organization of the collection, disposal and treatment of surface wastewaters at the construction phase	Difficulty in evaluating the expected scale of the wastewater impact during the construction and operation of the facility	Lack of the water consumption and water discharge balance in the current situation	Water consumption and water discharge balance has been developed.
Generation of production and consumption wastes	Lack of a valid draft regulation on generation of the wastes and limitations for their placement. Lack of information on the existing sites for temporary storage of wastes.	Lack of final technology solutions based on completeness of equipment, development prospects, and procurement requirements. Lack of final data on the list and volumes of the used construction materials, construction machinery and vehicles. Lack of the final version of the master plan and construction site layout plan for arrangement of waste collection sites.	Difficulty in evaluating the expected scale of impact of wastes as a potential source of environmental pollution	Lack of specialized companies, which can take the CSFSF wastes	

10 ASSESSMENT OF IMPACT OF CONSTRUCTION, OPERATION AND ACCIDENTS AT THE CSFSF ON THE TERRITORY OF THE NEIGHBORING STATES

10.1 General Provisions

The planned activities in construction and operation of the spent VVER-reactor nuclear fuel storage facility (CSFSF) are subject to the transboundary environmental impact assessment with regard to the requirements of the Convention on Environmental Impact Assessment in Transboundary Context [26] ratified by Ukraine on 19 March 1999 [27].

The purpose of this section is preliminary proof of the absence of transboundary impact during the construction, operation, accidents and decommissioning of the CSFSF in Ukraine.

The nearest neighboring countries under the possible impact of the CSFSF are Belarus (13 km) and the Russian Federation (220 km).

Due to the fact that the Convention on Environmental Impact Assessment in a Transboundary Context [26] was not ratified by the relevant state bodies of the Russian Federation, the impact on the territory of this state is not considered.

The Convention on Environmental Impact Assessment in a Transboundary Context [26] was ratified by the Republic of Belarus (Presidential Decree No. 487 of 20 October 2005).

10.2 Impact Characteristics

The main CSFSF impact factor is radiation, so the analysis of the environment on the territory of the Republic of Belarus will be held on three main parameters characterizing the radiation environment:

- the volumetric concentration of radionuclides in the air;
- the additional surface contamination of soil;
- the additional exposure of the population.

10.3 Justification Of The Estimation Methods And Software Used

The evaluation of radiation impact on the components of the environment and the population is carried out using the software system GENII 2.10. The computer code GENII was developed for the US Environmental Protection Agency (EPA) by the National Pacific Northwest Laboratory of the US Department of Energy (US DOE (PNNL)) on the basis of the models of internal dosimetry recommended by the ICRP and the procedures of assessment of the radiological risks in accordance with the US Federal Guideline No. 13 (US Federal Guidance Report 13) [120, 121].

GENII System was developed with the aim to implement the modern, technically certified, and documented software product for the calculation of doses and radiation risks related to the releases of radionuclides into the environment. GENII System includes features for calculating the radiation doses as a result of routine and accidental releases.

When evaluating the doses received by the personnel and the public as a result of emergency emissions at the CSFSF, the EIA was based on the underlying code of GENII, the model of atmospheric trail (straight Gauss dispersion model), and the model of accidental exposure and internal dosimetry.

10.4 Source Data

The shortest distance from the CSFSF site to the state between Ukraine and the Republic of Belarus is 13 km to the north (the area of abandoned settlement Khutor Les). On the part of the Republic of Belarus, the area belongs to the Polesye State Radiation Ecological Reserve, on the

territory of which there is no permanent population due to significant radioactive contamination of the lands as a result of the Chernobyl disaster of 1986. The lands of the reserve are withdrawn from the economic use. The reserve personnel works in shifts.

Since the use of this area for living and economic activities is possible in the future, the assessment of impact of the construction and operation of the CSFSF on the territory of the Republic of Belarus will be done for the area within 13 km from the CSFSF.

The basic document regulating the requirements of the Law of the Republic of Belarus “On Radiation Safety of the Population” in the form of basic dose limits, permissible levels of exposure to ionizing radiation and other requirements to limit human exposure, is the document of the Republic of Belarus GN 2.6.1.8-127-2000 [122].

In accordance with this document, the limit of the annual effective dose received by the population is 1 mSv. The same document lists the permissible volumetric activity values concerning the air inhaled by the population ($DOA_{нас}$,Bq/m^3). Below are the values of $ДОА_{нас}$ (GN 2.6.1.8-127-2000 [122]_ for some of the radionuclides:

- ^{60}Co..... 1.1 E+01 Bq/m³;
- ^{90}Sr..... 2.7 Bq/m³;
- ^{137}Cs..... 2.7 E+01 Bq/m³;
- ^{238}Pu..... 2.7 E-03 Bq/m³;
- ^{241}Pu..... 1.4 E-01 Bq/m³;
- ^{241}Am..... 2.9 E-03 Bq/m³.

10.5 Assessment Of The Impact During Construction

The preparation of the site for construction of the storage facility implies earhworks, which may result in the radioactive contamination of the air with dust.

10.5.1 Air Pollution

The additional average annual volumetric air pollution on the border of Belarus (within 13 km) as a result of the CSFSF construction, according to IFS [24], is estimate as follows:

- ^{137}Cs..... 3.0 E-08 Bq/m³;
- ^{90}Sr..... 5.9 E-09 Bq/m³;
- TUE..... 3.5 E-10 Bq/m^3.

The values indicated are negligible compared to the permissible volumetric activity in the inhaled air in the Republic of Belarus (GN 2.6.1.8-127-2000 [122]) — see Table 10.4.

10.5.2 Contamination Of The Soil Surface

On the nearest border with Belarus (13 km southwest of the CSFSF), the additional surface contamination with $^{134+137}$Cs, ^{90}Sr and alpha-emitting TUE as a result of CSFSF operation will be 0.2 Bq/m², 0.04 Bq/m² and 0,002 Bq/m² respectively, which is negligible.

10.5.3 Additional Exposure Of The Personnel And The Population

Additional individual effective doses on the border of Belarus (13 km) as a result of construction of the CSSNF, according to IFS [24], will be about 4.0 E-5 mSv. This negligibly small value is by five orders of magnitude lower than the annual effective dose limit for the population of Belarus (GN 2.6.1.8-127-2000 [122]).

10.6 Assessment Of The Impact During Operation

10.6.1 Assessment Of The Impact During Normal Operation Of The CSFSF

The radiation impact during normal operation of the CSFSF, due to considerable distance, is very little and will not cause any adverse impact on the air, soil and the health of the population of the border areas of the Republic of Belarus.

10.6.2 Assessment Of Impact During The Design Basis Accident With The Maximum Consequences

10.6.2.1 Air Pollution

On the border with the Republic of Belarus, the maximum additional average annual concentration of ^{60}Co in the lower layers of the atmosphere will be 1.82E-07 Bq/m³.

10.6.2.2 Contamination Of The Soil Surface

On the border with the Republic of Belarus, the maximum additional contamination with ^{60}Co will be 2.7E-07 Bq/m³.

10.6.2.3 Additional Exposure Of The Personnel And The Population

The additional individual effective dose from all the sources of radian on the border with the Republic of Belarus will be 1.3E-09 Sv.

10.6.3 Assessment Of Impact During The Beyond Design Basis Accident

10.6.3.1 Air Pollution

On the border with the Republic of Belarus, the maximum additional average annual concentration of radionuclides in the lower layers of the atmosphere will be as follows:

- ^{60}Co..... 9.5 E-04 Bq/m³;
- ^{90}Sr..... 6.70E-03 Bq/m³;
- ^{137}Cs..... 1.05E-02 Bq/m³;
- TUE..... 2.10E-03 Bq/m³.

10.6.3.2 Contamination Of The Soil Surface

On the border with the Republic of Belarus, the maximum additional contamination of soils with radionuclides will be as follows:

- ^{60}Co..... 1.4 E-02 Bq/m²;
- ^{90}Sr..... 1.00E+03 Bq/m²;
- ^{137}Cs..... 1.60E+03 Bq/m²;
- TUE..... 3.18E+02 Bq/m².

10.6.3.3 Additional Exposure Of The Personnel And The Population

The additional individual effective dose from all the sources of radian on the border with the Republic of Belarus will be 9.34E-05 Sv.

10.7 Conclusions On The Transboundary Impact Of The CSFSF

On stage IFS stage [24], in accordance with the Convention on Environmental Impact Assessment in a Transboundary Context [26], the activities in the neighbouring states in raising awareness about the possible impact of the CSFSF were held. The report on such activities is provided in Annex Ш. Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

The analysis of the design values of radiation impact on the components of the environment in the border areas of the Republic of Belarus as a result of construction, normal operation and accidents at the CSFSF suggests as follows:

- the construction and normal operation of the CSFSF will not lead to significant adverse impact on the state of the air, soil and border areas of the Republic of Belarus as well as the public health throughout the period of existence (100 years);
- in the case of the design basis accident with the heaviest consequences during operation of the CSFSF, the air and soil pollution, as well as the additional exposure of the population in the border areas of the Republic of Belarus will be negligible compared to the normative criteria, established by the radiation safety standards of the Republic of Belarus (GN 2.6.1.8-127-2000 [122]);
- in the case of the beyond design basis (hypothetic) accident during operation of the CSFSF, the air and soil pollution, as well as the additional exposure of the population in the border areas of the Republic of Belarus will not lead to significant changes in the radiation situation, which is acceptable given the low probability of such events.

The analysis of the design values of radiation impact on the components of the environment in the border areas of the Republic of Belarus as a result of construction, normal operation and accidents at the CSFSF, carried out and the design stage, proves the conclusions state in the IFS as to the transboundary impact of the CSFSF.

11 STATEMENT ON THE ENVIRONMENTAL IMPACT OF ACTIVITIES

Statement on the environmental impact of activities and data on its publication are provided in the following Annex: Щ Volume 12.2 Environmental Impact Assessment. Part 2. Annexes.

11.1 Data On The Planned Activities, Goals And Ways Of Their Implementation

The Central Spent Fuel Storage Facility (CSFSF) is a nuclear facility of national importance. The decision on construction and location of CSFSF was adopted by the Law of Ukraine “On The Management Of Spent Fuel: Location, Design And Construction Of The Centralized Storage Facility For Spent Fuel Of The Domestic VVER Nuclear Power Plants” following the Investment Feasibility Study approved by the Resolution of the Cabinet of Ministers of Ukraine No. 131-r of 04 February 2009.

Main results of the study:

- CSFSF is to be located on the site between the villages of Stara Krasnytsia, Buryakivka, Chystogalivka and Stechanka in Kyiv Region within the exclusion zone with radioactive contamination after the Chernobyl disaster;
- the storage of spent nuclear fuel to be used is a surface “dry” storage with double-barrier insulation system;
- CSFSF lifetime — 100 years;
- CSFSF capacity — 16529 SFAs, including: 12010 pcs of VVER-1000 SFAs and 4519 pcs of VVER-400;

The CSFSF is based on the technology by Holtec International (hereinafter — Holtec). Main elements of the technology:

- MPC—multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT) (transfer vehicle);
- transporter car for HI-STAR.

The project provides for the reception of HI-STARs with MPCs, transfer of the MPCs from the HI-STARs to HI-STORMs, concrete-casting of the HI-STORMs’ shells, and the storage of the HI-STORMs, filled with spent nuclear fuel in the territory of the CSFSF.

Binding of the technology to a specific nuclear power unit will be made under the modifications projects in accordance with the current legislation in the field of nuclear energy.

EIA materials as part of the Project are developed on the basis of the EIA approved by the Cabinet of Ministers of Ukraine as part of the CSFSF investment feasibility study, with consideration of requirements of the normative-legal acts in the field of environmental protection, which became effective following the submission (26.08.2008) of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study.

CSFSF designing process shall be performed in three stages. Assessment of the CSFSF environmental impact was carried out at the first stage of the design, as part of the investment feasibility study. The EIA results were approved by Decree of the Cabinet of Ministers of Ukraine No. 131-r of 04 February 2009 on the basis of the comprehensive conclusion (positive) issued by Ukrderzhbudekspertyza SE on 26 August 2008 under No. 84/54/288o.

- EIA as part of the CSFSF project (second approvable design stage) was carried out with consideration of:

- refinement of design solutions of the technology provider;
- raw data, regulated by the Law of Ukraine on Regulation of the Town Planning Activity;
- requirements of the normative-legal acts in the field of environmental protection, which became effective following the provision (26.08.2008) of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study.

11.2 Significant Factors, Which Affect Or May Affect The State Of The Environment, Taking Into Account The Possibility Of Environmental Emergencies

During implementation of the planned activities there are no significant factors, which affect or may affect the state of the environment, taking into account the possibility of environmental emergencies.

Additional radiation exposure in case of hypothetical accidents is insignificant. Maximum additional doses of the personnel exposure to the radiation will not result in exceeding the reference levels; and those calculated for the population are much lower than the limit set by NRBU-97.

Analysis of the calculated indicators of the radiation effects on components of the environment in the border areas of the Republic of Belarus at construction, normal operation and accidents in CSSNF shows:

- construction and normal operation of the CSFSF will not lead to significant negative impacts on the state of air, soil and health of the population of the border areas of the Republic of Belarus throughout the entire period of existence (100 years);
- in case of a design accident during operation of the CSFSF with most severe consequences, air and soil pollution, as well as additional exposure of the population of the border areas of the Republic of Belarus, will be negligible compared to the statutory criteria established by the radiation safety regulations of the Republic of Belarus;
- in case of a hypothetical off-design accident at the CSFSF, air and soil pollution, as well as additional radiation exposure of the population of the border areas of the Republic of Belarus, will not lead to significant changes in the radiation situation, and that, given the minor probability of such accident, remains acceptable.

Analysis of the calculated indicators of the radiation effects on components of the environment in the border areas of the Republic of Belarus at construction, normal operation and accidents at the CSFSF was performed at the Design stage and supports conclusions on the CSFSF's transborder impact, which are laid down in the investment feasibility study.

11.3 Quantitative And Qualitative Indicators For Assessing The Environmental Risk Levels And Safety Of The Planned Activity For The Life Of The Population, As Well As Measures To Ensure Implementation Of This Activity In Accordance With The Environmental Standards And Regulations

No thermal pollutions or evaporations are anticipated during the CSFSF operation. The CSFSF operation does not affect the intensity of solar exposure, temperature, wind speed, humidity, atmospheric inversions, fog duration, and other climatic characteristics. With that being said, there is no impact on the climate and microclimate.

Under normal conditions of work and in case of accidents, additional radiation exposure is extremely insignificant.

Due to a sufficient distance from the site to the the territories with controlled levels of the living environment, the pollutant emissions will not have negative impact on health and lifestyle of the population of the adjacent areas. Analysis of the results of the calculations of surface pollutant concentrations shows that implementation of this project is performed with adherence to the respective sanitary and hygienic standards for each pollutant considered.

In terms of air pollution, the operation of the facility is permissible.

Acoustic effects of the facility operation will be of a permanent nature and will accompany the activities at the facility throughout the entire operation period. Analysis of the obtained results of the calculations of acoustic effects show show that the noise discomfort zone of the technological equipment does not exceed the boundaries of the SPZ and will not affect the formation of further sound field.

Operation of the facility, in terms of expected noise, is acceptable.

The impact of electric and electromagnetic fields during operation of the facility will be permanent and will accompany the facility operation during the entire operation period.

The impact of electrical equipment (transformers, generators, electrical drives, diesel generator power units) is absent. The impact of radio antennas is permissible. Due to a quite large distance from the facility to the territories with controlled quality of the living environment, the site operation will not result in exceeding the sanitary and hygienic standards. Electromagnetic field generated around the radio facilities (radio antennas) is safe for the human health.

Operation of the facility, in terms of electric and electromagnetic impact, is acceptable.

There are no active karst and karst-suffosion processes, as well as landslides and shifts that could lead to disruption of normal operation of the facility.

Implementation of this project gives no direct discharges into the aquatic environment.

Results of the environmental impact assessment are provided in the project with consideration of refinement of the CSFSF technology, equipment and infrastructure and with consideration of requirements of normative-legal acts in the field of environmental protection, and confirm the EIA results represented in the investment feasibility study. Environmental impact of the planned activity is acceptable.

Assessment Results For The Risk Of The Planned Activity Impact On The Environment:

Radiation contamination risk assessment

- the impact on the environment does not exceed the current state of the environment, does not exceed the exposure standards valid for the E&CRZ, and can be considered acceptable (according to the reference levels)

Assessment of the human health risk from air pollution by chemicals

- the risk of non-carcinogenic effects is extremely low, the likelihood of adverse effects increases pro rate to the increase of the hazard coefficients for certain substances;
- the risk of carcinogenic effects is conditionally acceptable;
- the social risk of the planned activities is conditionally acceptable.

Analysis of the results obtained from the performed calculations and assessment of the CSFSF radiation impact shows that the risk of the facility for the environment and public health is acceptable.

Analysis of the results obtained from the performed calculations during assessment of the risk of the air pollution with chemical contaminants to the public health shows that the risks of the planned activity impact on the environment are assumed acceptable.

Upon the assessment of the risks, implementation of this project is not subject to any restriction.

11.4 List Of Residual Impacts

Residual effects of the planned activity during construction will be as follows:

- radiation impact due to dust raising;
- contaminant emissions from the construction equipment and machinery;
- acoustic impact of the construction equipment and machinery;
- generation of wastes.

Residual effects of the planned activity during operation will be as follows:

- radiation impact;
- contaminant emissions from the CSFSF infrastructure;
- acoustic impact of the CSFSF infrastructure;
- impact of the electric and electromagnetic fields of the communication antennas;
- generation of wastes.

Actions envisaged by the project will provide an acceptable level of residual impacts on all environmental objects.

11.5 Adopted Measures To Inform The Public About The Planned Activity, Purpose And Ways Of Its Realization

For the purpose of informing the public about the proposed activity, taking into account the requirements of the Convention On Access To The Information, Public Participation In Decision-Making And Access To Justice In The Environmental Matters" ratified by Ukraine on July 6, 1999, the following actions were take at the feasibility study stage:

- publication of the Statement of Intent (25.01.2007);
- holding of a public consultation process on the construction of the central storage facility for nuclear fuel from the VVER nuclear power plants of Ukraine (after 06.02.2008);
- holding of a round table in Slavutych on the construction of the CSFSF (28.02.2008);
- holding of a round table in Ivankiv on the construction of the CSFSF (01.03.2008);
- public hearings on the planned activity in Slavutych, Kyiv Region (22.03.2008);
- publication of the Environmental Impact Statement (07.03.2007).

Following the transparency and openness principles of the environmental policy of Energoatom National Nuclear Energy Generating Company and in accordance with the requirements of the Ukrainian laws, information on the planned activity is kept up to date on the official website of Energoatom National Nuclear Energy Generating Company.

Materials on Public Relations under the CSFSF Project

posted on the official website of Energoatom National Nuclear Energy Generating Company at (http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/press/).

For the purpose of informing the public about the planned activity, the Project stage involves the following actions:

- publication of the Environmental Impact Statement;
- updating of the information

related to this project on the official website of Energoatom National Nuclear Energy Generating Company (http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/official/);

11.6 The Obligation Of The Customer In Relation To Implementation Of The Design Solutions In Accordance With The Rules And Regulations Of Environmental Protection And Ecological Safety Requirements At All Stages Of Construction And Operation Of The Facility

Operating organization — Energoatom National Nuclear Energy Generating Company — will ensure:

- safe operation in accordance with the regulations, operating instructions, and technological regulations valid in Ukraine;
- appropriate management structure, and maintenance personnel qualification;
- continuous monitoring during operation of all activities to ensure compliance with the environmental requirements.

Glossary

HI-STAR 190 UA	– External cask for receiving and storing spent nuclear fuel loaded into a multipurpose sealed container. It serves as a protective outer jacket for the sealed MPC, and provides protection against gamma and neutron radiation.
HI-STORM 190	– HI-STORM 190 outer protective cask or concrete storage module designed to receive and place sealed multipurpose casks loaded with the spent nuclear fuel for long-term storage. The cask offers protection against gamma and neutron radiation, ventilation, protection against wind-blown objects, accident and environmental impacts on MPC casks with spent fuel.
HI-TRAC 190	– HI-TRAC 190 transfer cask. This is the transfer cask where the MPC is kept during fuel loading, unloading, drying, sealing, and other transfer and process operations and power units, and the transfers into the HI-STAR transfer/provisional storage cask. HI-TRAC offers biological protection and protects the MPC loaded with the spent nuclear fuel.
Metamic-HT	– Metamic-HT neutron absorber is a composite material consisting of the pure Al metal matrix with the addition of nano-sized aluminum oxide particles and fine boron carbide particles.
Impact	– shall be understood as adding any material substance into environment or its removal from environment, or other actions giving rise to changes in its condition (DBN A.2.2-1-2003 [10])
Reference impact	– shall be understood as the environmental impact taking place within allowed limits without causing excessive changes (DBN A.2.2-1-2003 [10])
Gas-aerosol discharge	– shall be understood as the ingress of radioactive substances into the atmospheric air from process loops and ventilation systems of a plant (DHN 6.6.1-6.5.001-98 [14])
Dose	– shall be understood as a measure of the ionizing radiation impact on a substance
Supervised area	– shall be understood as an area of the potential impact of radioactive discharges and emissions of a radiation/nuclear facility where technology processes are monitored to ensure radiation safety or a radiation/nuclear facility (DHN 6.6.1-6.5.001-98 [14])
Background radiation	– shall be understood as radiation from sources that make up natural radiation background (DHN 6.6.1-6.5.001-98 [14])
Ionizing radiation	– shall be understood as (electromagnetic, corpuscular) radiation that ionizes and excites its atoms and molecules directly or indirectly when interacting with a substance (DSP 6.177-2005-09-02 [16])
Impact sources	– shall be understood as artificial and natural objects (or components thereof), processes and phenomena than affect environment (DBN A.2.2-1-2003 [10])

Reference levels (RL)	–	shall be understood as radiation hygiene regulations of Group One whose numeric values are set on the basis of the actual level of the radiation welfare attained at the radiation/nuclear facility or area in question. The RL value is specified by the management of the plant in concurrence with State Sanitary/Epidemiological Supervision agencies in order to keep exposure of personnel and/or population below dose limits and carry out radiation dosimetry control (DHN 6.6.1-6.5.001-98 [14])
Multi-purpose cask (MPC)	–	shall be understood as a sealed cask consisting of a cellular fuel basket for the SNF storage placed into a cylindric-shaped cask shell (MPC hermetic casing). MPC is a containment case for storage conditions. The MPC design offers two containment cases (inside and outside) for the SNF stored inside. Core elements of an MPC include its inside and outside cask shells, inside and outside bottoms, inside and outside caps, a fuel basket, drain and vent of the inside cap, and the outside cap gas filling orifice.
Natural environment	–	shall be understood as a set of natural factors and environmental objects of natural provenance or development (DBN A.2.2-1-2003 [10])
Social environment	–	shall be understood as a set of social and household living conditions of the population, socio-economic relations among people and groups of people, as well as between themselves and tangible or spiritual values created by them (DBN A.2.2-1-2003 [10])
Environment	–	shall be understood as a set of natural and social (including the human life milieu) and technology-induced conditions of existence of the human society (DBN A.2.2-1-2003 [10])
Artificial environment	–	shall be understood as an artificially created component of the environment that consists of technology-related and natural elements (DBN A.2.2-1-2003 [10])
Environmental protection	–	shall be understood as a suite of international, national, regional, local, administrative/commercial, technology-related, and public activities focused on preserving and supporting sustainable use of nature, renewal, protection, and development of natural resources.
Environmental Impact Assessment (EIA)	–	shall be understood as determining scopes and levels of the influence of a planned activity on environment, measures aimed at preventing or mitigating the impacts in question, sustainability of design solutions from the point of view of the environmental safety.
Risk	–	shall be understood as a probability of a certain negative environmental impact that can occur at a certain time or under certain circumstances due to the planned activity (DBN A.2.2-1-2003 [10])
Buffer area (SZZ)	–	shall be understood as an area around a radiation/nuclear facility where the human exposure level under normal operating conditions can exceed the dose limit. Category B individuals are prohibited from residing within the buffer area, while productive activities not related to the radiation/nuclear facility are restricted and radiation control shall be exercised in the area (DHN 6.6.1-6.5.001-98 [14])
Fuel basket	–	A fuel basket is a welded cellular structure with openings used to accommodate spent fuel assemblies of the appropriate type.

Environmental safety	– shall be understood as the condition of the natural environment that makes it possible to prevent environmental situation from deteriorating and the hazard to human health from arising. Law of Ukraine “On Environmental Protection” [3]. “Assurance of environmental safety and maintenance of environmental balance within the territory of Ukraine shall be the duties of the state”, Constitution of Ukraine [1].
Ecology	– is classically understood as a discipline of biology that studies interactions of plants, animals, fungi, microorganisms, and viruses among themselves, and between them and the environment. Ecology studies supraorganismal systems, their structures and operation at a level of a population, an ecosystem, biotic communities and biosphere. Modern ecology also studies impacts of civilizational processes on the environment in order to prevent negative consequences of human technology-related activities.

Abbreviations and Acronyms

NPP	–	Nuclear power plant
VVER	–	Water-Water Power Reactor (a reactor of PWR type)
SEZMA	–	State Exclusion Zone Management Agency of Ukraine
DP NAEK Energoatom	–	State-owned Enterprise “Energoatom National Nuclear Energy Generating Company”
Ekotsentr	–	State-owned Specialized Research and Production Enterprise “Chernobyl Radioecology Center”
DSP Chernobyl NPP	–	State-owned Specialized Enterprise “Chernobyl Nuclear Power Plant”
IC-engine	–	Internal combustion engine
E&CRZ	–	Exclusion and compulsory resettlement zone
BDBA	–	Beyond-design-basis accident
GTU	–	Geotechnical units
CES	–	Contaminant emission source
NS	–	Noise source
CMU	–	Cabinet of Ministers of Ukraine
RL	–	Reference level
MDBA	–	Maximum design-basis accident
MDE	–	Maximum design earthquake
MPC	–	Multipurpose cask
NASU	–	National Academy of Sciences of Ukraine
RD	–	Regulatory documents
EIA	–	Environmental Impact Assessment
OP API	–	Separated unit “Atomproektinzhiniring”
SFA	–	Spent fuel assemblies
SNF	–	Spent nuclear fuel
DBA	–	Design-basis accident
PAO KIEP	–	Public Joint Stock Company ENERGOPROEKT Kyiv Research and Development Institute
MAC	–	Maximum allowed concentration
MAL	–	Maximum allowed level
DBE	–	Design-basis earthquake
PAs	–	Protected areas
RTF	–	Radio transmitting facilities
RW	–	Radioactive waste
RLC	–	Radio link communication
RF	–	Radio facility
Media	–	Mass media outlets
FPS	–	Fire protection system
TE	–	Transiranium elements
IFS	–	investment feasibility study
CGO	–	Central Geophysical Observatory
CSFSF	–	Central Spent Fuel Storage Facility
EMF	–	Electromagnetic field

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Annex A
(mandatory)
Qualification Certificate Of The Executive In Charge Of The Engineering And Construction Design In Terms Of Life Safety And Health, And Environment Protection

Annex Б
(mandatory)
Terms of Reference For The Development Of the EIA Materials As Part Of The Project "Construction Of The Central Spent Fuel Storage Facility For The VVER Nuclear Power Plants In Ukraine"

Annex B
(mandatory)
Statement Of Intention And Data On Publication

Annex Г
(mandatory)
Planning Terms and Restrictions

Annex Д
(mandatory)
The recommendations of public hearings on the placement of the CSFSF for the VVER nuclear power plants in Ukraine

Annex E
(mandatory)
CSFSF Site Layout Plan

Annex Ж
(mandatory)
Data On Meteorological Characteristics And Background Air Pollution Around Site Of Projected Activity

Annex И
(mandatory)
Map Of Radiation Impact Sources

Annex K
(mandatory)
Estimated Radiation Impact During Operation

K.1 Estimate at MDBA

K.2 Estimate at BDBA

Annex M
(mandatory)
Map Of Contamination Sources Within The CSFSF Site

Annex H
(mandatory)
Estimated Concentration Of Pollutants In The Lowest Atmospheric Layer During Operation

H.1 Estimated Concentration Of Pollutants In The Lowest Atmospheric Layer During Operation (without regard to the background)

H.2 Estimated Concentration Of Pollutants In The Lowest Atmospheric Layer During Operation (without regard to the background)

Annex П
(mandatory)
Map Of Noise Sources And Calculated Points Within The CSFSF Site

Annex P
(mandatory)
Calculated Sound Pressure

P.1 Calculated Sound Pressure In The Design Points Of The Projected Site

P.2 Sound Pressure Maps

Annex C
(mandatory)
Estimated Environmental Impact Of RF

Annex T
(mandatory)
The CSFSF Water Consumption To Water Disposal Balance

Annex У
(mandatory)
Map Of Observation Wells On The CSFSF Site

Annex Φ
(mandatory)
List, Production Volumes And Hazard Classes Of Non-Radioactive Waste

Annex X
(mandatory)
The CSFSF Site Landscaping Map

Annex Ц
(mandatory)
Estimated Environmental Impact Of The Projected Activity

Annex Ч
(mandatory)
Estimated Pollution In The Lowest Atmospheric Layer During Construction

Ч.1 Estimated Pollution In The Lowest Atmospheric Layer During Construction (without regard to the background)

Ч.2 Estimated Pollution In The Lowest Atmospheric Layer During Construction (without regard to the background)

Annex Ш
(mandatory)
Report On The Activities In The Neighbouring States In Raising Awareness About The Possible Impact Of The CSFSF In The Transboundary Context

Annex Щ
(mandatory)
Statement Of Environmental Effect Of The Activities And The Data On Publication

Appendix C2

EnergoAtom. 2007. Centralized Spent Nuclear Fuel Storage Facility (CSNFSF) for VVER-Type Reactors of the Ukrainian Nuclear Power Plants, Investment Feasibility Study, Analytical Summary.

MINISTRY OF FUEL AND ENERGY OF UKRAINE

State scientific-engineering center for control systems and emergency response		**National Nuclear Energy Generating Company "Energoatom"**
Open Joint-Stock Company Kiev ……		

CENTRALIZED SPENT NUCLEAR FUEL STORAGE FACILITY (CSNFSF) FOR WWER-TYPE REACTORS OF THE UKRAINIAN NUCLEAR POWER PLANTS

Investment Feasibility Study Analytical Summary

Kyiv –2007

TABLE OF CONTENTS

1. LIST OF ABBREVIATIONS 4
2. INTRODUCTION 5
2.1. Baseline Information 5
2.2. Place and role of SNF Management 5
2.3. SNF Pileup Forecast for WWER-type reactors 7
2.4. Potential SNF Management Scenarios 9
2.5. Current SNF Management Scenario for WWER-based Reactors at Ukrainian NPPs 9
2.6. SNF Management Solution Selection for WWER-based SNF at CSNFSF 10
2.7. IFS Primary Aim and Objectives 11
2.8. Essential SNF Storage Requirements and Initial IFS Technical Assumptions 12
2.9. CSNFSF Major Lifecycle & Design Stages 13
3. CSNFSF CONSTRUCTION NECESSITY AND PRACTICALITY SUBSTANTIATION 14
3.1. Baseline data 14
3.2. Potential SNF Management Scenarios at the end-of-life stage of the NFC 14
3.3. Major SNF Management Options – Comparative Analysis Results 16
4. CSNFSF CONSTRUCTION SITE SELECTION AND SUBSTANTIATION PROCESS 17
4.1. General CSNFSF construction site selection algorithm 17
4.2. Selection of three potential construction sites 17
4.3. "KhNPP" Site – Brief Description 19
4.4. ChNPP Site – Brief Description 22
4.5. "SDF" Site – Brief Description 24
4.6. Analysis and comparison of ecological, radiation control, technical and economic siting criteria for suggested construction sites 26
4.7. Most favorable CSNFSF construction site location selection 27
5. PRIMARY TECHNICAL SOLUTIONS 29
5.1. Primary SNF Management technology solutions 29
5.2. CSNFSF Facility Specifications 31
5.3. Primary construction solutions 34
6. SAFETY PRACTICES 38
6.1. Nuclear safety 38
6.2. Radiation safety 40
6.3. Fire safety 46
6.4. Occupational safety 47
7. RADIOACTIVE WASTE MANAGEMENT 49
7.1. LRW Management 49
7.2. SRW Management 49
8. CONSTRUCTION MANAGEMENT 51
8.1. CSNFSF Construction Phases 51
8.2. Physical Volumes of Construction and Assembly Works 52
8.3. Construction staffing requirements 52
8.4. Construction Material Needs 53
8.5. Energy and water resources requirements 53
9. CSNFSF OPERATION 54
9.1. Operational Stages 54

9.2. Staffing Requirements 54
9.3. Estimated Energy & Water Requirements 54
10. CSNFSF WITHDRAWAL FROM SERVICE / DECOMMISSIONING 56
10.1. General principles 56
10.2. CSNFSF Decommissioning Strategy 56
10.3. RW Management during decommissioning 57
11. ENVIRONMENTAL IMPACT ASSESSMENT 58
11.1. Environmental Components and Impact Types analyzed by EIA 58
11.2. Site environmental description 59
11.3. Social Environment Description 68
11.4. Technogenic environment description 69
11.5. Geological environment impact assessment 70
11.6. Aerial Environment Impact Assessment 70
11.7. Open / ground waters impact assessment 74
11.8. Ground surface impact assessment 75
11.9. Flora and fauna impact assessment 78
11.10. Social environment impact assessment 78
11.11. Technogenic environment impact assessment 80
11.12. Environmental Impact Minimization Efforts 80
11.13. Controlled Access Area Definition. CSNFSF's Permissible Emission Threshold Definition 83
11.14. Residual impacts summary. Ecological risks assessment. 83
11.15. Environmental Impact Assessment in its Transboundary Context 83
12. CONCLUSIONS 91
REFERENCES 92

1. LIST OF ABBREVIATIONS

ARSMS	-	Automated radiation situation monitoring system
NPP	-	Nuclear power plant
SFP	-	Spent fuel pool
MPC	-	Multipurpose [fuel] canister
HLRW	-	High-level radioactive waste
HM	-	Heavy metal
SFA	-	Spent fuel assembly
SNF	-	Spent nuclear fuel
[SE] NNEGC "Energoatom"	-	[State Enterprise] "National Nuclear Energy Generating Company "Energoatom"
SAR	-	Safety Analysis Report
EZ	-	Exclusion Zone – category of the territory that suffered from radioactive contamination as a result of the Chernobyl Disaster
WFS	-	Withdrawal from service; Decommissioning
PPE	-	Personal protective equipment
BDBA	-	Beyond-design-basis accident
CA	-	Control area
IAEA	-	International Atomic Energy Agency
"KhNPP" Site	-	Suggested construction site for centralized SNF storage facility, located at Khmelnytsky NPP Construction Plant
"ChNPP" Site	-	Suggested construction site for centralized NSF storage facility, located near NSF storage facility #2 at Chernobyl NPP (under construction)
"SDF" Site	-	Suggested construction site for centralized SNF storage facility, located near "Vector" LRW Storage and Disposal Facility
MDBA	-	Maximum design-basis accident
MDE	-	Maximum design earthquake
EIA	-	Environmental Impact Assessment
SDE	-	Site design earthquake
RW	-	Radioactive waste
LRW	-	Liquid radioactive waste
ILW	-	Intermediate Level [Radioactive] Waste
CAA	-	Controlled access area
MCS	-	Monitoring & Control System
RMS	-	radiation monitoring system
NFA	-	Nuclear fuel assembly
SRW	-	Solid radioactive waste
IFS	-	Investment Feasibility Studies
TUE	-	Transuranic elements
CSE	-	Centralized Storage Enterprise
CSNFSF	-	Centralized SNF Storage Facility of the WWER-type reactors of the NPPs of Ukraine
ChNPP	-	Chernobyl NPP
NEC	-	Nuclear energy complex
NF	-	Nuclear fuel
NFC	-	Nuclear fuel cycle
NP	-	Nuclear plant (nuclear facility)

2. INTRODUCTION

2.1. Baseline Information

2.1.1. The development of the investment feasibility study (hereinafter referred to as IFS) for centralized spent nuclear fuel storage facility of the WWER-type reactors of the NPPs of Ukraine (hereinafter – CSNFSF) is governed by the international treaties ratified by Ukraine [1-4], laws of Ukraine [5-10,34], legislative regulations [11-15] and other documents.

2.1.2. CSNFSF IFS was developed under order from State Enterprise "National Nuclear Energy Generating Company "Energoatom" (SE NNEGC «Energoatom», Kyiv) by Kyiv scientific-research and design-and-engineering institute "Energoproekt" (KIEP, Kyiv).

2.1.3. This document is an analytical summary (hereinafter – AS) of the IFS documentation, comprised in order to raise awareness of the public at large with principal terms and conditions of the IFS, including assessed social, sanitary, ecological and other implications resulting from CSNFSF's construction and operation. This document was developed by State scientific-engineering center for control systems and emergency response (SSEC CSER, Kyiv) under order from NNEGC "Energoatom".

2.1.4. This AS presents summarized baseline information, assumptions and their substantiations, as well as provides general technical solutions and assessment results, as stipulated by CSNFSF IFS and its corresponding sections and documents listed below:

- Baseline information for CSNFSF design, substantiation and feasibility study [16];
- Alternative SNF Management methods and their evaluation and analysis [17];
- Primary technology solutions [18];
- Nuclear and radiation safety [19];
- CSNFSF Sites evaluation and comparison [20];
- General Site Layout and Transportation [21];
- Primary Construction Planning & Management Solutions [22];
- CSNFSF Technical and Economic Performance Indicators [23];
- Overall Summary Estimate [24];
- Environmental Impact Assessment [25,26];
- Draft Environmental Impact Statement [27].

2.1.5. This AS is a summary document only. It does not contain any additional data, original assessments or independent conclusions. It is entirely based on the information provided in the CSNFSF IFS. At the same time some information in this document was structurally re-ordered to improve general readability compared with the original IFS structure.

Information provided in Section 2 of this AS was detailed in the CSNFSF IFS documents [16,23].

2.2. Place and role of SNF Management

2.2.1. Internal energy consumption growth, as well as growth of electrical energy export supplies forecast for the coming decades, as well as limited fossil fuel deposits suitable for use in conventional thermal power plants and respective ecological problems, combined with the absence of significant unused water-power resources in Ukraine and pessimistic forecasts for commercial use of non-conventional power sources – all these factors imply that nuclear energy sector, currently demonstrating high competitiveness, has no viable alternatives.

2.2.2. Nuclear power plants in Ukraine currently operate a total of 15 reactors, 2 of which are of type WWER-440, the other 13 are type WWER-1000. The dynamics of nuclear power generation in comparison with the total electrical energy generation in Ukraine in the past

decade is shown in Figure 2.1 below.

As one can see, nuclear energy complex (hereinafter – NEC) has been generating a substantial amount (over 40%) of electric energy in Ukraine for an extended period of time. This makes the stability of NEC operation a very import factor for stable economic development of the whole country.

[X-axis: Years
Y-axis: Energy generated (terawatt/hours)
Dark-blue bars: Total amount of electrical energy generated
Yellow bars: incl. Energy generated by Ukrainian NPPs]

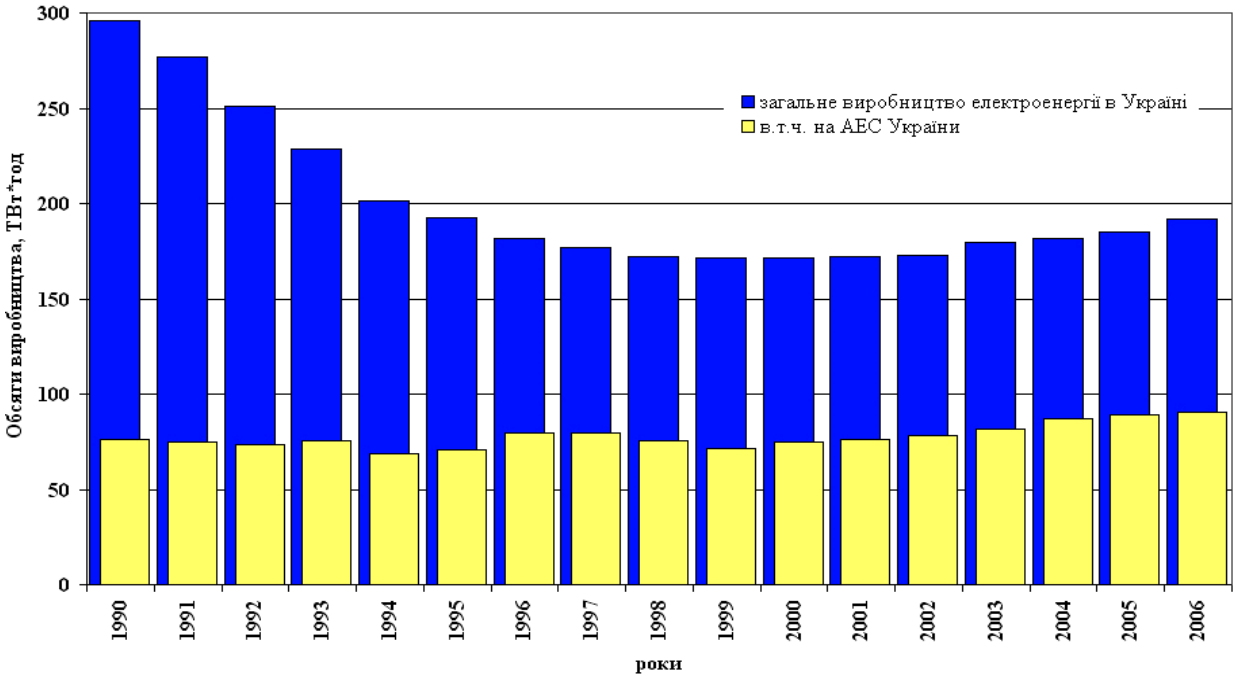

Figure 2.1. Ukrainian Electric Energy Generation in 1990 – 2006.

2.2.3. Summarized data on NPPs currently in operation in Ukraine is provided in Table 2.1 below. Designed operating period for the nuclear power reactors currently in use has been defined back in 1970es. NPP unit operating period was then set at 30 years, the underlying design data being quite conservative. At the same time, global experience and international practices, as well as assessment data for nuclear power reactors in use at Ukrainian NPPs indicate a potential technical possibility to extend the duration of the operating period beyond its designed ending date. Based on this estimate, an extension of the ending date for the power reactors currently in use for additional 15 years has been adopted as a baseline for all assessments, design estimates and substantiations in CSNFSF IFS (see Table 2.1).

2.2.4. Nuclear power generators operate on nuclear fuel. Nuclear fuel cycle (hereinafter – NFC) has three basic stages – initial stage, reactor stage and an end-of-life stage. Initial stage includes uranium ore mining and milling, uranium hexafluoride (UF6) fabrication, physical uranium milling through U^{235} isotopic enrichment to the values stipulated by the NPPs design documentation, uranium hexafluoride conversion into uranium dioxide, fabrication of nuclear fuel (in form of reactor fuel pellets), nuclear fuel assemblies (hereinafter – NFA) and the delivery of NFAs to the NPPs.

NFC's reactor stage includes nuclear fuel consumption inside the reactor unit while generating electric energy and temporary spent nuclear fuel (SNF) storage in the spent fuel pools

(SFP) at the reactor sites.

The end-of-life stage of the nuclear fuel cycle begins with spent nuclear fuel being discharged from SFPs and ends with its reprocessing or storage.

Table 2.1. Operating NPPs of Ukraine: Summarized Data.

NPP Name	Unit Number	Reactor type	Installed nuclear capacity (MW)	Reactor power start-up date	Designed ending date	Extended ending date (Decommissioning date)
Zaporizhzhia	1	WWER-1000/320	1000	10.12.1984	10.12.2014	10.12.2029
NPP	2	WWER-1000/320	1000	22.07.1985	22.07.2015	22.07.2030
	3	WWER-1000/320	1000	10.12.1986	10.12.2016	10.12.2031
	4	WWER-1000/320	1000	18.12.1987	18.12.2017	18.12.2032
	5	WWER-1000/320	1000	14.08.1989	14.08.2019	14.08.2034
	6	WWER-1000/320	1000	19.10.1995	19.10.2025	19.10.2040
Yuzhnoukrainsk	1	WWER-1000/302	1000	31.12.1982	31.12.2012	31.12.2027
NPP	2	WWER-1000/338	1000	06.01.1985	06.01.2015	06.01.2030
	3	WWER-1000/320	1000	20.09.1989	20.09.2019	20.09.2034
Rivne NPP	1	WWER-440/213	415	22.12.1980	22.12.2010	22.12.2025
	2	WWER-440/213	420	22.12.1981	22.12.2011	22.12.2026
	3	WWER-1000/320	1000	21.12.1986	21.12.2016	21.12.2031
	4	WWER-1000/320	1000	10.10.2004	10.10.2034	10.10.2049
Khmelnytsky	1	WWER-1000/320	1000	22.12.1987	22.12.2017	22.12.2032
NPP	2	WWER-1000/320	1000	07.08.2004	07.08.2034	07.08.2049

2.2.5. SNF Management during end-of-life stage is one of the primary focuses of NEC for all countries with developed nuclear power industry. This also remains one of the priority concerns for IAEA. Addressing this concern, together with the general NPP safety, NPP decommissioning and radioactive waste (RW) Management draws most scrupulous attention of public at large and shapes public perception of nuclear power industry in general.

2.3. SNF Pileup Forecast for WWER-type reactors

2.3.1. The following estimates were used in CSNFSF IFS to forecast SNF pileup based on the annual spent nuclear fuel assembly (SFA) discharge volumes from the respective reactor types outlined below:

- WWER-440-type reactors – 84 (72) NFAs per year;
- WWER-1000-type reactors:
  - for Standard baseline-design NFAs – 48 NFAs per year;
  - for modified (beyond-baseline-design) NFA[A]s – 42 NFAs per year.

2.3.2. SNF pileup dynamics forecast is outlined below (see Figs. 2.2, 2.3) and includes Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP only. Zaporizhzhia NPP is not included in the forecast, as its SNF is piled up at an on-site storage facility, see Section 2.5.2 below).

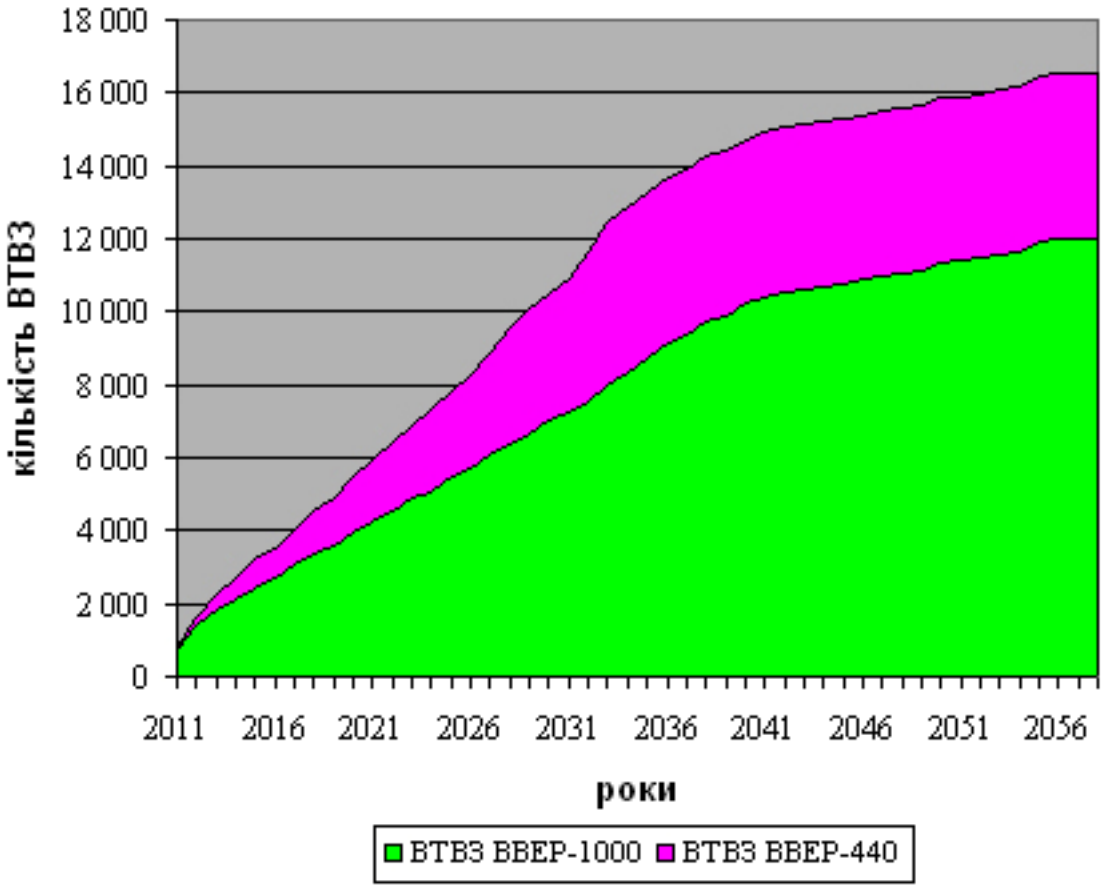

Fig. 2.2. SNF Pileup Dynamics Forecast for WWER-type reactor SFAs.
[X-axis: Years; Y-axis: Number of SFAs;
Green segment: WWER-1000 SFAs; Magenta segment: WWER-440 SFAs]

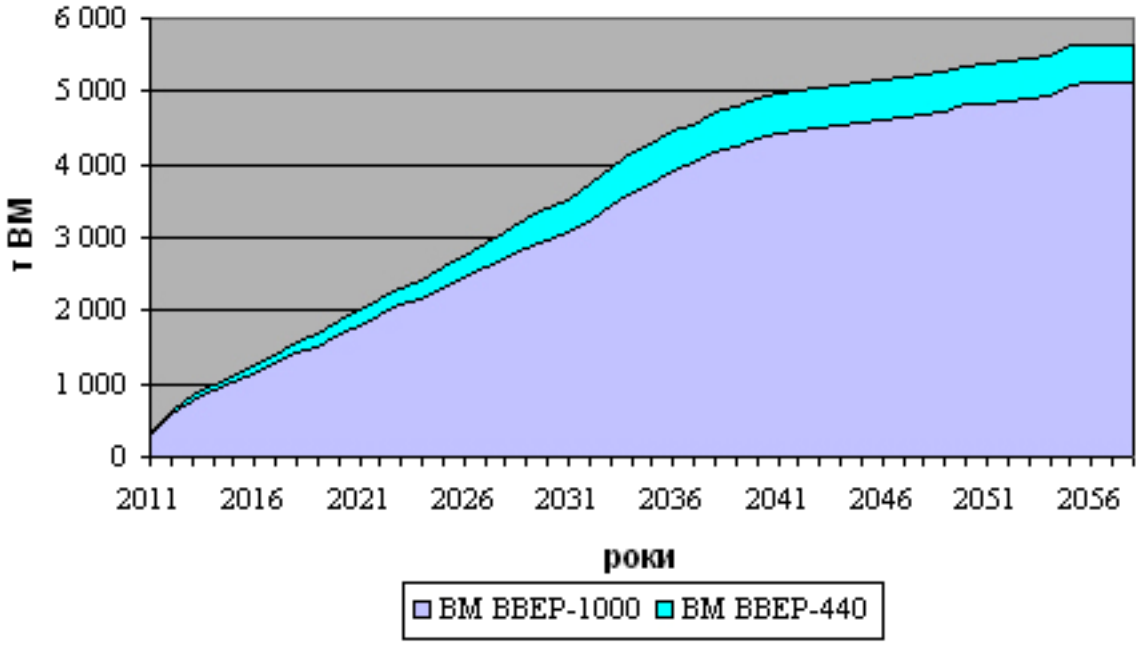

Figure 2.3. Forecasted SNF pileup dynamics (recalculated as heavy metal weight).

[X-axis: Years; Y-axis: heavy metal weight (tons);
Pale-blue segment: WWER-1000 SFAs; Cyan segment: WWER-440 SFAs]

2.3.3. A total of 5648 tons of heavy metals (hereinafter – HM) from SNF shall be piled up as a result of reactor operation at Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP prior to their respective decommissioning / extended ending dates (see Table 2.1.). 90% of that amount (approx. 5106 tons of HM) shall come from WWER-1000-type reactors. Most active SNF input is expected in the first several years upon storage facility commissioning – approx. 169 tons of HM per year. This is caused by the necessity to maintain reserve requirements for available storage in spent fuel pools, that would be kept in use temporarily to store SNF prior to the CSNFSF commissioning date.

2.4. Potential SNF Management Scenarios

2.4.1. End-of-life stage of the nuclear fuel cycle potentially denotes two basic alternative SNF Management scenarios:

- Open nuclear fuel cycle (ONFC);
- Closed nuclear fuel cycle (CNFC).

2.4.2. In an open nuclear fuel cycle, upon SFA cooling time in a spent fuel pool (SFP) SNF then undergoes the conditioning process and finally gets permanently stored at an underground (geological) storage facility, that is designed to guarantee long-term radioactive waste decay products hold-up / actinide elements hold-up necessary to prevent any potentially harmful environmental impact.

According to the global assessment practices, conditioning and encapsulation of 1 ton of SNF produces 0,2 cu.m. of intermediate level waste (ILW) and 1,5 cu.m. of high-level radioactive waste (HLRW) in form of conditioned SNF.

2.4.3. Closed nuclear fuel cycle (CNFC) provides the opportunity to use the residual energy of the SNF. This is achieved through SNF reprocessing, that results in releasing uranium and plutonium, that are subsequently used in nuclear fuel fabrication for fast fission reactors and in MOX-fuel for thermal reactors.

2.4.4. Certain countries with highly-developed nuclear energy industry currently proceed with long-term SNF storage while deferring their decision on SNF Management scenario selection for an indefinite time in future. This approach in the global practice is called “deferred decision approach".

2.4.5. Nuclear power plants worldwide generate approx. 10500 tons of heavy metal SNF yearly, of which 7500 tons of HM are stored and 3000 tons of HM are reprocessed.

2.5. Current SNF Management Scenario for WWER-based Reactors at Ukrainian NPPs

2.5.1. All WWER-based Ukrainian NPPs upon reaching target nuclear fuel burn-up ratio discharge SFAs into SFPs, where SFAs are being cooled down for at least 3 years in order to reduce SNF radioactivity and SNF residual heat.

2.5.2. Zaporizhzhia NPP utilizes a container-based on-site dry storage facility for further storage of WWER-1000 SFAs.

2.5.3. Current SNF Management Scenario for other WWER-based Ukrainian NPPs (Rivne NPP, Khmelnytsky NPP, Yuzhnoukrainsk NPP) utilizes design-based technical solutions that were originally developed in 1970es:

- Upon SFA cooling time, WWER-440-based SNF is being sent for reprocessing to Russia (RT-1 Production Facility at Federal State Unitary Enterprise (FSUP) "Mayak" (special rail car suitable for SNF transportation and handling belongs to RT-1). According to the current contract, RT-1 facility undertakes to store spent fuel decay, re-process SNF, and prepare re-processed vitrified HLRW for a return to Ukraine no later than 20 years after initial SNF handover for processing (HLRW return costs are not included into the current contract);
- Upon SFA cooling time, WWER-1000-based SNF is being sent for reprocessing to Russia (RT-2 Production Facility at Federal State Unitary Enterprise "Krasnoyarsk MCC" (KMCC) (special rail car suitable for SNF Management and transportation belongs to RT-2). According to the current contract, RT-2 Facility undertakes to store spent fuel decay, re-process SNF, and prepare reprocessed high-level solidified waste (HLSW) and valuable re-processed products for a return to Ukraine upon expiration of AFR storage period (HLSW / valuable reprocessed products return costs are not included into the current contract). At the moment RT-2 is only able to provide AFR storage services, as no on-site reprocessing facilities are currently available).

2.5.4. Existing design-based technology solutions for Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP are based on a concept earlier adopted in the USSR. This concept favored closed nuclear fuel cycle, where SNF had to be reprocessed in order to retrieve residual enriched isotopes for reusal purposes. As of today, the deployment of this concept is actually stalled at various stages thereof.

There are currently no national regulations defining the SNF Management scenario at an end-of-life stage of the nuclear fuel cycle in Ukraine. Bulk amount of SNF generated earlier by all Ukrainian NPPs is currently being stored at temporary locations. Therefore, a "deferred decision approach" is in fact applied to the SNF generated by Ukrainian NPPs, which is similar to the national practices of the most countries that use nuclear-energy-based technologies.

2.6. SNF Management Solution Selection for WWER-based SNF at CSNFSF

2.6.1. «Energy Strategy of Ukraine for the period until 2030» [35] stipulates for the construction of a centralized dry storage facility for WWER-based SNF.

2.6.2. Dry SNF storage facility essentially means that two types of technology solutions can be used:

- Chamber storage;
- Container storage.

Both solutions provide comparable safety features and are similarly priced. It has to be noted, that chamber storage solution would require larger capital investment amounts at an initial stage.

2.6.3. Solution selection for the CSNFSF has been accomplished through special bidding, conducted by SE NNEGC "Energoatom" in 2003-2005 under the international "turnkey project bidding" procedure. Representatives of the Ministry of Energy and Coal Industry of Ukraine, State Nuclear Regulatory Committee (SNRC) of Ukraine, National Energy and Utilities Regulatory Commission of Ukraine and NNEGC "Energoatom" were appointed to the Evaluation Committee Board.

2.6.4. The following technical and financial bids were received during the bidding process:

- Bid from a joint consortium consisting of: CJSC "Ukratomenergobud", CJSC "Novokramatorsk Machinery Factory", LLC "Energetychni Investycii", NPIC "STRUM" (all companies mentioned herein – Ukraine);
- Bid from "Holtec International" (USA).

Both bids received were based on the dry SNF storage solution with the use of multipurpose ("transportation" + "storage") canisters (hereinafter – MPC).
The bid by the consortium suggested the use of container-based dry storage technology, jointly developed by GNB (Germany), Skoda J.S. (Czech Republic) and Joint-Stock Company "I.I. Polzunov Scientific and Development Association on Research and Design of Power Equipment" (NPO CKTI, Russia) specifically for WWER-based (WWER-1000, WWER-440) SNF.
This technology solution featured:

- The use of metal or reinforced concrete MPCs intended to store 19 WWER-1000 SFAs or 84 WWER-440 SFAs each;
- SFA discharge and on-site loading into MPCs (in the reactor rooms);
- SNF MPC transportation to the CSNFSF location;
- Landfill-type SNF MPC storage (on the reinforced concrete basement slabs) at the CSNFSF location.

2.6.5. Technology submitted by «Holtec International» suggested:

- The use of MPCs intended to store 31 WWER-1000 SFAs or 85 WWER-440 SFAs each;
- SFA discharge and on-site loading into MPCs (in the reactor rooms);
- SNF MPCs to be transported to the CSNFSF in a special protective containment cask (shipping cask);
- SNF MPCs to be stored in special ventilated storage containers for further landfill-type storage or underground (near-surface) storage CSNFSF location.

2.6.6. Technical offers submitted by both bidders were considered acceptable for further deployment under existing conditions in Ukraine. As a result of further supplementary assessment the offer submitted by "Holtec International" was recognized to be more advantageous.

2.7. IFS Primary Aim and Objectives

2.7.1. The primary aim of the CSNFSF IFS was the justification of the necessity and practicality of the project aimed to construct a site suitable for long-term SNF storage / permanent disposal [dumping] of SNF from Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP, as well as its technical and economic feasibility, based on the basic principles of Ukrainian state policy on utilizing nuclear energy.

CSNFSF IFS was not intended to provide justification for the choice of the potential SNF Management scenario at an end-of-life stage of the nuclear fuel cycle at the Ukrainian NPPs (open nuclear fuel cycle / closed nuclear fuel cycle), or to specify any definite dry storage technology solution for safe long-term SNF storage / permanent disposal [dumping] of SNF.

2.7.2. The following primary objectives were achieved by the conducted IFS:

- Justification of the necessity and practicality of the CSNFSF construction;
- Specification of the list of facilities of the CSNFSF;
- Dimensions specification for the CSNFSF construction site;
- Definition of the initial infrastructure necessary to commission CSNFSF;
- Selection of the most appropriate location for the CSNFSF construction site;
- CSNFSF Environmental Impact Assessment;
- CSNFSF Construction Costs Assessment;
- CSNFSF Staff Radiation Exposure Assessment;
- Specification of primary construction management solutions as well as definition of CSNFSF construction milestones and deadlines;
- Initial Project Overlay Specification, Initial Layout Drawings Evaluation, Initial On-Site Inner Tracks and intrasite roads Planning;

- Most Comfortable Delivery Route Recommendation based on the SNF Delivery Routes Evaluation (NPPs to CSNFSF);
- Cost Assessment for CSNFSF Start-Up Facility Commissioning;
- Specification of the Cost-Performance-Indicators for CSNFSF Design Capacity & Start-Up Facility;
- CSNFSF Deployment Milestones Definition;
- Drafting CSNFSF Deployment conclusions and recommendations; defining residual uncertainties; composing early project execution plan.

2.8. Essential SNF Storage Requirements and Initial IFS Technical Assumptions

2.8.1. The following essential SNF Storage Requirements and initial technical assumptions were adopted in the course of drafting the IFS:

- CSNFSF design lifetime shall be at least 100 years;
- CSNFSF's SNF storage technology shall be compatible with the existing SNF Management technology, as well as with the existing NPP's handling and transportation equipment for SNF;
- CSNFSF design capacity shall accommodate deposition and storage for:
  - WWER-1000 SFAs – 12 500 pcs.;
  - WWER-440 SFAs – 4 000 pcs.;
- Total CSNFSF SNF Storage Volume shall amount to approx. 5650 tons HM;
- CSNFSF's start-up storage capacity shall be gradually expandable;
- CSNFSF Start-Up Storage Capacity shall accommodate:
  - WWER-1000 SFAs – at least 2 500 pcs.;
  - WWER-440 SFAs– at least 1 080 pcs.;
- CSNFSF shall provide SNF Pre-Storage Processing capabilities for:
  - WWER-1000 SFAs – at least 504 pcs. /year;
  - WWER-440 SFAs – at least 192 pcs. /year.

2.8.2. The following initial assumptions were adopted in the process of developing the IFS:

- Basic technical solutions and IFS performance indicators shall assume the use of HI-STORM 100S SNF storage technology (Holtec International, USA), as stipulated by the turnkey international bidding procedures for CSNFSF;
- Environmental Impact Assessment (hereinafter – EIA) within the IFS shall be conducted based on the Design Basis Accident data provided by "Holtec International";
- Considering the fact, that the most suitable construction site for the CSNFSF deployment is located within the Exclusion Zone (Territory that suffered from radioactive contamination as a result of Chernobyl Disaster) (hereinafter – EZ), one of the primary objectives for the EIA is to assess potential CSNFSF impact on the existing radiation situation within the EZ;
- IFS shall evaluate the necessity and practicality for CSNFSF construction, considering the current and estimated future cost assessment information (provided by SE NNEGC "Energoatom") with regards to the cost of SNF removal and transportation to Russia and its comparison to the cost of CSNFSF capital equipment (provided by Holtec International);
- IFS shall define CSNFSF's major cost-performance indicators for the SNF storage technology selected as a result of bidding procedures;
- IFS shall take into consideration that an automated radiation situation monitoring system (ARSMS) within the EZ is already in place. No additional monitoring system within the CSNFSF controlled access area (CAA) and control area (CA) shall be required.

2.9. CSNFSF Major Lifecycle & Design Stages

2.9.1. CSNFSF major lifecycle stages correspond to the stages stipulated by the current legislative and regulatory guidelines of Ukraine for nuclear facilities (hereinafter – NF):

- design;
- construction;
- commissioning;
- operation;
- decommissioning.

CSNFSF Operation stage is planned to have two basic sub-stages (periods):

- active use period (45-50 years), stipulates delivery of multipurpose canisters (MPCs) with spent fuel assemblies (SFAs), as well as gradual filling of storage capacity;
- passive use period (50-55 years), stipulates long-term SFA storage prior to the decision-making process on further SNF Management Scenario in Ukraine and subsequent deployment thereof.

2.9.2. In accordance with the regulations [14] on designing complex facilities, CSNFSF design shall be accomplished in three sub-stages:

- Investment feasibility study (IFS);
- Design Planning;
- Detailed Design Documentation.

This particular approach allows for refinement and rectification of the decisions and estimates initially made during the IFS stage, as well as consideration of refined and/or updated baseline information and additional design engineering details. This, however, stipulates that such refinements and rectifications shall not lead to any revisions within the IFS principal scope or conclusions thereto.

3. CSNFSF CONSTRUCTION NECESSITY AND PRACTICALITY SUBSTANTIATION

Information provided in this Section 3 of the AS has been thoroughly detailed in the CSNFSF IFS documentation [16,23,24].

3.1. Baseline data

3.1.1. In the process of substantiation of the necessity and practicality/justifiability of the CSNFSF construction the IFS has reviewed several different SNF Management scenarios for the SNF at the end-of-life stage of the nuclear fuel cycle at Rivne NPP, Khmelnytsky NPP, Yuzhnoukrainsk NPP and compared economic and cost parameters thereof, with regard to the existing national and worldwide practices. The following parameters were used as baseline data.

3.1.2. International studies indicate that the estimated cost of SNF transportation by rail between the NPP and intended storage location amounts to US$40-60 per 1kg HM. [28].

3.1.3. CSNFSF storage scenario assumes that a special train shall be used to transport SNF between the NPP and CSNFSF by rail. One trip shall ensure SNF transportation in the amounts sufficient for one core refueling of the reactor unit.

3.1.4. Internationally assessed cost of a long-term SNF storage for the period of T years for IFS purposes is calculated as follows:

$$\text{PRICE (US\$/1kg HM)} = 50 + T * 5$$

3.1.5. Direct SNF handling and transportation cost (including handover and preparation for storage) for SNF stored at CSNFSF amounts to UAH 1807 /1kg HM. This cost estimate includes:

- Capital investment costs;
- Operating costs for CSNFSF active operation period;
- Accrued costs for SNF storage during CSNFSF passive operation period;
- Accrued costs for CSNFSF decommissioning.

3.1.6. Upon expiry of long-term SNF storage period SNF can be reprocessed or dumped as liquid radioactive waste (LRW). OECD NEA estimates the cost of SNF reprocessing in the rage of US$540 – 720 /1kg HM [28]. Nuclear operators estimate this cost to grow up to US$1000 – 1100 /1kg HM by the year 2030.

3.1.7. The cost of SNF reprocessing offered by Russian facilities has a tendency to grow annually. The estimated cost of such services by 2030 is therefore expected to reach the average world prices (US$1000 – 1100 /1kg HM).

3.1.8. OECD NEA estimates [28] indicate that the average cost of HLRW disposal [dumping] upon SNF reprocessing ranges between US$80 – US$200 /1kg HM (average cost of $140/1kg HM is used for IFS assessment and evaluation purposes).

International studies estimate the cost of LRW direct disposal in the range of US$300 – US$600/1kg HM [28] (average cost of $450/1kg HM is used for IFS assessment and evaluation purposes).

3.2. Potential SNF Management Scenarios at the end-of-life stage of the NFC

3.2.1. The following options were reviewed in the process of modelling potential SNF Management scenarios at the end-of-life stage of the NFC:

- SNF Reprocessing;
- Long-term SNF storage;

- Long-term HLRW storage (HLRW resulting from SNF Reprocessing);
- Deep geological SNF disposal;
- Deep geological HLRW disposal.

Final goals of SNF reprocessing (MOX-Fuel fabrication, valuable materials recovery, etc.) were not taken into consideration as such that do not influence the necessity and justifiability of CSNFSF construction.

3.2.2. A total of 10 potentially available options for SNF Management scenarios at the end-of-life stage of the NFC were defined in the IFS. The practicality of certain options and their deployability in Ukraine or at the alternative location outside Ukraine was taken into account. (see Table 3.1.) For the purposes of IFS Russia was considered as an alternative location outside Ukraine, as the current provider of SNF reprocessing services to Ukraine.

Table 3.1. Potential NFC end-of-life stage options

Option #	SNF Reprocessing	SNF Reprocessing Location	Long-Term SNF Storage	Long-Term SNF Storage Location	Long-Term HLRW storage	Long-Term HLRW Storage Location	Deep geological SNF disposal	SNF Disposal Location	Deep geological HLRW disposal	HLRW Disposal Location
1	+	Russia	+	-	+	Ukraine	-	-	+	Ukraine
2	-	-	+	Ukraine	-	-	+	Ukraine	-	-
3	+	Ukraine	+	Ukraine	+	Ukraine	-	-	+	Ukraine
4	+	Ukraine	+	Russia	+	Ukraine	-	-	+	Ukraine
5	+	Ukraine	+	Russia	-	-	-	-	+	Ukraine
6	+	Russia	+	Russia	+	Russia	-	-	+	Russia
7	+	Russia	+	Russia	-	-	-	-	+	Ukraine
8	-	-	+	Russia	-	-	+	Ukraine	-	-
9	+	Russia	+	Ukraine	+	Ukraine	-	-	+	Ukraine
10	+	Russia	+	Ukraine	-	-	-	-	+	Ukraine

Qualitative analysis of the potential options conducted within the IFS has resulted in the conclusions below: Options 3,4,5 imply a reprocessing facility in Ukraine is / shall be made available, which is not currently intended. Besides that, worldwide best practices for SNF reprocessing indicate SNF reprocessing to be economically feasible only if the volumes subject to reprocessing are substantial and are aimed at subsequent reuse of nuclear fuel in the NFC. Ukrainian SNF volumes from its four available NPPs cannot be considered substantial. Options 3,4,5 were therefore excluded from further consideration within IFS.

Option 6 implies both storage, reprocessing and subsequent HLRW waste disposal is to be done in Russia. Whereas current Russian legislation does not allow the disposal of other countries' LRW on the territory of Russia, Option 6 was excluded from further consideration.

Option 7 differs from Option 1 only as it does not include long-term HLRW storage prior to its disposal in Ukraine. Therefore, cost parameters of Option 7 are similar to Option 1, which deemed separate consideration of Option 7 inadvisable.

Option 8 differs from Option 2 only by implying a different SNF long-term storage location. Therefore, separate consideration of Option 8 was deemed inadvisable.

Options 9 and 10 differ from Option 1 only by implying SNF Long-Term Storage prior to its transportation for reprocessing. Therefore, separate consideration of Options 9 and 10 was deemed inadvisable.

Therefore, as a result of qualitative analysis within IFS, Options 1 and 2 were selected for further technical and cost parameter analysis.

3.3. Major SNF Management Options – Comparative Analysis Results

3.3.1. Option 1 («Reprocessing in Russia») implies that SNF shall be exported from Ukrainian NPPs over to Russia, where it will be temporarily stored. SNF export shall continue until the nuclear power reactors currently in operation shall be decommissioned. SNF shall be temporarily stored in Russia until the reprocessing facility [in Russia] is put into operation. General SNF reprocessing shall commence in 2020 and continue for 30 years in equal annual proportions. Reprocessing shall include low-level and intermediate level radioactive waste disposal, as well as vitrification and temporary storage of HLRW in Russia for 50 years, after which HLRW shall be returned to Ukraine for permanent disposal.

3.3.2. Option 2 («CSNFSF»), implies that prior to CSNFSF launch SNF shall be exported from Ukrainian NPPs over to Russia in minimally required volumes subject to the SFPs maximum allowed storage levels. SNF exported to Russia is subject to temporary storage and reprocessing. HLRW produced as a result of such reprocessing shall be returned to Ukraine in accordance with the procedure specified in Option 1.

After 2011 SNF discharged from Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP shall be transported to CSNFSF for temporary storage for the term of 50 years. Upon expiry of such temporary storage term, SNF is subject to deep geological SNF disposal.

3.3.3. The following CSNFSF cost factors were taken into account for the purposes of estimating the cost of Option 2:

- CSNFSF start-up facility estimated construction cost;
- Subsequent construction stages' estimated construction cost;
- CSNFSF running costs during active operation stage;
- CSNFSF running costs during passive operation stage;
- Standard depreciation costs for CSNFSF facilities and equipment;
- Maintenance and repair costs for CSNFSF facilities, systems and equipment for the duration of its respective operation;
- CSNFSF decommissioning / withdrawal from service costs;
- Additional expenses that account for CSNFSF construction and operation in EZ.

3.3.4. A comparison of the aggregate SNF Management costs at Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP at the end-of-life stage of the nuclear fuel cycle (NFC) and its respective itemized distribution for Options 1 and 2 is outlined in the Table 3.2 below.

Table 3.2. NFC End-of-life Stage – SNF Management Cost Comparison (million UAH)

	Option 1			**Option 2**			
	Total	**including**		**Total**	**including**		
		SNF Transfer, Storage and Reprocessing	**HLRW Disposal**		**SNF Transfer and Storage**	**SNF Disposal**	**HLRW Disposal** (SNF export until 2011)
Lowest cost estimate	**31 198**	27 985	3 213	**15 362**	5 875	8 556	931
Average cost estimate	**33 608**	27 985	5 623	**24 332**	9 868	12 835	1 629
Highest cost estimate	**36 017**	27 985	8 032	**29 651**	10 210	17 113	2 328

Total expenditures under Option 1 are estimated in the range of UAH 31bn – 36bn (average cost estimated at UAH 33,6bn. Major expenditures fall for the cost of transportation, storage

and reprocessing services rendered by Russia. Expenditures attributed for return and permanent disposal of HLRW in Ukraine are estimated in the range of UAH 3,2bn – 8,0bn, which amounts to 10-22% of total expenditures.

Potential cost fluctuation under Option 2 may lead to a double increase in total cost, which is therefore ranged between UAH 15,4bn – 29,7bn (at 2006 values). 40% of the total cost is attributed to SNF transportation and storage costs at CSNFSF, less than 10% fall for HLRW permanent disposal (reprocessing products from SNF exported to Russia prior to 2011,), and the majority of expenditures (over 50%) is related to SNF disposal.

3.3.5. Option 1 implies that the majority of expenditures falls for the active operation period of the nuclear power reactors currently in use in Ukraine (2007 – 2049), peak expenditures fall for 2018 – 2032. Cost of SNF storage and reprocessing in Russia in 2011-2049 is estimated at approx. 93% of the total expenditures under Option 1. For the period between 2007 and 2049 nuclear power plant units at Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP shall produce approx. 1656 billion kWh of electrical energy. Therefore, electricity rates for respective NPPs shall account approx. 1,9 – 2,2 kopecks/kWh [for these purposes].

Option 2 calculations indicate that electricity rates for the above-mentioned NPPs shall account 0,9 – 1,8 kopecks/kWh [for these purposes].

3.3.6. Based on calculations and assumptions related to aggregate cost and expenditures distribution over time, IFS concludes that Option 2, that implies CSNFSF construction and subsequent operation, is more favorable when compared to Option 1, that implies SNF export, storage and reprocessing in Russia with subsequent return and disposal of HLRW, generated from SNF reprocessing, in Ukraine.

3.3.7. CSNFSF construction complies with the fundamental principles of state nuclear energy usage policy. It shall further support safe operation of the nuclear power plants in Ukraine over the long term, regardless of the state of future relations with Russia in the field of SNF storage and reprocessing.

3.3.8. CSNFSF shall support the execution of “deferred decision” approach in Ukraine with respect to the subsequent final decision on the optimal Management scenario for the end-of-life stage of the nuclear fuel cycle (SNF reprocessing or permanent disposal).

4. CSNFSF CONSTRUCTION SITE SELECTION AND SUBSTANTIATION PROCESS

Information provided in this Section 4 of the AS has been thoroughly detailed in the CSNFSF IFS documentation [20,23].

4.1. General CSNFSF construction site selection algorithm

4.1.1. CSNFSF construction site selection and substantiation within IFS included three stages:

- Stage 1 – Selection of three potential construction sites;
- Stage 2 – Analysis and comparison of ecological, radiation control, technical and economic siting criteria for suggested construction sites;
- Stage 3 – Summarizing the comparative results and selection of the most favorable construction site.

4.2. Selection of three potential construction sites

4.2.1. Selection of tree potential construction sites to host CSNFSF included:

- Legislation and regulatory requirements analysis;
- Defining general initial selection criteria for potential CSNFSF construction sites;
- Selection of CSNFSF location options;
- Defining criteria for comparative analysis of options;
- Selection of potential construction sites for subsequent consideration.

4.2.2. According to the provisions of the Law of Ukraine "On the use of nuclear energy and radiation" [6], CSNFSF shall have a nuclear facility status.

The analysis of Ukrainian legislation and regulatory framework conducted as a part of IFS has shown lack of sufficient direct regulatory framework for potential CSNFSF construction. In this respect IFS has taken the requirements of the direct regulatory requirements stipulated by НП 306.2.105-2004 performance requirements document [36], as well as a number of extra performance requirements for construction sites of:

- Nuclear power plants (as nuclear facilities);
- LRW storage facilities (in its long-term storage requirements section);
- Standard manufacturing facilities.

It was further taken into account that CSNFSF is subject to all Ukrainian norms and regulations governing radiation and nuclear safety and LRW Management.

In addition to nuclear and radiation safety requirements, IFS has summarized requirements on environmental protection in the CSNFSF area, as well as technogenic environmental impact protection regulations, including those on:

- Social and ecological environment protection;
- Natural environment protection;
- Technogenic environment protection.

4.2.3. IFS assumed the following general initial selection criteria for potential CSNFSF construction sites:

- Construction sites that require new project land allocation shall not be considered, as the most of Ukrainian territory is allocated for social-economic use, whereas project land allocation, including substantiation, review and approval thereof for any new nuclear facility shall require significant amount of time;
- The following options shall therefore be considered (in order of preference):
  - Existing NPP sites;
  - Territories adjacent to existing NPP sites;
  - Exclusion Zone territory.

4.2.4. As a result of performed analysis, IFS has identified the following options as potentially suitable CSNFSF construction site locations:

- Rivne NPP Site and adjacent territory ("RNPP" Option);
- Khmelnytsky NPP Site and adjacent territory ("KhNPP" Option);
- Yuzhnoukrainsk NPP Site and adjacent territory ("YuNPP" Option);
- Zaporizhzhia NPP Site and adjacent territory ("ZNPP");
- Exclusion Zone territory ("EZ ChNPP" Option).

4.2.5. The following comparison criteria, organized in two sub-groups, were identified in IFS for CSNFSF location analysis:

- Technical criteria, comprising technical factors, natural geographic factors, as well as construction sites' technogenic factors;
- Licensing criteria, describing land allocation process, CSNFSF construction approval process, as well as participation of public at large in this approval process.

4.2.6. The analysis of initial options has resulted in following conclusions:

- "YuNPP" and "ZNPP" Options are deemed unfavorable, due to the fact that CSNFSF could not be located within the limits of NPP site. Furthermore, land seizure and reallocation in the adjacent area would be required in order to proceed with construction;
- "RNPP" Option is deemed unfavorable due to existing ongoing underwashing (karst-suffosion process) in the subsurface soil bed [due to unsuitable geological conditions].

4.2.7. IFS has determined the following three potential construction sites should be selected for further consideration, as a result of comparative analysis of all technical and licensing criteria:

- Construction site located at Khmelnytsky NPP construction plant (hereinafter – "KhNPP Site");
- Construction site located near centralized SNF storage facility #2 (currently under construction) (hereinafter – "ChNPP Site");
- Construction site, located near "Vector" Facility and centralized LRW disposal facility (currently in planning stage) (hereinafter – "SDF Site").

4.3. "KhNPP" Site – Brief Description

4.3.1. "KhNPP" potential construction site is located on the territory of Slavuta district, Khmelnytsky Oblast', 100km north of Khmelnytsky and 45km south-east of Rivne. The site is located on the premises of Khmelnytsky NPP and borders with the construction plant of the 2nd NPP unit on the west. Khmelnytsky NPP itself is located on the left bank of the Horyn River, between Netishyn city, Dorohoschcha village and Pivneva Hora village. The location of "KhNPP" Site is shown on the base map below (Fig. 4.1).

4.3.2. "KhNPP" Site is located within the West-Ukrainian province of the forest-steppe zone of Ukraine. Forest-steppe zone of Ukraine is divided into three physiographic areas – Volyn Upland, Male Polissya (forest-steppe landscape) and Northern Podillya (mixed woodland landscape).

Fig.4.1. "KhNPP" Site Location Base map

[Grey Zone, Upper Right Segment – NETISHYN;
Red Spot – "KhNPP" Site – suggested for CSNFSF construction
Lower Right Segment – Khmelnytsky NPP
Lower Left Segment – Pivneva Hora village]

4.3.3. Khmelnytsky NPP site is spatially located in the southern part of Volyn megablock at its interconnection with Podillya megablock, within the boundaries of Novohrad-Volynsky block.

"KhNPP" site is located near the nodal intersection of Chernyakhivsk sublateral zone and a diagonal Khmelnyk crust fracture. However, this particular area exhibits insignificant neotectonic activity and low amplitude values (20-30 m) of vertical movements on crust fracture sides per Quaternary Neogene Period (a period of 26 million years). This generally allows to disregard vertical neotectonic shifts in the earth shell in the generic neotectogenesis; average vertical shift velocity in those crust fractures is insignificant and amounts to 0,001-0,02 cm/km/1000 years.

Generally, the territory exhibits favorable geological engineering profile with no dynamically unstable or collapsible soils and no active karst.

Geological composition for survey depth of up to 60 meters exhibits the following soil types (listed downwards): modern quaternary technogenic soils, upper- and mid-quaternary fluvioglacial deposits with underlying sediments of Czartoryski / Berestove Vendian rocks. Due to significant difference between the absolute elevation marks on the natural landscape, as well as on the planned surfaces within the construction site boundaries, depth and lithological composition of quaternary deposits for different sites vary widely.

According to the microseismic zoning of the KhNPP site, current seismic hazard levels constitute: DBE = 5.0 points (Richter Scale), MDE = 6.0 points (Richter Scale).

4.3.4. Hydrographic system within the 30km impact range of Khmelnytsky NPP includes Horyn River basin, lakes, ponds, water reservoirs and a network of water reclamation channels. Within 30 km radius of Khmelnytsky NPP Horyn River has 37 confluent rivers with lengths varying from 10 to 80 kilometers, as well as approx. 220 smaller confluents with lengths under 10km. The distance between potential CSNFSF construction site and Horyn River constitutes 1,9 km.

NPP service water supply sources are Horyn River and Hnyly Rih River. Design flood elevation levels for 0,01% flood constitute 197,840m for Horyn River and 193,700m for Hnyly Rih River. Grade elevation levels for NPP construction plant constitute 206,000m (WDM point), 224,0 – 222,000m). This implies that maximum flood levels from meltwaters and rainwater do not constitute any danger for NPP facilities.

An artificial off-channel water reservoir used for NPP equipment cooling is located adjacent to the site. Normal headwater elevation for this water reservoir is located three meters below NPP construction site grade elevation. Surcharged headwater elevation for the reservoir under 0,01% flooding (assessed probability of once per 10000 years) exceeds normal headwater elevation by 0,7 meters.

Current ground water elevation on site is 3,00 – 4,00m (absolute elevation marks [AEM] 202,000-203,000m), at WDM point – 7,00-16,00m (AEM 206,000-215,000m), at the construction plant – 1,00-4,00m (AEM 202,000-205,000m).

4.3.5. Maximum observed wind speed during multi-year observation period peaked at 38 and 40m/s. Wind gusts frequency (wind gusts up to 21-35m/s) is approximately once every 10 years. Extreme winds (windstorms) observed 9 to 10 times over the last 30 years' period. Low winds frequency (™⌊ 2m/s) during cold period – 32%, over a 12-month period – 26%.

Average year-round temperature equals 6,8°C, highest temperature observed – 36,6°C,

lowest observed temperature – -33,6°C.

Average fog frequency: during the year – 15%, during cold period – 28%.

According to the tornadic zoning map "KhNPP" site belongs to a tornado-free (safe) region. According to the tornado register of USSR (1945 – 1986), as well as according to the information available from Ukrainian hydrometeorological service (1986 – 1997) there were no tornadoes registered within the 30km range of KhNPP. Design vortex intensity class for potential CSNFSF construction location equals to 2,75 [90]. Assessed yearly tornadic probability ratio is $14x10^{-7}$.

4.3.6. There are no cities with population over 100 000 inhabitants within the 25km range of the site. Population density is 74 inhabitants per square km. The nearest populated community, located 2,7km north-west of KhNPP reactor unit #2, is the city of Netishyn (pop. 34,750). Ostrih (pop. 14,250) is located 11km away from KhNPP, Slavuta (pop. 37,800) is 13 km away, Izyaslav (pop. 18,300) is 21km away, Zdolbuniv (pop. 28,500) is situated at a distance of 35km, and the distance to the city of Rivne (pop. 245,000) is 45km.

4.3.7. There are no industrial facilities that could potentially impact the storage facility's operational safety within 10km range. There are also no recreational zones of national standing or national natural parks within 25km range of NPP.

4.3.8. A Class III railroad segment (Shepetivka – Zdolbuniv – L'viv railroad) is located at an approximate distance of 8-9km (distance measured over the air), on the northern boundary of Kryvyn village. Railroad segment features a class III wayside railway station "Kryvyn". An 8,4km-long stub track that connects the railway station with the ballast stone pit "Siltse" is attached to the railway station. The stub track features a river-crossing bridge over Horyn River. A class IV railroad station "Siltse" is located in the immediate vicinity of the bridge crossing. A stub track connects the NPP to the station, that was recently renovated to accommodate the connection.

Berdychiv – Shepetivka – Ostrih, a motor road of state importance is situated 6,3 km to the north of the site. Site entry is possible via a 6,3km-long service road (access way) that is attached to the above-mentioned motor road of state importance. Additional access roads connecting the site with the Berdychiv – Shepetivka – Ostrih motor road are also available.

No water connection available.

4.3.9. NPP construction plant is deemed to be the most favorable location within the site to host CSNFSF construction. The location currently hosts open-air construction warehousing facilities, goods yard crane tracks and a stub track that leads to the steam turbine rotor blading facility. Construction site design absolute elevation mark is 206,000m.

Initial on-site construction preparation efforts include:

- Construction of railroad section with estimated length of 506 – 1670m;
- Construction of Access Road / Service Road with estimated length of 980m;
- KhNPP Infrastructure Tie-In;
- Crane deinstallation;
- Demolition of existing buildings;
- Concrete Pavement Demolition;
- Internal Clearance Area Organization.

SNF delivery from other NPPs shall be organized via the territory of construction plant of KhNPP units 1 & 2.

4.4. ChNPP Site – Brief Description

4.4.1. Suggested "ChNPP" Site administratively belongs to Chornobyl district of Kyiv Oblast. The site is situated at the center of Exclusion Zone (EZ) – a territory under special form of administrative governance. EZ lands are removed from commercial turnaround and are free from any zoning allocations, all the population was evacuated. Site is located directly in the center of 10km EZ zone within boundaries of Chornobyl NPP control access area. Suggested construction site borders on the east with Chornobyl NPP SNF Storage Facility #2 location. ChNPP site location is shown on the base map below (see Fig. 4.2).

4.4.2. Site is located on the north of Kyiv Oblast within Kyiv Polissya area at the interfluve of Pripyat River and Uzh River.

4.4.3. From the tectonic standpoint the location is situated at the junction of two regional structures of the East European Creaton (Moesia plate) – Ukrainian Shelf, Dnipro-Donets Aulacogen (DDA) and Pripyat Downwarp.
Teteriv zone of fractures is comprised of two arms: I – west arm, II – east arm. West arm of the Teteriv fracture is longer than the east arm. The location is situated practically centered between two arms of the Teteriv zone of fractures. According to geodetic data, actual movement velocity for Teteriv zone of fractures I constitutes 0,1-0,6 mm per year, and 0,1-0,4 mm per year for Teteriv zone of fractures II. South-eastern arm of Teteriv fracture I and a segment of Teteriv fracture II between Radomyshl and a juncture with DDA's southern near-edge fractures zone.

According to the microseismic zoning of the ChNPP construction plant location, current seismic hazard levels constitute: DBE = 5.0 points (Richter Scale), MDE = 6.0 points (Richter Scale).

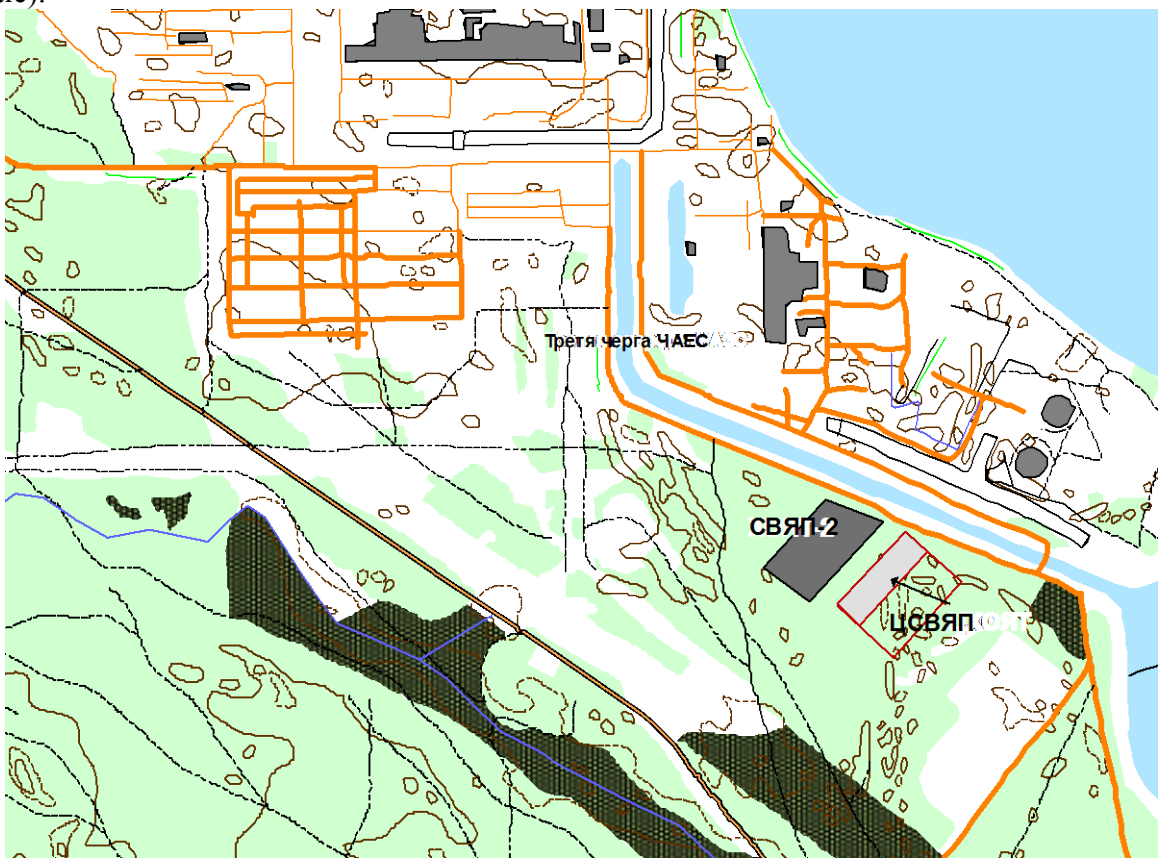

Fig.4.2. "ChNPP" site location base map.

Geomorphic terrain analysis shows that the site is located on the I elongated fluvial ter-

race of the Pripyat River. Absolute elevation marks range between 113,700 – 117,000m.

Axial geological record (listed downwards) consists of upper quaternary alluvial (fluvial facies, old river bed facies on the shallow horizon; beach and old river bed facies on the lower horizon, stream bed facies, etching), mid-quaternary alluvial deposits underlaid by argil sand grounds dating back to Mid-Paleogene (Eocene) period at a depth of 29,60-31,50m. Geological record predominantly consists of river gravel; clay soils with alluvial deposits of moderate thickness are only present in the immediate subsoil layer.

Generally, ChNPP site exhibits favorable geological engineering profile with no dynamically unstable or collapsible soils and no active karst.

4.4.4. Hydrological conditions of the area are determined by the hydrological regime of the Pripyat River (right tributary of the Dnipro River). Since 1996 the segment of the Pripyat River immediately adjacent to the suggested site is in the backwater area of Kiev Reservoir. Pripyat River is situated 4km away from the suggested site.

Assessed maximum water levels of Pripyat River at the suggested CSNFSF site (including the values from backwater area of Kiev Reservoir and respective diversion dams) with assessed probability of P=0,01% are located at an absolute evaluation mark of 111,400m. Flooding of the area is not anticipated.

Maximum ground water elevation levels under 0,01% flooding for CSNFSF location depend on the water elevation levels at take-out channel and ChNPP cooling pond. Current ground water elevation levels constitute 3,0 – 4,0m (AEM 111,00m); estimated seasonal water elevation fluctuation – up to 2m (absolute elevation mark of the maximum assessed groundwater level at 113,00m.

4.4.5. Average year-round temperature is 6,7°C, highest temperature observed – 39°C, lowest observed temperature – -35°C.

4.4.6. Heavy winds (wind speed over 15m/s) is observed 13 days a year on the average with an occasionally observed frequency of up to 38 days a year). Wind gusts (20-30m/s wind speed) are observed with a frequency of 5 events per 10 years. Maximum wind speed (at 0,01% occurrence) reaches 47,3m/s. Low winds frequency (wind speed below 2m/s) - 50-60% during the year.

Average year-round fog frequency - 21 %.

ChNPP site is located in the area with elevated tornadic occurrence:

- Annual tornadic probability ratio (vortex ratio) for the area equals $1x10^{-6}$;
- Design vortex intensity class K_p= 3,0.

4.4.7. There are no populated communities within the 30km range of Exclusion Zone. The Closest located cities to Chornobyl NPP are: Slavutych – at a distance of 44km (population 25,200); Ivankiv – at a distance of 50km (population 40,000); Chernihiv – at a distance of 76km (population 310,000); Kyiv – at a distance of 110km (population 2,8M).

4.4.8. There are no industrial facilities that could potentially impact the storage facility's operational safety within 10km range. There are no recreational zones or plow lands within 30km radius.

4.4.9. Chornobyl NPP service railroad track is located in the immediate vicinity of SNF Storage Facility #2 (0,4km away). Service railroad track connects to the public railroad network operated by Ministry of Transport and Communications of Ukraine through Yaniv wayside railway station.

Chornobyl – Chornobyl NPP public motor road is situated adjacent to the SNF Storage Facility #2 site and allows transportation by road.

No water connection available.

4.4.10. Suggested CSNFSF location site is situated south-east to the existing WDM point, next to the location of SNF Storage Facility #2. Suggested location borders with the location of SNF Storage Facility #2 on the north-west and with the take-out channel on the north-east (see Fig.4.2).

Certain use of existing infrastructure and road network of Chornobyl NPP SNF Storage Facility #2 is possible at the initial stage of construction organization on site.

Initial on-site construction preparation efforts include:

- Undersoil excavation and grading;
- Construction of service railroad track with estimated length of 170m.

4.5. "SDF" Site – Brief Description

4.5.1. Similarly to the location of ChNPP site, "SDF" site administratively belongs to Chornobyl district of Kyiv Oblast and is located in the Exclusion Zone. "SDF" site is situated between evacuated villages of Buryakivka, Chystohalivka and Stechanka, bordering on the west with RW Storage and Disposal Center ("Vector" Facility). The location of "SDF" site is shown on the base map below (see Fig. 4.3).

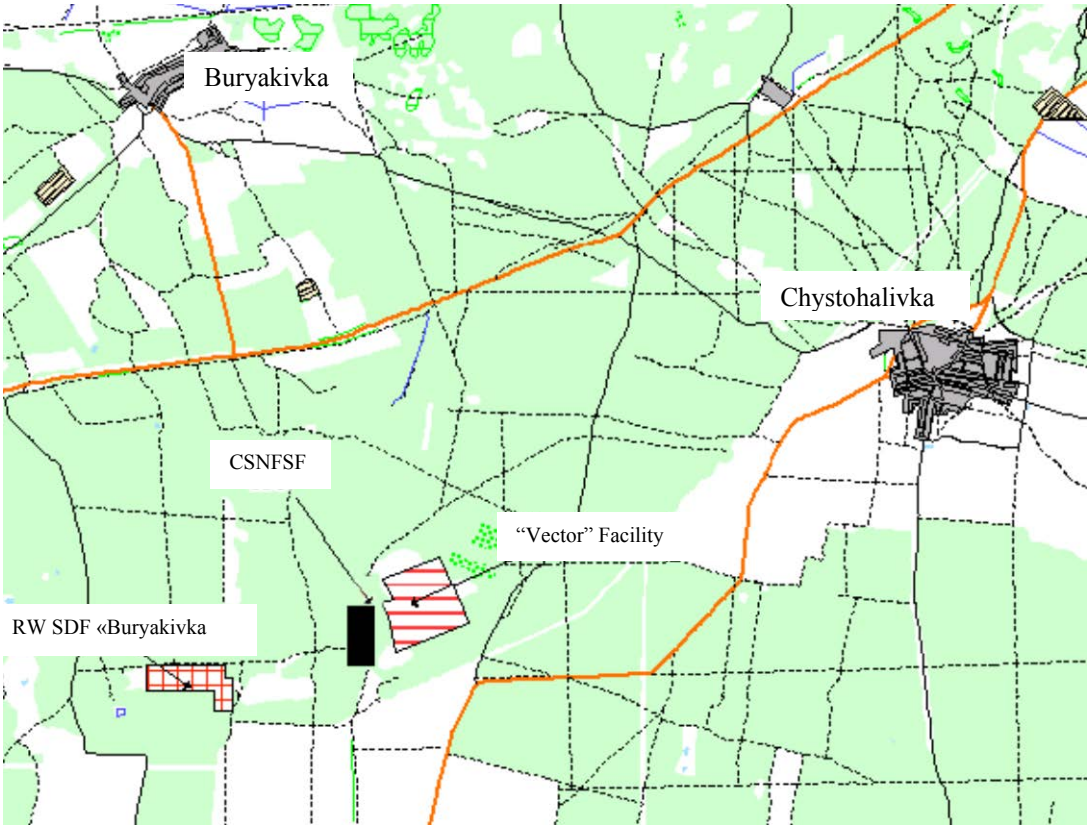

Fig.4.3. "SDF" Site Location Base Map.

4.5.2. The location is situated within the limits of Kyiv Polissya moraine outwash plain, at the interfluve of Pripyat River and its right tributary – Uzh River. The site is located in the Exclusion Zone. The landscape is predominantly undulating, with ridges below 10m in central and south-eastern parts of the territory; ridges are covered with pine forest (approx. 16m high). Absolute elevation marks range between 132,000-135,000 m with ridge elevation marks of up to 152,000m.

4.5.3. Suggested site is located within the boundaries of Dnipro-Donets Rift (Aulacogen) in the vicinity of its junction with the north-eastern bank of Ukrainian Crystalline Massif (Shield).

Modern tectonic movements analysis along with the structural tectonic study of the territory and structural analysis of the Paleogene and quaternary deposits in the geological platform indicate that the site is located outside of the areas of neotectonic dislocations or fractures.

Geological composition for survey depth of up to 79 meters exhibits the following soil types (listed downwards): Eocene formations of Upper Paleogene (Buchak – Kaniv sands and Kiev marl), overlapped by quaternary deposits. Loamy grounds at the north-western part of the territory are underwashed. Quaternary deposits (listed upwards) are exhibited with ancient-to-mid quaternary fluvioglacial sands overlapped by midquaternary fluvioglacial sands with supez and clay veins, with inclusions of Moraine solids and glaciolacustrine soils. General thickness of quaternary deposits averages predominantly around 50 meters.

Assessed seismic hazard levels for the location constitute: DBE = 5.0 points (Richter Scale), MDE = 6.0 points (Richter Scale).

4.5.4. Ground water levels are found at the depth range of 8 to 21 meters under ground. (absolute elevation marks range 122,000-127,000m). Seasonal ground water levels fluctuation can reach 1,5m. Water table exhibits sloping in the north-eastern direction (towards Pripyat River valley); certain part of the territory exhibits water table sloping in the south-west direction (toward Uzh River valley).

Assessed maximum water elevation levels for Pripyat River at suggested location (including the values from backwater area of Kiev Reservoir and respective diversion dams) with assessed probability of P=0,01% are located at an absolute evaluation mark of 111,400m. Flooding of the area is not anticipated. Construction site can be planned at the 138,000m elevation mark. Suggested CSNFSF site is located outside of potential inundation range; distance to Pripyat River – 10km, distance to Uzh River – 8km.

Geohydrology conditions exhibit high protection potential against radioactive contamination.

4.5.5. Suggested construction site belongs to construction climatic zone IIв (Construction Rules and Regulations [СНИП] 2.01.01-82) with moderate continental climate and positive moisture balance – average annual precipitation exceeds actual evaporation.

Hydrometeorological stats and vortex stats for “SDF” site are similar to “ChNPP” site stats outlined in Section 4.4.5 above.

4.5.6. There are no populated communities within the 30km range of Chornobyl NPP (Exclusion Zone). The Closest located cities to “SDF” site are: Ivankiv – at a distance of 43km (population 40,000); Slavutych – at a distance of 58km (population 25,200); Chernihiv – at a distance of 90km (population 310,000); Kyiv – at a distance of 110km (population 2,8M).

4.5.7. There are no industrial facilities that could potentially impact the storage facility’s operational safety within 10km range. There are no recreational zones or plow lands within 30km radius.

4.5.8. One-track-railroad line is situated 5km north of the suggested location; distance to the nearest sideway station Yaniv – 10km. The line is currently out of service and requires renewal maintenance at the section between station Vilcha and station Shepelychi.

“Vector” Facility site is connected to Chornobyl NPP and Yaniv Station with a number of motor roads that allow transportation by road.

No water connection available.

4.5.9. Site suitable to host CSNFSF can be planned in the immediate vicinity of Vector Storage and Disposal Facility (SDF) near the north-western or western site boundaries.

Certain use of existing infrastructure and road network of Vector Facility is possible at the initial stage of construction organization on site.

Initial on-site construction preparation efforts include:

- Deforestation;
- Undersoil excavation and grading;
- Construction of service railroad track with estimated length of 6,4km.

4.6. Analysis and comparison of ecological, radiation control, technical and economic siting criteria for suggested construction sites

4.6.1. The analysis of ecological siting criteria for the three suggested sites included:

- Suggested sites' natural conditions review;
- Suggested sites' social conditions review;
- Definition of Comparative Analysis Methodology;
- Selection of environmental factors reviewed for the purpose of site comparison;
- Definition of Comparison Criteria for sites;
- Selection of ecologically most-favorable site option.

Ecological comparison of the three suggested construction sites, conducted within IFS, allowed to conclude that all the three sites could be considered equivalent with regard to a wide range of natural, technogenic and social factors. IFS defined "SDF" site as the most-suitable option to host CSNFSF with regard to ecological factors in general.

Most important factors that favored such a decision are listed below:

- Greatest separation from surface-water bodies, ground water intakes and water intake stations of major population centers, that provides for highest ecological safety of the population;
- Lowest groundwater levels combined with highest terrain elevation, that facilitates pollutant dispersion in the environment, pollutant binding within soil column and therefore reduces its predicted environmental concentration within the range of potential impact.

4.6.2. Radiation comparison of the sites included:

- Definition of Comparative Analysis Methodology;
- Definition of Comparison Criteria for sites;
- Radiation Impact Assessment for normal operation, design-basis accident (DBA) (with maximum impact) and beyond-the-design-basis (hypothetical) accident (BDBA)at the suggested sites;
- Site Comparison against all radiation impact criteria;
- Selection of most-favorable site option based on comparison results.

The following indicators were considered as radiation impact criteria for the purposes of IFS:

- Radiation situation on the site;
- Staff Radiation Exposure Intensity at construction stage;
- Collective Radiation Exposure under normal operation;
- Collective Radiation Exposure in case of DBA;
- Impact area in case of BDBA.

Having compared all sites' radiation criteria IFS concludes that sites located within Exclusion zone, namely ChNPP and SDF sites, enjoy most favorable location for the purposes of CSNFSF construction, whereas the latter ("SDF" site) has marginal advantage.

4.6.3. Cost-Performance Indicators Analysis of the sites included:

- Sites' distinctive features review with regard to variable capital costs (including predevelopment costs, infrastructure costs and construction management costs);

- Sites' distinctive features review with regard to transportation conditions;
- Determining distinctive technical features of the sites;
- Comparative analysis of the sites against cost-performance indicators;
- Selection of most-favorable site option based on comparison results.

A comparative study of three suggested construction sites, conducted within IFS, allowed for following conclusions.

Most economically favored location is "KhNPP" site. However, "KhNPP" site has certain construction limitations that disable further potential expansion beyond initial design layouts.

The difference in variable capital costs between "KhNPP" site and its closed competitor with regard to technical and economic performance indicators – ChNPP – constitutes UAH30,9 million, or less than 10% of the total capital costs. Primary factors that triggered variable cost increase at "SDF" and "ChNPP" sites were additional costs attributed to rotational work system within the Exclusion Zone (UAH5,3 million and UAH4,6 million respectively), as well as service railroad construction costs (for "SDF" site only).

4.7. Most favorable CSNFSF construction site location selection

4.7.1. Selection of the most-favorable site option with regard to the results of all conducted comparative studies included:

- Systematization and compilation of the results of all conducted comparisons;
- Defining most-favorable construction site;
- Most favorable construction site's strengths and weaknesses study;
- Potential Residual Uncertainties Review.

4.7.2. CSNFSF's long-term operation emphasizes the importance of ecological and radiation factors versus technical and economic factors. Based on this assumption IFS determined "SDF" site as the most favorable construction site.

4.7.3. The advantages of "SDF" site include:

- Location suitable to host design capacity CSNFSF facilities (approx. 5650 tons HM);
- Significant distance from large cities;
- Location in the Exclusion Zone with no population and no expected return of the lands into commercial turnaround in the nearest future;
- Job creation with employment opportunities for qualified personnel retiring upon Chornobyl NPP withdrawal from service;
- Minimization of freight traffic interference from other objects' operation and construction;
- Minimal scope of land planning efforts (grading and leveling) due to flat terrain profile;
- Significant distance from large Ukrainian waterways;
- Low ground water levels that exclude the probability of subsoil water logging and area flooding throughout the whole period of operation of CSNFSF;
- Opportunity to use the infrastructure of the adjacent Vector facilities;
- Minimal amount of facilities generating potential cumulative environmental impact
- Partial radiological remediation of the territory during groundworks and construction.

4.7.4. "SDF" site exhibits the following disadvantages:

- Deforestation of significant territory (8,6ha) required;
- Lengthy service railroad construction required (6,4km-long segment between Shepelychi Station and construction site). (NB: Cost reduction possible in case of joint 3,7km-long segment construction with Vector Facility).

4.7.5. The following potential residual uncertainties that have no direct impact on the result of the comparison will have to be resolved before the commencement of CSNFSF project:

- (for “ChNPP” and “SDF” sites only) Financing issues resolution and performance of renewal maintenance on “Ovruch – Vilcha” railway segment (this segment is also subject to use by Vector Facility and other Exclusion Zone facilities currently under construction);
- (“SDF” site only) Shared participation and financing settlement for the construction of service railroad segment [stub] between Shepelychi Station and CSNFSF. (shared use of the segment by CSNFSF and Vector Facility expected).

5. PRIMARY TECHNICAL SOLUTIONS

Information provided in this Section 5 of the analytical summary is detailed in CSNFSF IFS documentation [18,23].

5.1. Primary SNF Management technology solutions

5.1.1. "Dry storage" technology (inert-gas-filled confinement) is expected be used at CSNFSF for SNF storage. Compared to "wet" storage (water-filled storage), "dry storage" is more suitable in terms of ecological and economic factors. Dry storage excludes factors caused by SNF criticality (by absence of water acting as neutron moderator), reduces quantity of generated liquid radioactive waste and the need for respective infrastructure, reduces atmospheric pollution by radioactive elements, etc.

5.1.2. The IFS considers storage technology by Holtec International, that was selected as a result of bidding procedure, and is used for SNF storage by NPPs in USA. This technology consists of the following operations:

- On site loading of SFAs into MPC (Fig.5.1) in the reactor room with the use of HI-TRAC transfer cask (Fig.5.2);
- On-site [reactor room] MPC drainage, filling with inert gas (helium), welding of the two MPC hermetically-sealed barriers;
- On-site [reactor room] MPC top plate sealing tightness and welding quality check;
- Transfer of sealed MPC into HI-STAR shipping cask with the use of HI-TRAC transfer cask;
- Shipment of trainload with HI-STAR shipping casks (Fig.5.3) over to CSNFSF;
- Reception of trainload onto the refuge and switching service track at CSNFSF's location;
- Transfer of MPC from HI-STAR shipping casks into HI-STORM storage containers for further storage (Fig. 5.4) at the reception facility;
- Removal of HI-STORM containers with MPC and their transfer into the storage area with the use of caterpillar conveyor;
- Long-term storage of HI-STORM-containers with SFAs.

5.1.3. SNF storage system is a completely passive system that fulfills the following functions:

- Safe and hermetic localization of fissive radioactive material with the use of two static MPC barriers that prevent radioactive leakage of radionuclides from SFAs into the environment;
- Safe long-termed MPC storage in a shielding container (HI-STORM), that prevents straight ionizing radiation from influencing personnel and the environment;
- SFA Protection from extreme natural or technical influence during its storage in HI-STORM containers.

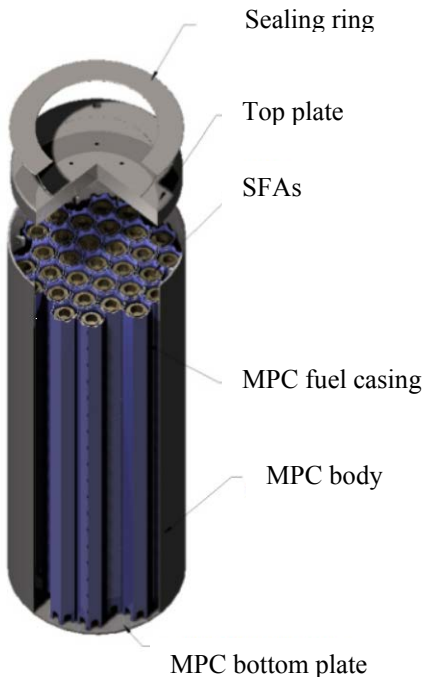

Fig.5.1. MPC. General View.

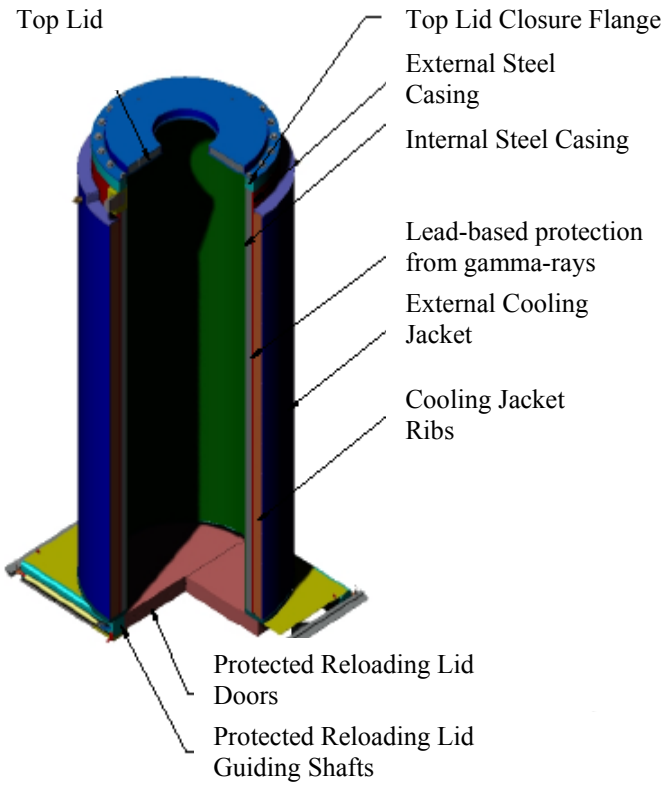

Fig.5.2. HI-TRAC Transfer Cask. General View

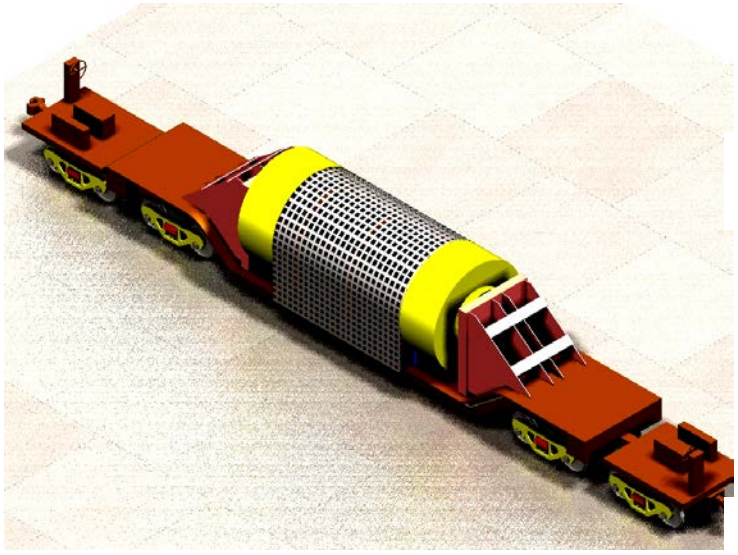

Fig.5.3. HI-STAR Rail Car equipped with shipping cask. General View.

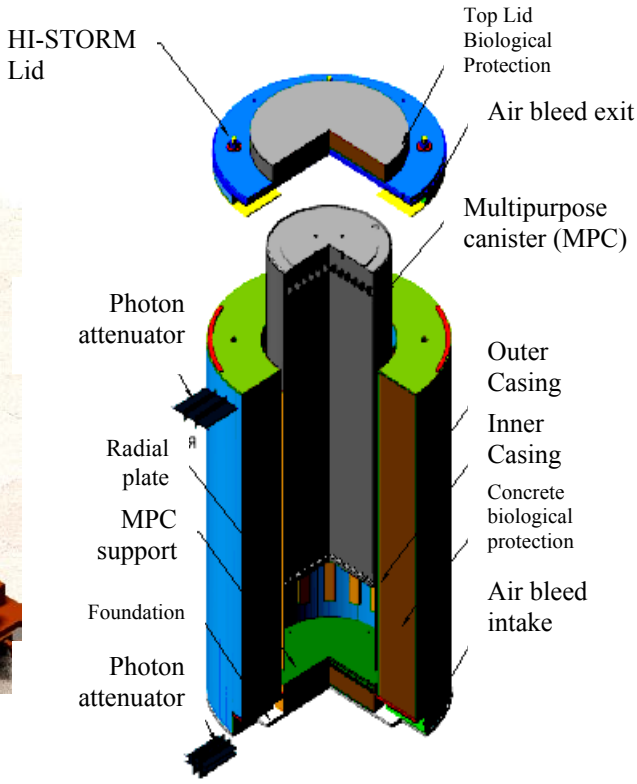

Fig.5.4. HI-STORM Storage Container. General View

5.2. CSNFSF Facility Specifications

5.2.1. Holtec International technology-based CSNFSF consists of:

- On-site loading areas, where SFAs are being loaded into MPCs and HI-STAR casks are being prepared for transportation, to be located at each WWER-based NPP unit;
- Off-site transportation system to accommodate SFA-filled HI-STAR casks' transportation from NPPs over to CSNFSF;
- CSNFSF on-site buildings and facilities;
- In-house on-site transportation system (conveyors).

5.2.2. Loading areas, where SFAs are being loaded into MPCs and HI-STAR shipping casks are being prepared for transportation, shall be located in the reactor rooms of NPP units at Khmelnytsky, Rivne and Yuzhnoukrainsk NPPs. The following transportation-and-handling operations shall be conducted at the on-site loading areas:

- SNF preparation for loading, including placement of HI-TRAC transfer cask with MPC into SFP;
- Loading of SFAs with SFP cooling period of at least 5 years into MPC (Fig.5.5);
- Removal of HI-TRAC with MPC from spent fuel pool;
- Drainage, filling with inert gas (helium) and MPC sealing (Fig.5.6);
- Moving MPC into HI-STAR shipping cask (Fig.5.7);
- Sealing HI-STAR shipping cask;
- HI-STAR preparation for transportation (installing HI-STAR shipping cask onto a rail platform, installing shock absorbers (dampers), fasteners and protective shielding) (Fig.5.8).

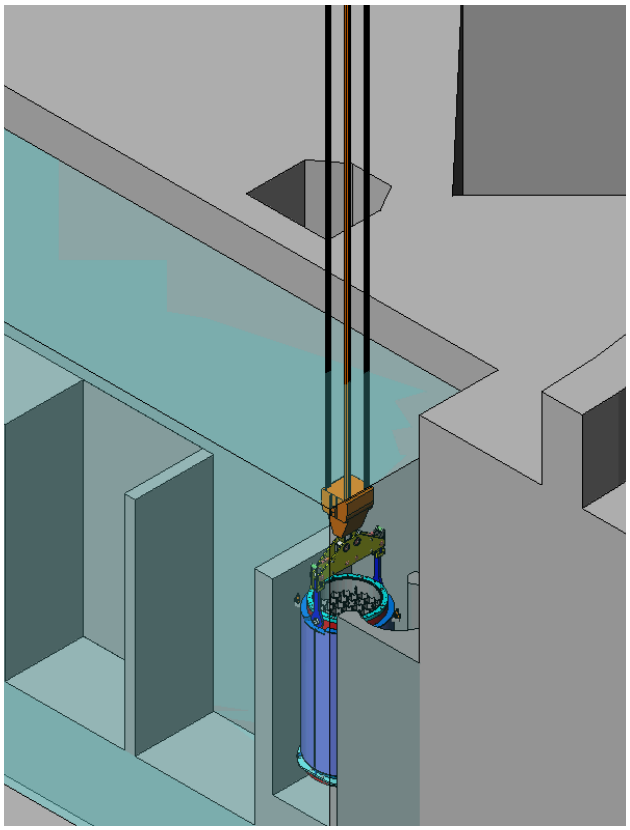

Fig.5.5. Loading SFAs into MPC.

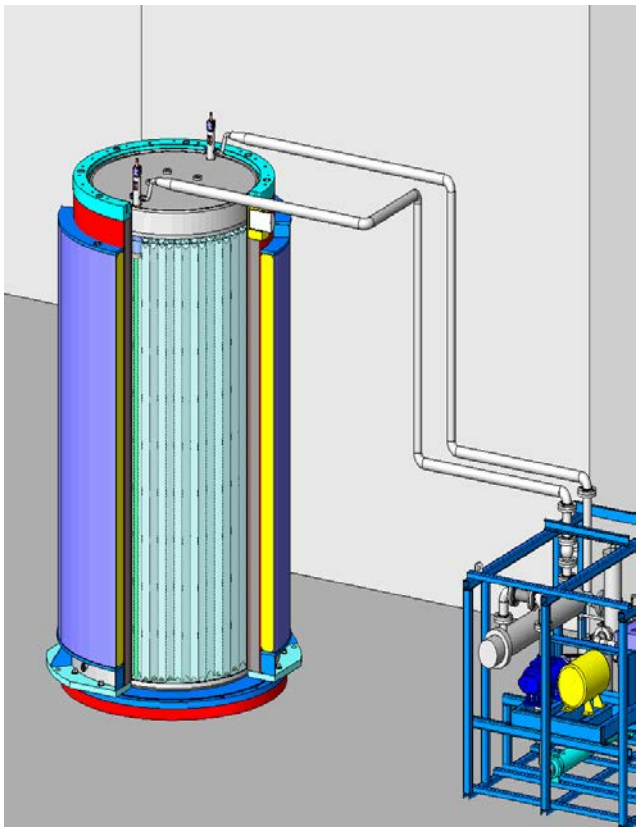

Fig.5.6. MPC Drainage, helium-filling and sealing.

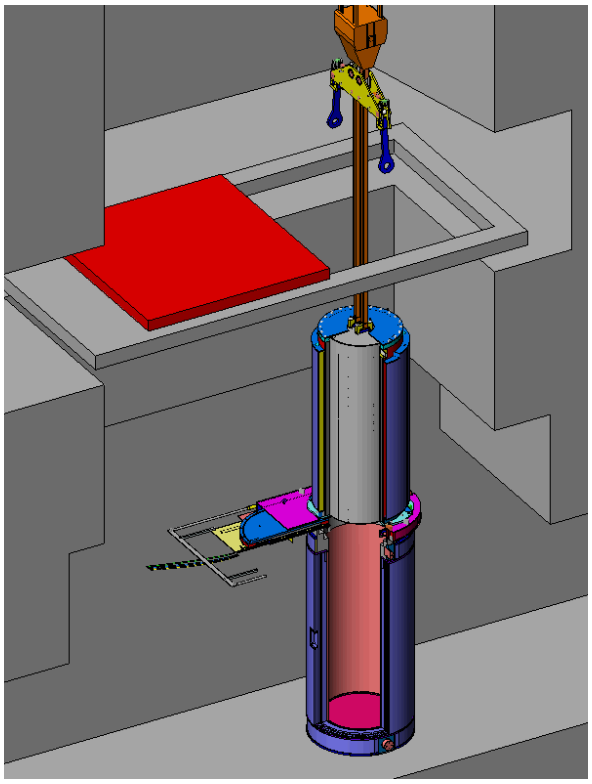

Fig.5.7. MPC removal into HI-STAR shipping cask.

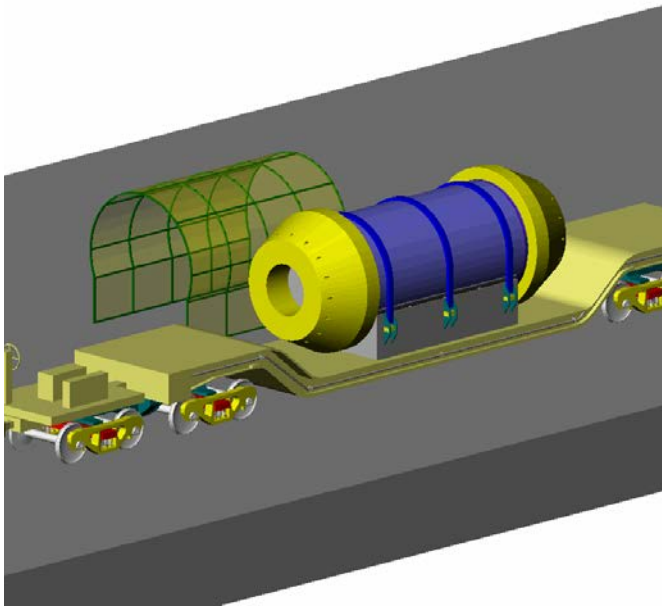

Fig.5.8. Preparing HI-STAR shipping cask for transportation.

5.2.3. Major functions of the off-site transportation system include:

- Delivery of SFA-filled shipping casks from NPPs to CSNFSF site via railroads of the Ministry of Transportation and Communications of Ukraine;
- Delivery of empty shipping casks to NPPs for further loading of SFAs via railroads of the Ministry of Transportation and Communications of Ukraine;
- Maneuvering container train within CSNFSF site.
- Removal of SNF from NPPs shall be performed by special container train.

5.2.4. Key elements of CSNFSF facility complex are:

- Reception Facility (building) (Fig.5.9);
- SNF Container Storage Area (Fig.5.10).

Reception facility is intended for reloading MPCs from HI-STAR shipping casks into HI-STORM long-term storage containers. MPC reloading shall be performed in a reception area using HI-TRAC transfer cask.

SNF container storage area is a passive container storage system for HI-STORM storage containers that have are equipped with hermetically sealed MPC barriers and a bioprotective barrier of a HI-STORM container.

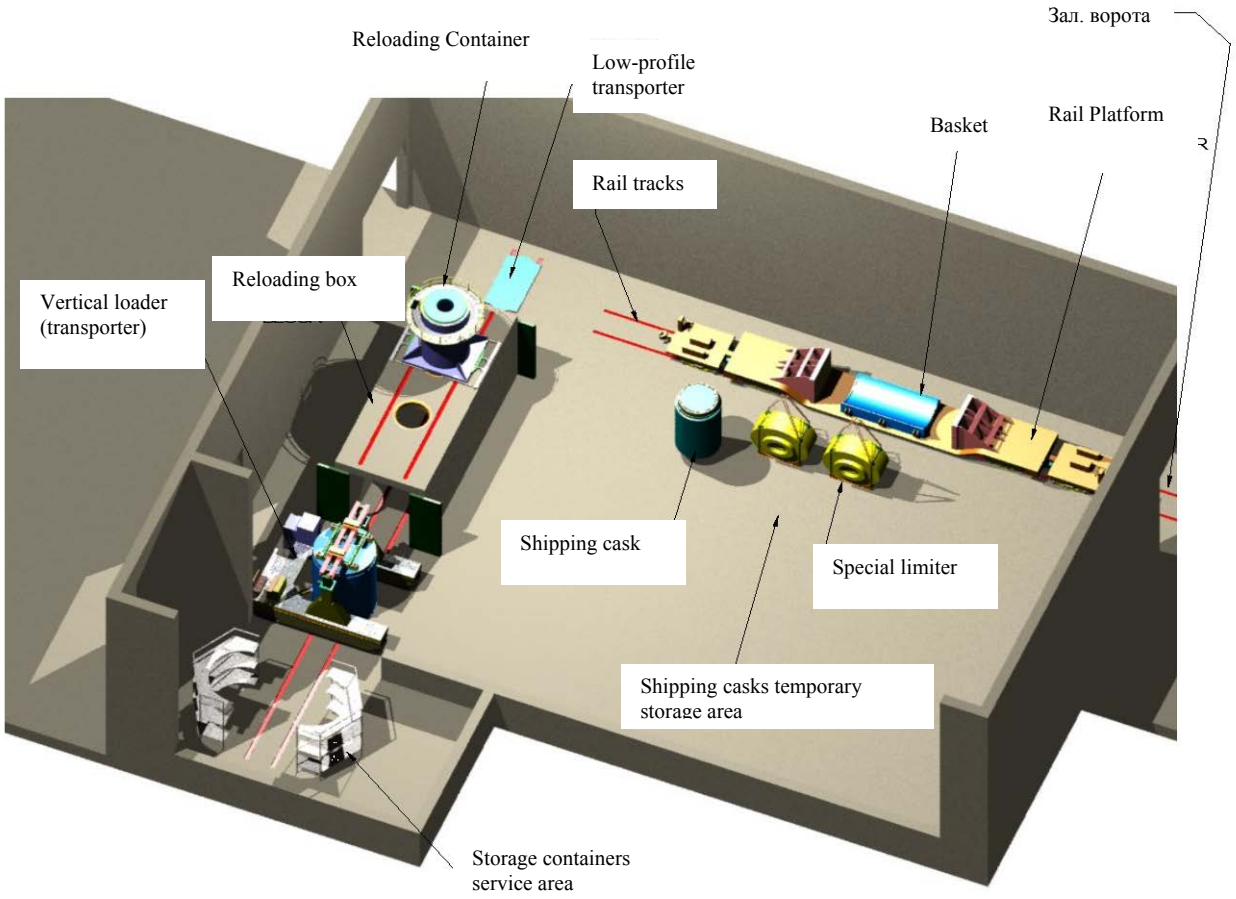

Fig.5.9. Reception facility. Suggested layout.

Fig.5.10. Storage area with HI-STORM storage containers

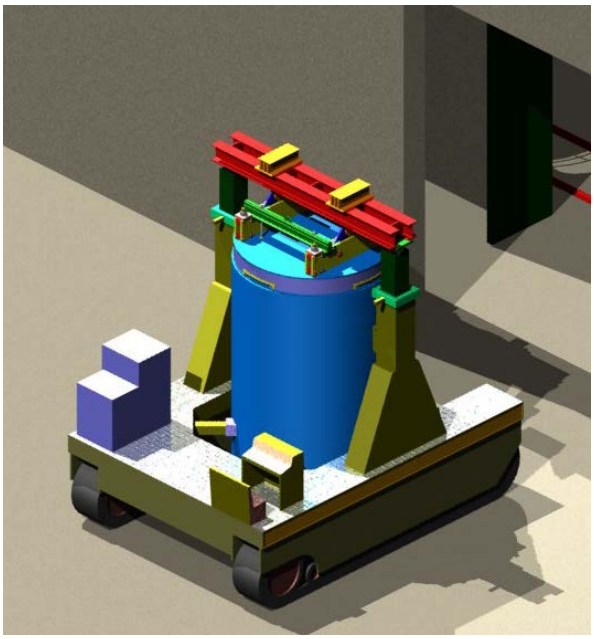

Fig.5.11. Transferring HI-STORM container from reception facility over to storage area

5.2.5. In-house on-site transportation system is based on the use of vertical loader (transporter) for lifting and positioning of HI-STORM storage (Fig.5.11).

5.2.6. CSNFSF general operation support systems include:

- Monitoring and Control System (hereinafter - MCS);
- Radiation Control System;
- Physical Protection Engineering and Technical Service;
- Nuclear material accounting and inventory system;
- Water supply system;
- Sewage system;
- Electrical Power Supply System;
- Communications Network;
- Fire safety system;
- HVAC;
- Radioactive Waste Management System.

Monitoring and control over CSNFSF technological processes shall be performed from main and local control boards.

5.3. Primary construction solutions

5.3.1. General size of CSNFSF fenced site area equals 644x182m. IFS stipulates the following buildings and structures belonging to CSNFSF:

- Reception building (MPC reception and reloading area) that includes „dirty" service workshops, personnel airlock and CSNFSF main control board;
- HI-STORM containers storage area;
- Maintenance building with MPC storehouse featuring filler shed for filling HI-STORM shell rings with concrete;
- Maintenance & Storage Garage for conveyor transporter;
- Garage for 4 vehicles, including minor remedial maintenance workshops and a decontamination facility;
- Maintenance shed for inspection and maintenance of one container rail car and holding area for one escort rail car;
- Electrical equipment building;
- Refueling station with two fuel columns and two underground fuel reservoirs for two fuel types;
- Administrative building that includes office space, assembly hall, cafeteria and civil defense public works;
- Motorway entry checkpoint;
- Railway entry checkpoint;
- Special SNF Train holding track;
- Sewage Pumping Station;
- Firefighting water-supply and pumping facility;
- Firefighting water drum / water reservoir;
- Rainwater accumulating storage tank;
- Guardhouse.

5.3.2. Buildings and structures listed in Section 5.3.1 above belong to Class III Nuclear

and Radiation Safety, except for Reception Facility and SNF Container Storage Area that belong to Class I.

5.3.3. Normal and extreme operating loads for CSNFSF buildings and structures located at "SDF" site are provided in Tables 5.1 and 5.2 below. Combined load values for on-site structures are listed in Table 5.3.

Table 5.1. Normal operating loads.

Load type	**Load value**	**Overload (Safety) Factor**	**Dynamic Response Factor**	**Notes**
1. Own weight		1,1 (0,9)	-	Depends on design documentation
2. Technological loads, incl.: - crane equipment loads; - construction loads				Depends on installed equipment
3. Snow load (kgf/m^2)	70	1,4		СНиП 2.01.07-85
4. Wind load (kgf/m^2)	70	1,4		СНиП 2.01.07-85

Table 5.2. Extreme (design) loads for CSNFSF structures (Cat. I / II) .

Load type	**Design load values for**	
	Cat. I structures	**Cat. II structures**
1. Snow load (kgf/m^2)	210	100*
2. Wind load (kgf/m^2)	75	42*
3. Climatic Temperature (°C)		
In winter	- 45	- 22*
In summer	45	29*
Vortex Class	3.0	-
Wind speed, m/s	81	-
Wind force (kgf/m^2)	150	-
Delta-p (kgf/m^2)	800	-
Seismic load, pts. (Richter)	6	5.0**

* Estimated loads as per СНиП 2.01.07/

** Loads as per ПНАЭ Г–5-006-87.

Table 5.3. Combined loads

Combo Type		Combo#	Dead loads (DL)	Live loads								Notes
				Short-term (ST)	Long-term (LT)	Specific loads						
						Extreme snow	Extreme wind	Extreme Temp.	Vortex	Seismics S_{MDE}	Airblast	
Main		1	+	1 LT	-	-	-	-	-	-	-	Notes 1,3
		2	+	-	1 ST	-	-	-	-	-	-	
		3	+	0.95 (LT)	0.9 (LT)	-	-	-	-	-	-	
Specific	Seismics	1	0,9 DL	0.8 LT (except snow)	0.5 (snow+cnstr)	-	-	-	-	-	-	
	Extreme Snow	1	+	0.95 (tech)	-	-	-	-	-	-	-	
		2	+	-	0.8 ST (except snow)	-	-	-	-	-	-	Note 1
		3	+	0.95 (tech)	0.8 LT (except snow)	-	-	-	-	-	-	
	Extreme Temp	1	+	0.95 (LT)	-	-	-	-	-	-	-	
		2	+		0.8 ST	-	-	-	-	-	-	
		3	+	0.95 (LT)	0.8 ST	-	-	-	-	-	-	
	Extreme Wind	1	+	0.95 (LT)		-	-	-	-	-	-	Note 1
		2	+	-	0.8 ST (except snow)	-	-	-	-	-	-	
		3	+	0.95 (LT)	0.8 ST (except	-	-	-	-	-	-	

					snow)							
	Vortex	1	0,9 DL	-	-	-	-	-	-	-	-	
		2	0,9 DL	0·95 (LT)	-	-	-	-	-	-	-	
		3	0,9 DL	-	0·8 Σ ST (except wind)	-	-	-	-	-	-	
	Airblast	1	+	0·95 (LT)	-	-	-	-	-	-	-	Note 1
		2	+	-	0·8 Σ ST	-	-	-	-	-	-	
		3	+	0·95 (LT)	0·8 Σ ST	-	-	-	-	-	-	

Notes:

1. Snow load has a K=0,3 coefficient (for long-term loads) or K=1.0 (for short-term loads).

2. When assessing specific seismic compo loads, snow load values are assumed as per СНиП 2.01.07-85.

3. When assessing crane load as a short-time live load, crane load shall be assessed with a 0,5 coefficient as per СНиП 2.01.07-85, Section 7и. For the purposes of CSNFSF design all physically-possible and least-favorable crane positions shall be considered.

6. SAFETY PRACTICES

Information provided in this Section 6 of the analytical summary is detailed in CSNFSF IFS documentation [18,19].

6.1. Nuclear safety

6.1.1. Main nuclear safety criteria for CSNFSF systems is not to exceed Keff neutron multiplication factor of $K_{EF} = 0,95$ under normal operation conditions or design-based accident. K_{EF} values must not exceed the indicated value even in case of solid flooding of the storage area or in case water elevation / distribution or density levels reach the thresholds that trigger maximum K_{EF} values [29].

According to the requirements [29], $K_{еф}$ design and operating values assessment is to be conducted under the following conservative assumptions:

- For nuclear fuels with different degrees of enrichment, nuclear fuel with maximum enrichment degree shall be taken into account;
- NFA absorber elements, as well as absorber elements in the storage constructions shall be neglected if they are not fixed or in case their efficiency decreases as a result of baseline event;
- SNF shall be considered fresh fuel if its K_{EF} value decreases with nuclear fuel burn-up, except for cases, when fuel burn-up fraction is used as a nuclear safety factor and is monitored via special monitoring equipment.

6.1.2. In accordance with the regulatory requirements, CSNFSF nuclear safety shall be ensured via the following factors:

- Limiting of SFA placement increments within MPC;
- Limiting the weight of fissive nuclear materials in each separate MPC;
- Use of heterogeneous neutron poison by placing and affixing Metamic ceramet material within MPC;
- Technological processes limitations;
- Technological parametric control of the SNF storage and management systems complex.

Besides, IFS does not consider fuel element jacket as an engineering barrier regardless of its state. This approach ensures safe and secure SNF storage even in case SFA jackets were damaged prior to their placement in storage, or in case fuel element jackets become damaged within their respective storage periods.

6.1.3. Suggested primary nuclear safety technological features for SNF management comprise:

- On-site MPC loading at NPP unit;
- MPC Transportation from NPP over to CSNFSF;
- Operations and procedures conducted at reception facility at CSNFSF;
- On-site transportation within CSNFSF;
- SNF Storage within storage area.

6.1.4. The following technical features ensure nuclear safety at the stage of MPC loading at NPP unit:

- MPC engineering features, incl. two hermetically sealed barriers (sealed MPC casing and fuel jacket), cellular structure and the use of Metamic heterogeneous neutron poison;
- MPC drainage and inert gas filling (helium);
- MPC sealing tightness and welding quality check;
- Use of special tubes for damaged fuel elements storage.

6.1.5. Suggested primary nuclear safety technical features at the stage of SNF transportation from NPP to CSNFSF (except technical features for MPC), include:

- Low HI-STAR shipping cask elevation due to horizontal transportation and the use of special rail car [platform];
- Use of special damping shock absorbers to protect shipping cask in case of emergency [wreckage];
- Ensuring proper levels of SNF heat dissipation into MPC that is being transported inside HI-STAR shipping cask.

6.1.6. Technical features that are related to ensuring nuclear safety during operations and procedures performed at CSNFSF reception facility, are directed at decreasing the probability of mechanical damage to MPC and excluding the probability of water access to SFAs in case of loss of sealing of MPC. Those features include:

- Class I Safety design and construction of reception facility;
- Use of equipment with seismic design and increased reliability features;
- MPC handling is only possible within reloading box;
- No water inlets within transportation-and-utility line corridor and reception box thereby excluding water access to reloading box;
- Remote supervision over all technological operating procedures;
- Neutron emission control within transportation-and-utility line corridor.

6.1.7. The following nuclear safety features are suggested by IFS for the stage of on-site transportation at CSNFSF:

- Limited per-run nuclear material transportation capacity (transporter is to carry only one HI-STORM shipping cask with MPC per run);
- No water is used by transporter design or on its routes;
- Low container elevation levels during transportation (elevations below 28cm) due to special transporter design features (HI-STORM storage container is designed to survive 28cm fall with no damage to the container or its contents);
- Minimal possible length of transportation routes for HI-STORM-loaded transporter runs between reception facility and container storage area; no transit interference with other transported freight at CSNFSF;
- Transporter speed limited by design (transporter operates at low speeds).

6.1.8. Nuclear-safety-related technical features during SNF storage at container storage area are aimed at:

- Ensuring MPC protection against external environmental impact;
- Ensuring MPC protection against external technogenic impact, including sabotage [subversion];
- Ensuring neutron interaction isolation between MPCs;
- ensuring sufficient heat dissipation from MPC.

The following technical measures are foreseen by IFS to achieve safety levels described above:

- use of HI-STORM protective container for MPC storage. HI-STORM is designed to handle extreme impact, incl. airplane crash;
- When stored at container storage area, HI-STORM storage containers are separated by distance, sufficient to exclude mutual neutron interaction between two neighboring MPCs;
- Rainwater system is designed for collection and drainage of maximum daily rainfall amounts for the CSNFSF location, in order to avoid storage area flooding;
- Static uninterruptible temperature control at HI-STORM intake and output vent ducts, showing MPC and SFA heat dissipation status;

- CSNFSF construction location has low groundwater elevation altitude and groundwater fluctuation, that excludes site flooding and/or water access to MPC via HI-STORM vent ducts;
- CSNFSF construction location is situated far from water reservoirs and rivers, that excludes site flooding and/or water access to MPC via HI-STORM vent ducts;
- Securing container storage area as a critical area within CSNFSF security perimeter; access to critical for staff without additional clearance is forbidden;
- Scheduled container area inspection by CSNFSF staff in order to avoid potential vent ducts choking and ensure their timely cleaning;
- Use of non-combustible construction materials for container storage area to exclude fire probability.

6.1.9. IFS supplied information on Keff neutron multiplication factor preliminary estimates, performed by «Holtec International» when drafting technical bidding offer for CSNFSF construction. According to estimated results, HI-STORM storage containers are suitable for storage of WWER-440 and WWER-1000 fuel elements.

Detailed Keff estimates for normal operation conditions and design accident events shall be supplied at the general design stage of Safety Analysis Report (hereinafter – SAR).

6.2. Radiation safety

6.2.1. Ensuring radiation safety at all stages of CSNFSF lifecycle is achieved by implementing general principles, stipulated in [11]:

- Justification principle: any decision that alters the radiation exposure situation should do more good than harm. This means, that by introducing a new radiation source, by reducing existing exposure, or by reducing the risk of potential exposure, one should achieve sufficient individual or societal benefit to offset the detriment it causes;
- Dose limits application principle: the total dose to any individual from regulated sources in planned exposure situations [other than medical exposure] should not exceed the appropriate limits [recommended by ICRP];
- Protection optimization principle: the likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.

6.2.2. The implementation of the above principles is achieved by selecting optimal technical solutions and conducting a certain complex of radiation protection efforts, including organizational, radiation-hygienic and technical efforts. A general structure of such complex of efforts in presented in Figure 6.1 below.

Radiation protection efforts shall be planned, performed and controlled in accordance with documentation that shall be developed for each particular stage of CSNFSF lifecycle (construction, commissioning, operation and decommissioning).

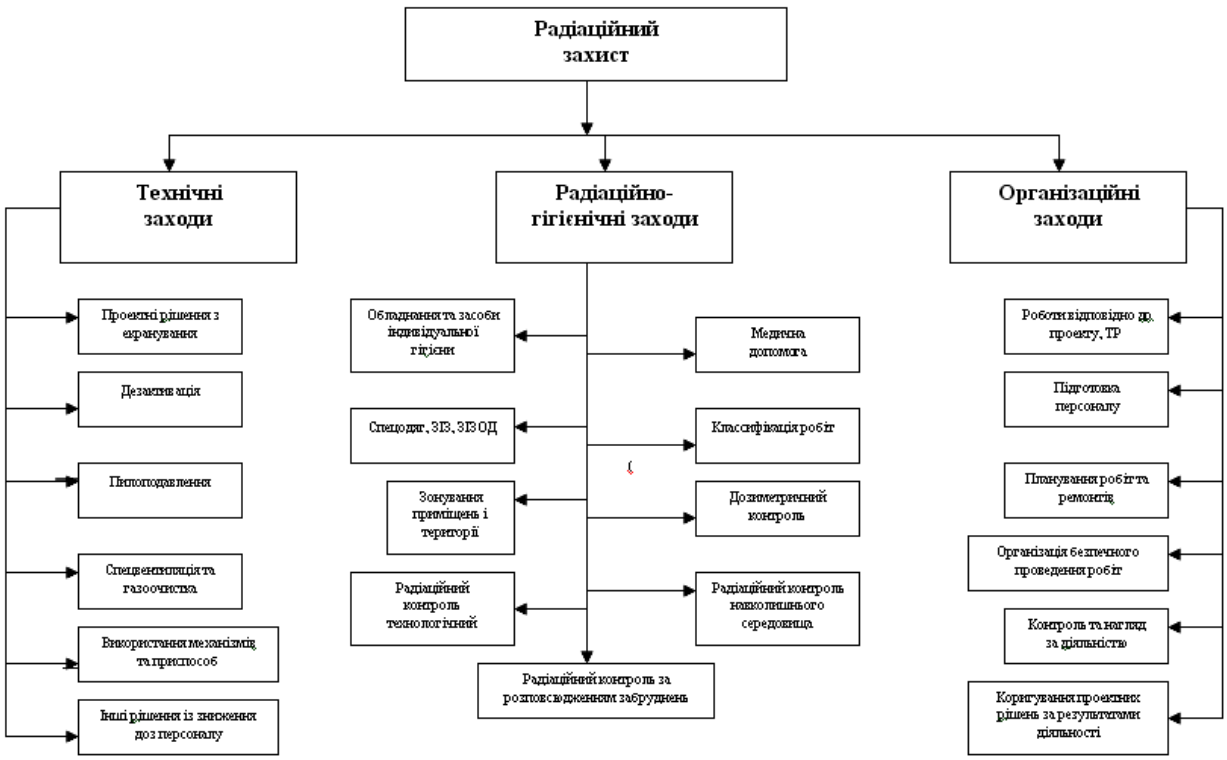

Fig.6.1. Radiation Prevention Measures: Structural Organigram.

Radiological protection			
Technical Measures	**Hygienic Measures**		**Prevention Measures**
Shielding design solutions	Personal hygiene equipment and tools	Medical aid	Design-based efforts
Decontamination	Protective clothing, PPE	Classification of works	Staff Training
Dust suppression	Territorial and spatial zoning	Dosimetric control	Work-planning, maintenance and repairs planning
Ventilation and gas treatment system	Instrumental radiation control	Environmental Radiation Control	Worksite safety routines
Use of mechanical systems and tools	Radiation Monitoring of Discharge / Release Proliferation		Worksite inspections and checks / supervision
Other personnel exposure minimization solutions			Design Updates / Corrections based on operation results

6.2.3. A short-term increase in volumetric concentration of radionuclides at the ground level at "SDF" construction site might occur under normal sitework conditions at CSNFSF construction stage. Such increase might be caused by dust elevation during groundworks and will inflict additional surface contamination of the adjacent area and radiation exposure of the construction workers. Most critical in this respect is service railway construction that will interfere with "western" trace of radioactive fallout that was caused by the 1986 Chornobyl Accident.

IFS assessed, that maximum ground level air activity during such groundworks shall constitute on the average:

- for ^{137}Cs - 4,7 Bq/cu.m;
- for ^{90}Sr - 0,9 Bq/cu.m;
- for alpha-emitting transuranic elements (hereinafter – TUE) - 0,05 Bq/cu.m.

A conservative assessment performed by IFS for maximum total individual effective dose for construction workers under normal sitework conditions equals to 3,34 mSv (including 2,20 and 1,14 mSv from internal and external radiation exposure respectively), which does not exceed permissible exposure levels for class A workers [11].

Emergency situations analysis, performed by IFS for CSNFSF construction stage at "SDF" site has resulted in following conclusions. All internal baseline events during construction stage, caused by 'falling load' events or by equipment malfunctions shall not cause any exposure of construction workers. The only critical external baseline even that may cause notable radiation for workers is a hypothetical forest fire, happening at the pre-development stage (before deforestation is complete. A conservative assessment performed by IFS for maximum total individual effective dose for construction workers (at 4km distance, which corresponds to maximum ground level concentration) shall equal to 0,1 – 0,7 mSv depending on weather conditions, which does not exceed permissible levels for Class A workers [11].

"SDF" site is located with Exclusion Zone territory, which is subject to ground-level contamination reference levels set by ГН 6.6.1.076-01 [30]. Since radioactive contamination levels of adjacent territories is equivalent to those at construction site, no significant additional contamination of adjacent territories due to radioactive dust fall shall occur.

6.2.4. According to the solutions considered by IFS, technical foundation of radiation safety control system at the stage of CSNFSF operation is comprised of five subsystems:

- Process radiation monitoring subsystem;
- Dosimetric monitoring subsystem;
- Individual dosimetric control subsystem;
- Environmental radiation monitoring subsystem;
- Radioactive contamination non-proliferation monitoring subsystem.

Radiation monitoring by those subsystems shall be technically performed via the following measures:

- Continuous remote monitoring;
- Fixed local instrumentation monitoring;
- Mobile [hand-portable] instrumentation monitoring;
- Lab sampling and analysis monitoring.

Radiation situation in the area and inside CSNFSF buildings and structures during CSNFSF operation is defined by a number of factors, influenced both by CSNFSF operating technology and by factors not related to its operation. Major non-related factor for "SDF" area is the ground contamination caused by the 1986 Chornobyl Accident. Background radiation level during CSNFSF operation shall depend on the efficacy of decontamination measures performed at the stage of construction (ground stripping excavation). Its contribution to aggregate radiation exposure dose upon completion of decontamination measures is assessed to be lesser than currently.

Factors that impact radiation situation in the area and inside CSNFSF buildings and structures and are determined by CSNFSF operating technology include impact from the following ionizing radiation sources:

- HI-STAR shipping casks with MPC;
- MPCs with SFAs, placed inside HI-STAR shipping casks;
- MPCs with SFAs, placed inside HI-STORM storage containers;
- MPC with SFAs, placed inside HI-TRAC transfer cask;
- Exhaust ventilation equipment and filters;

- LRW containers;
- Radiation-contaminated equipment and facility surfaces;
- Radiation-contaminated personal protective equipment (PPE) that are located in the personal access hatch;
- Additional radiation-contaminated PPEs.

According to the assessments conducted by IFS, the following technological operations are considered to be most critical in terms of radiation exposure dosage under CSNFSF's normal operation conditions:

- On-site MPC loading at the NPP unit – MPC sealing, welding and leakage check (individual exposure dose per 1 MPC – 200 mRem, up to 20 MPCs annually);
- MPC reloading at CSNFSF reception facility – reception of HI-STAR shipping cask (individual exposure dose per 1 MPC – 20 mRem, up to 20 MPCs annually);
- SNF storage in CSNFSF container storage area – temperature monitoring equipment inspection (individual exposure dose per 1 MPC – 5,4 mRem/year at container storage area design storage capacity of 458 MPCs stored inside HI-STORM storage containers).

In order to ensure that 20 mSv/year exposure limits, set by [11] for Class A personnel, shall not be exceeded, IFS suggests that above-mentioned most critical technological operations at the stages of NPP-based MPC loading and MPC reloading at CSNFSF reception facility shall be performed by 2 and 4 individuals respectively.

As per IFS assessment, exposure dose rate (EDR) directly in the storage area shall amount to 30-60 mR/year. Maximum possible individual effective dose and its dependency from actual distance to CSNFSF storage area (at maximum design storage capacity) is provided at Fig. 6.2 below. The analysis has shown, that under normal operation conditions of CSNFSF, technology solutions, suggested by IFS, shall guarantee that radiation exposure dosage values shall be kept at a reasonably achievable low levels throughout the whole long-term SNF storage duration.

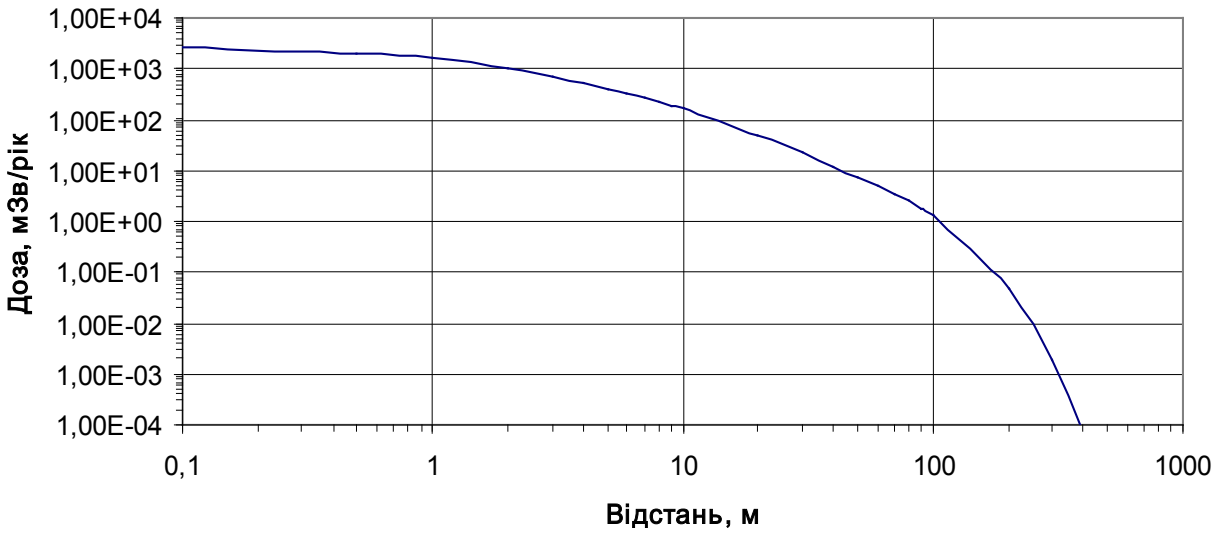

Fig.6.2. Maximum possible individual effective dose and its dependency from actual distance to CSNFSF storage area. [X-axis: Distance, meters; Y-axis: Dosage, mSv/year]

A list of accident initiators, considered by IFS for «Holtec International» complies with the requirements of ПНАЭГ-14-029-91 [29] and НП 306.2.105-2004 [36]. Completeness substantiation for the list of accident initiators shall be conducted at the general design stage of SAR.

A brief analysis of CSNFSF accident events is based on «Holtec International» data, obtained during HI-STORM licensing procedure in the U.S. The following accident initiation events were considered by the IFS for the purposes of CSNFSF operation:

- Abnormal operation conditions' initiators:
  - Weather anomalies (abnormally high air temperature);
  - Partial clogging of MPC fuel element jacket vents;
  - Partial clogging of HI-STORM storage containers' vent ducts;
  - HI-STORM / HI-STAR MPC handling irregularities (drop accident);
  - Irregularities during reloading MPC from HI-TRAC transfer cask to HI-STAR shipping cask (seizure accident);
- Design-basis-accident initiators:
  - earthquake;
  - vortex;
  - lightning strike;
  - severe winds, windstorms;
  - flooding during high-water discharge (river floods, seasonal floods);
  - severe snowstorm;
  - heavy rainfall;
  - Random genesis ground shears (landslides, ground devolutions);
    Bank caving, slope wash, riverbed erosion;
  - Sinkhole collapse or surface subsidence, incl. those caused by groundwater caving;
  - Explosion, fire outside of site area;
  - Terroristic act and theft of nuclear material;
  - Fire inside CSNFSF;
  - Explosion outside CSNFSF;
  - Blackout;
  - Abnormal pressure increase inside MPC;
  - Radioactive material leakage [from MPC external surface into the environment];
- Beyond-Design-Basis-Accident (BDBA) Initiators:
  - hypothetical criticality accident (during on-site MPC loading at NPP);
  - obstructions [debris];
  - full clogging of HI-STORM vent ducts;
  - airplane crash (onto HI-STAR casks or HI-STORM containers with MPCs);
  - SFA cladding damage with MPC leakage;
  - HI-TRAC MPC drop event (38m fall) inside NPP reactor room.

IFS treats MPC radioactive contamination with ^{60}Co with activity levels of $2{,}67 \cdot 10^{9}$ Bq as a result of contact with SFP water, as an MDBA with highest assessable radiological consequences, as well as:

- Short-term contamination discharge from reception facility during MPC reloading procedure, or
- Extended duration contamination discharge from HI-STORM storage containers during MPC storage.

The results of effective exposure dose assessment from all impact sources, caused by HI-STORM radiation discharge event over 1-year period are provided in Figure 6.3 below.

The assessment of most severe BDBA event by IFS was performed based on «Holtec International» data on PWR nuclear power reactors spent nuclear fuel (USA). According to the considered BDBA event scenario, SFA cladding leakage inside a long-term stored HI-STORM storage container occurs, followed by internal pressure increase up to 1,4MPa inside MPC, which causes a radiation discharge into the environment with the speed of $3{,}3 \times 10^{-4}$ ncm^3/second. A cumulative 30-day effective exposure dose assessment results are provided in Figure 6.4 be-

low.

According to the results obtained by IFS, MDBA-caused radiation impact from CSNFSF at "SDF" construction site on social environment is considered negligible, whereas BDBA-caused radiation impact is considered acceptable.

Detailed radiation burden estimates for normal operation conditions, DBA event and BDBA event shall be conducted at the general design stage of SAR.

6.2.5. Qualitative analysis conducted within IFS for CSNFSF decommissioning stage (hereinafter – WFS (withdrawal from service) indicates, that exposure doses for the personnel are assessed at the levels significantly lower than those during operation stage. This conclusion is based on the fact, that major personnel radiation exposure is caused by external gamma-rays, whereas SFAs, as its primary source shall no longer exist at CSNFSF at the decommissioning stage. Major exposure doses shall be determined by decontamination of non-occupied spaces in the controlled area and the equipment thereof. Upon completion of decontamination works of the equipment and the non-occupied space personnel radiation exposure levels shall decrease significantly. A more detailed study of radiation safety matters at the decommissioning state shall be provided in the CSNFSF decommissioning framework document that shall be developed at the general design stage.

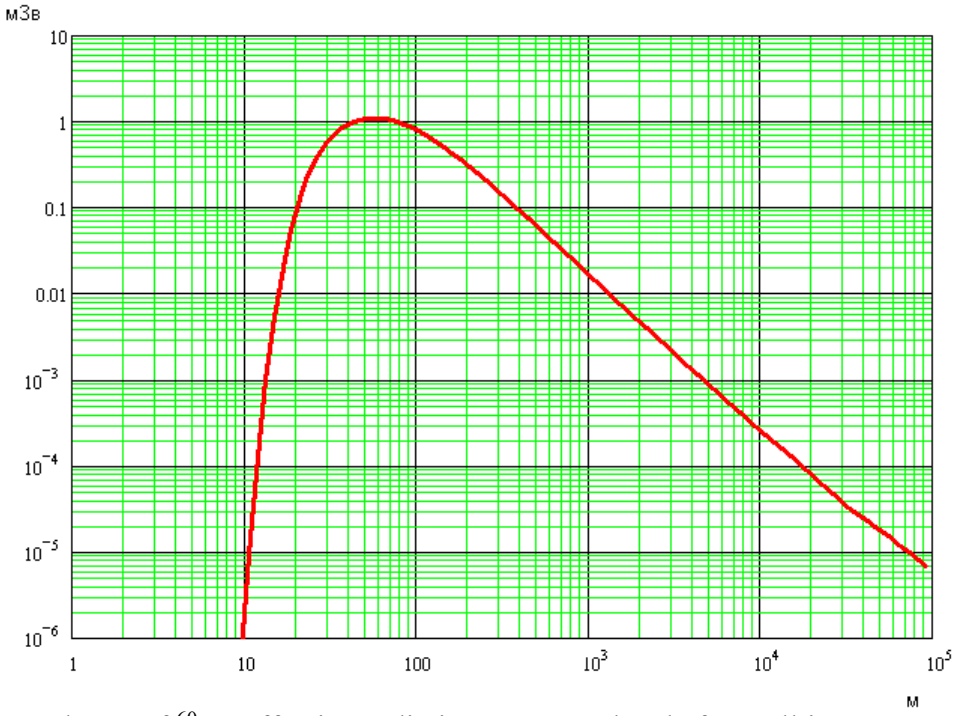

Fig.6.3. Dependency of ^{60}Co effective radiation exposure levels from all impact sources and distance from CSNFSF in case of MDBA event. [X-axis: meters, Y-axis: mSv]

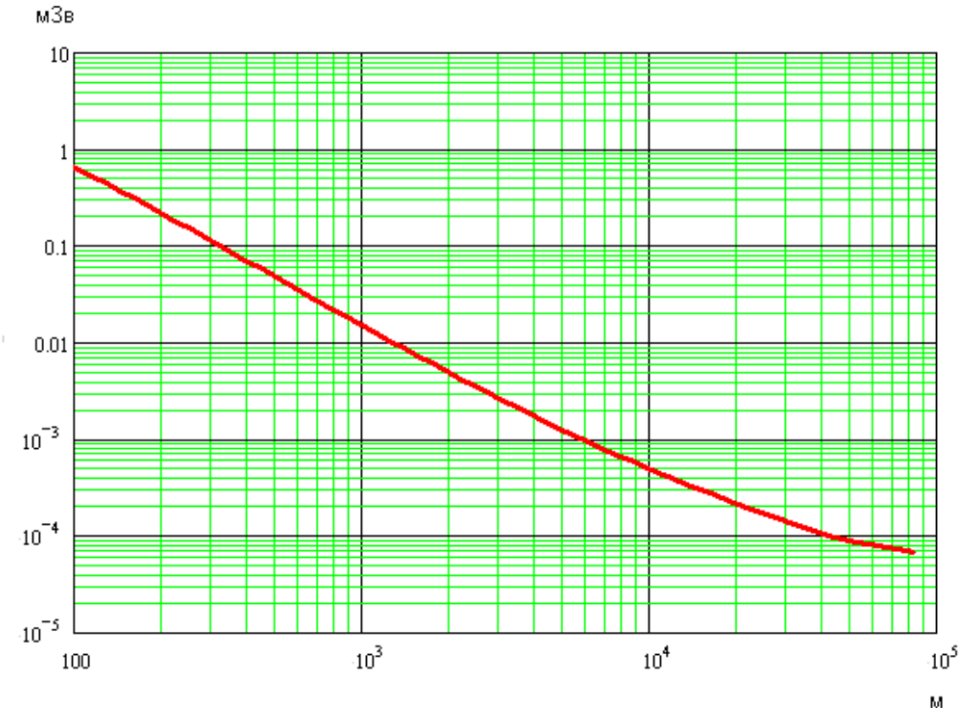

Fig.6.4. Cumulative 30-day effective exposure dose assessment results and its dependency from distance to CSNFSF in case of BDBA event. [X-axis: meters, Y-axis: mSv]

6.3. Fire safety

6.3.1. In accordance with the requirements of ДСТ 12.1.004-91 [31], IFS foresees ensuring CSNFSF fire safety through:

- fire prevention system;
- fire protection system;
- accident-preventive measures implementation.

6.3.2. CSNFSF fire prevention system suggested by IFS is based on certain measures aimed at:

- Prevention of combustive media emergence;
- Prevention of ignition sources, their introduction or contact with combustible media.

6.3.3. General fire protection solutions, studied by IFS, include:

- General architectural and building solutions, including:
  - General master layout solutions;
  - General space planning and construction decisions for CSNFSF buildings and structures;
- General electrical engineering solutions, including:
  - Electrical installation fire safety;
  - Fire protection systems electric power;
  - Escape lighting;
  - Lightning-discharge protection systems for buildings and structures;
  - Protective grounding systems for equipment and structures;
- General ventilation systems solutions;
- General firefighting water supply solutions, including:
  - External firefighting water lines;
  - Internal firefighting water lines;
- General automatic firefighting equipment solutions, including:
  - Automated fire alarm installations;

- Automated fire extinguisher installations;
- Smoke protection systems;
- Automated fire alarm system;

- General accident-preventive measures.

6.3.4. CSNFSF is expected to be equipped by high-pressure firefighting water line, that shall ensure external and internal fire extinguishing for buildings and structures, as well as automated water-based fire suppression installations. Autonomous water-based fire suppression system includes:

- Emergency water reservoirs;
- Fire-fighting pumping station;
- On-site firefighting water mains equipped with fire hydrants;
- Internal firefighting water line.

Two reinforced concrete water storage tanks (200 cu.m. each) shall serve as emergency water reservoirs. External and internal fire extinguishing system for buildings and structures foresees water mains to be attached to:

- Maintenance building with MPC storehouse;
- Maintenance & Storage Garage for conveyor transporter;
- Garage for 4 vehicles;
- Reception facility cable chutes

6.3.5. "SDF" site and CSNFSF are located in a way, that the maximum distance between the furthest located CSNFSF building or structure and the nearest firehouse, located at Vector Facility is less than 1km. Therefore, no separate firehouse (fire station) shall be required.

6.3.6. A more detailed study of fire safety matters shall be developed at the general design stage.

6.4. Occupational safety

The following occupational hazards present potential danger at all stages of CSNFSF life cycle:

- Electric shock;
- Drop of freight or goods, that are being transported by lifting facilities;
- Injuries caused by contact with rotating equipment parts, operating lifting equipment or transportation vehicles;
- Fire inflicted hazards;
- Elevated radiation background;
- Radioactive contamination of equipment surfaces.

6.4.1. A complex of organizational and technical measures, aimed at accident prevention and consequence mitigation in case of an accident is foreseen by IFS. These measures encompass:

- Industrial safety;
- Occupational hygiene.

6.4.2. In accordance with industrial safety requirements, IFS has foreseen the following measures, aimed at personnel protection from occupational hazards mentioned above:

- Personnel training;
- Accident-preventive measures aimed at personnel protection from electric shock or lightning stroke;
- Protective fencing for rotating equipment parts;
- Certain staircase elevation angle;

- Protective fencing for openings and construction lots;
- Color Coding of Pipelines;
- Personnel Escape Routes planning and construction;
- Pipeline Flange Connectors for Maintenance Duct Caps;
- Use of test equipment to conduct periodic static and dynamic load tests for lifting equipment;
- Periodic inspection and testing of personal protective equipment, tools, instrumentation, etc.

6.4.3. Occupational hygiene measures, suggested in IFS, include:

- Medical monitoring and first aid support;
- Catering provisioning;
- Welfare facilities, including certain facilities in the reception facility:
  - Sanitary inspection room;
  - Airlock area for personnel, working in transportation-and-utility line corridor;
- Personnel sanitary and hygiene facilities provisioning.

7. RADIOACTIVE WASTE MANAGEMENT

Information provided in this Section 7 of the analytical summary is detailed in CSNFSF IFS documentation [18].

7.1. LRW Management

7.1.1. LRW Management at CSNFSF includes radioactive waste collection, administration, accumulation and shipment for further reprocessing to ChNPP or other facility within EZ that has LRW reprocessing capabilities (applies to "SDF" site).

7.1.2. As per IFS, under normal operation conditions CSNFSF is supposed to generate low-level LRW only. Under normal operation conditions, during CSNFSF active operation stage, LRW is generated from the following sources:

- Waste water from decontamination of spaces in the secured access area (SAA);
- Waste water from SAA wash-sinks and safety showers, if water contamination levels exceed ДК$_Б$ TLV for potable water;
- Radiochemical laboratory waste;
- Waste water from equipment decontamination.

7.1.3. LRW management system includes the following elements (subsystems):

- Active drain system, that includes:
  - Gulleys;
  - Window wells;
  - Window wells drainage pumps;
  - pipelines;
- LRW level monitoring tank.

Active drain system is designed to accept 530m^3 of low-level liquid radioactive waste per year. LRW level monitoring tanks are designed for daily intake volume of 5,4 m^3 of waste water from SAA wash-sinks and safety showers (it is expected that in most cases waste waters shall not exceed TLV for normal sanitary sewerage).

It is further expected, that during CSNFSF passive operation stage a daily total of 2,46m^3 of waste water, resulting from sanitary-hygienic needs of the personnel, shall be generated.

It is suggested by the IFS, that LRW from "SDF" site shall be shipped to "Vector" Facility for further reprocessing by tank truck, that shall be rented from "Vector" Facility".

7.2. SRW Management

7.2.1. SRW Management at CSNFSF includes radioactive waste collection, administration, accumulation, containerization, temporary storage and shipment to ChNPP or storage and disposal facility for further reprocessing. (suggested for "SDF" site only).

7.2.2. As per IFS, the following SRW shall be managed during CSNFSF active operation stage:

- Used material;
- Used equipment (equipment out of order) beyond repair;
- Used personal protection equipment units (hereinafter – PPE);
- Cotton waste, cleaning material, tampons;
- Construction waste.

7.2.3. Estimated SRW volume under CSNFSF normal operation conditions during active operation period shall not exceed 65 m^3 of low-level solid radioactive waste per year.

Passive operation period shall generate personnel sanitary-hygienic SRW only (PPEs). Expected SRW volume shall not exceed 7,2m^3/year.

7.2.4. Low-level and intermediate-level SRW management shall be performed via the following technological procedures:

- collection at initial locations, radiation monitoring and primary packaging;
- delivery of primary-packaged SRW to SRW shipping container location, container loading;
- radiation monitoring of the container outer surfaces;
- outer services decontamination (protective coating application) where necessary;
- SRW containers' temporary storage in the designated segment of the transportation-and-utility line corridor of the reception facility;
- Installing containers onto transportation vehicle and transportation to the further handling location.

7.2.5. КТЗ-3,0-type reinforced concrete container and a КТ-0,2-type 200-liter container cask shall be used for transportation purposes.

7.2.6. It is suggested by the IFS, that SRW from "SDF" site shall be shipped for further reprocessing by transport belonging to ChNPP or SDF.

8. CONSTRUCTION MANAGEMENT

Information provided in this Section 8 of the analytical summary is detailed in CSNFSF IFS documentation [18,23].

8.1. CSNFSF Construction Phases

8.1.1. IFS stipulates that CSNFSF construction shall be completed in the following order:

- Start-up facilities construction phase (all CSNFSF buildings and structures plus 3 base slabs and on-site access roads at the container storage area (each base slab stores 32 HI-STORM storage containers). This construction phase includes:
  - Pre-development stage;
  - Primary construction stage;
- First construction phase (4 base slabs, 32 containers per slab);
- Second construction phase (4 base slabs, 32 containers per slab)
- Third construction phase (4 base slabs, 32 containers per slab).

Initial construction period (Start-up facilities phase) - 3 years.

Construction period for each subsequent construction phase - 1 year. Potential commissioning into service shall occur at 5-year intervals.

8.1.2. CSNFSF start-up facilities construction at its pre-development stage is expected to be performed in two simultaneous spreads:

- 1st spread:
  - Access-road construction works with bottom pitching;
  - Deforestation and stubbing works;
  - Unsuitable soils replacement;
  - Work-site protective fencing;
  - Emergency water reservoirs construction;
  - Interim interpad roads construction;
  - Construction yard set-up;
  - Laying interim intrasite water / sewage / power supply mains;
  - Grid connection works (connection of intrasite communications to off-site grids);
- 2nd spread:
  - Laying permanent off-site water / sewage / power supply utility mains;
  - Permanent on-site utility mains connection to existing off-site grids.

8.1.3. CSNFSF start-up facilities construction at its primary stage, that begins upon completion of pre-development works, is expected to be performed in 6 simultaneous spreads:

- 1st spread provides for subsequent construction of:
  - reception facility;
  - Maintenance facility with MPC storehouse;
  - Entry Checkpoint-1 facility;
- 2nd spread provides for subsequent construction of:
  - administrative building with Centralized Security Console ;
  - Electrical supplies building;
- 3rd spread provides for cast reinforced concrete slabs and road slabs construction for on-site conveyor transporter;
- 4th spread provides for:
  - Fencing construction and physical protection system installation;
  - Railcar maintenance facility construction;
  - Entry Checkpoint-2 facility construction;
- 5th spread provides for construction of CSNFSF miscellaneous buildings and structures:

- Sewage pumping station;
- Conveyor transporter garage;
- Garage for 4 vehicles;
- Guardhouse;
- Rainwater reservoir tanks;
- 2 fuel reservoirs (5 cu.m. capacity);
- Fuel column for vehicles;
- Intrasite fencing with physical protection system installation;
- Construction of intrasite grids, interpad road network and access road network (with bituminous concrete pavement);

- 6th spread provides for construction of a 6,7km-long railroad stub track between Shepelychi station and CSNFSF and a 300m-long side track at Shepelychi Station.

8.1.4. Subsequent CSNFSF construction phases include:

- Laying interim utility mains with grid connection to existing start-up facility grid;
- Construction of Interim roads and designated lay-down areas with bottom pitching;
- Construction of 4 special base slabs with service roads for conveyor transporter operation;
- Relocation of storage area protective fencing;
- Laying stationary utility mains and their connection to the grid.

8.1.5. The order of construction suggested by IFS may be changed at the construction planning stage that is expected to be performed at general design stage.

8.2. Physical Volumes of Construction and Assembly Works

8.2.1. General construction and assembly works and their respective volumes are provided in Table 8.1 below.

8.2.2. Soils subject to excavation stripping at the pre-development and site clearance stage (approx. 91,000m^3), and deforestation timber (approx. 45,500 tree trunks) may be attributed to radioactive waste. Certain radioactive waste production may occur during construction of a railway stub track that crosses "western" trace of radioactive fallout caused by the 1986 Chornobyl Accident. (50,0000 m^3).

Land allocation may be required for the purposes of RW stocking. Allocation estimates shall be determined at the general design stage.

Table 8.1. General construction and assembly works and their respective volumes

	Type of general construction and assembly works	Volume, total	Incl. start-up facility phase
1	Unsuitable soils stripping excavation, ,000 cu.m.	91,0	91,0
2	General excavation, ,000 cu.m.	159,1	125,7
3	Land-filling and back-filling, ,000 cu.m.	112,4	111,8
4	Cast-in-situ concrete and reinforced concrete structures, cu.m.	18 217,0	10 297,0
5	Prefabricated concrete and reinforced concrete structures, cu.m.	4 526,0	4 526,0
6	Construction steelwork, tons	176,7	176,7
7	Railroad tracks laying, km	8,6	8,6
8	Road and platform construction, ,000 sq.m.	64,0	41,3

8.3. Construction staffing requirements

8.3.1. IFS estimates CSNFSF start-up facility construction labor costs at 234,907 man-

days.

Average annual demand for construction workers for a 3-year construction phase constitutes 218 workers. Peak demand for construction workers is expected during Q3 of the 2nd year of construction and is estimated at 246 workers.

8.3.2. Subsequent CSNFSF construction phases and their respective labor costs are estimated at:

- For Phase I and Phase II construction – 43 200 man-days;
- For Phase III construction – 38 218 man-days.

Annual demand for construction workers for subsequent phases with expected construction period of 1 year per phase is estimated at:

- For Phase I and Phase II construction - 119 workers;
- For Phase III construction - 106 workers.

8.3.3. Rotational work system at "SDF" construction site provides for 15-day rotation cycles for construction workers in Chornobyl. Daily shuttle bus service between Chornobyl and CSNFSF construction site for construction workers shall be provided.

8.4. Construction Material Needs

8.4.1. Construction material needs (material, prefabricated structures, products) and their respective estimates (see Table 8.2 below) are determined by IFS based on the estimated volumes for general construction and assembly (see Table 8.1 above).

8.4.2. IFS stipulates that construction material and prefabricated structures shall be delivered from manufacturing facilities and enterprises in Korosten', Chornobyl, Kyiv and Kamyanets'-Podils'ky. A temporary ready-mixed concrete plant shall operate on-site to provide necessary quality of concrete mix and its respective quantity of 30 cu.m./hour.

Table 8.2. Construction material needs (materials, structures, products).

№ п/п	Material or structure name	Volume, total	Incl. start-up facility phase
1	Prefabricated concrete and reinforced concrete structures, cu.m.	4 526,0	4 526,0
2	Custom concrete, ,000 cu.m.	31,1	17,7
3	Construction steelwork, tons	186,7	186,7
4	Cements, ,000 tons	10,9	6,3
5	Gravel, ,000 tons	50,9	30,7
6	Sand, ,000 tons	23,5	14,6
7	Fittings, ,000 tons	2,3	1,3

8.5. Energy and water resources requirements

8.5.1. Expected energy load for the CSNFSF start-up facility construction phase is estimated at 1034 kW; energy load at subsequent construction phases is estimated at 130 kW.

One of six designed CSNFSF power supply lines shall be used to satisfy power supply needs during construction. A unit transformer substation shall be installed on-site with the electrical load characteristics of 10/0,4-0,23 kW supplied by one transformer unit with 1600 kW*A capacity.

8.5.2. Expected water load for production and hygienic purposes at the stage of start-up facility production is estimated at 3,74 liters per second; at subsequent construction phases - 1,0 liters per second.

9. CSNFSF OPERATION

Information provided in this Section 9 of the analytical summary is detailed in CSNFSF IFS documentation [18,23].

9.1. Operational Stages

9.1.1. IFS stipulates CSNFSF operation life-cycle shall have two stages, that differ from one another by the specificity of technological procedures performed:

- Stage I – active use period, when CSNFSF is expected to be loaded with SNF produced by Rivne NPP, Khmelnytsky NPP and Yuzhnoukrainsk NPP, as well as to store previously loaded SNF (duration of active use period is 45-50 years; final duration shall be determined by the amounts and intensity of loading SNF for storage at its storage area);
- Stage II – passive use period, when previously loaded SNF is being stored at CSNFSF (the duration of passive use period is estimated at 50-55 years and shall be finally determined by the decision-making process on further SNF Management Scenario in Ukraine and subsequent deployment thereof).

9.1.2. Active use period comprises the following technical procedures:

- On-site SFA loading into MPC in the NPP reactor room;
- Transportation of MPC from NPP to CSNFSF location;
- Reloading of MPC with SFAs (SNF) into HI-STORM storage containers;
- Installing HI-STORM containers for storage;
- Monitoring, inspection and maintenance of CSNFSF systems, structures and equipment.

9.1.3. Passive use period comprises monitoring, inspection and maintenance of CSNFSF systems, structures and storage facility [area] equipment.

9.2. Staffing Requirements

9.2.1. CSNFSF operation is expected to be staffed via a newly-created autonomous subdivision of SE NNEGC “Energoatom”.

9.2.2. IFS preliminary draft of the autonomous subdivision staffing plan includes:

- CSNFSF Management and Administration Unit;
- Technological procedures support unit;
- CSNFSF buildings and structures support and maintenance unit;
- CSNFSF Radioactive material and radioactive waste physical protection unit ;
- CSNFSF equipment and systems’ minor repairs and maintenance unit.

9.2.3. CSNFSF perimeter security, general equipment repairs, day-to-day capital construction, on-site construction and structural inspection, firefighting and fire prevention shall be performed by hired specialized third-party contractor companies.

9.2.4. The number of full-time staffing positions assessed by IFS (including shift-work schedules – up to 3 shifts per day) is:

- For active use period - 310 (incl. operating personnel – 147);
- For passive use period - 234 (incl. operating personnel – 90).

9.3. Estimated Energy & Water Requirements

9.3.1. IFS estimates annual CSNFSF power supply requirements as follows:

- During active use period – 1 162 900 kWh /year;
- During passive use period – 822 400 kWh/year.

9.3.2. Expected water demand for production and hygienic purposes during CSNFSF operation is estimated at:

- Active use demand – 4 732 cu.m. / year;
- Passive use demand – 2 465 cu.m. / year.

10. CSNFSF WITHDRAWAL FROM SERVICE / DECOMMISSIONING

Information provided in this Section 10 of the analytical summary is detailed in CSNFSF IFS documentation [18].

10.1. General principles

10.1.1. General decommissioning requirements for nuclear facilities are stipulated by current legislation [1-10,32,36,37].

10.1.2. Based on provisions of НП 306.2.02./1.004-98 [32], IFS has defined the following CSNFSF basic decommissioning principles:

- Ensuring low risk levels for personnel and environment;
- Minimizing radioactive waste production during decommissioning;
- Reducing economic costs.

The above-mentioned principles shall be taken into account at the next general design stage:

- During selection of materials (in order to facilitate decontamination);
- During definition of space arrangement plans (in order to facilitate access to the equipment and removal of radioactive material);
- During selection of construction solutions (in order to facilitate disassembly procedures and demolition);
- During selection of SNF storage solutions (in order to facilitate removal of SNF from CSNFSF storage area).

10.2. CSNFSF Decommissioning Strategy

10.2.1. CSNFSF Decommissioning stage shall begin upon adopting resolution on complete SNF removal from CSNFSF facility (approximately in 100 years). CSNFSF Decommissioning Strategy shall be determined by the resolution on the final goal of withdrawal from service. The following final goal options are considered by IFS in addition to the option of facility life extension:

- Construction of SNF storage facility with a different storage solution instead of CSNFSF;
- Declaring CSNFSF territory open for unrestricted free access [upon demolition --?].

10.2.2. Regardless of the option chosen, CSNFSF decommissioning shall have the following stages:

- Operational closure;
- Final site closure;
- Dismantling.

10.2.3. Operational closure stage and its procedures shall be identical for all identified options. The following procedures shall be completed within this stage:

- CSNFSF structures and elements engineering and radiation survey;
- Evacuation of existing SFA-filled storage containers for further disposal and/or reprocessing;
- Management of produced RW;
- Development of project documentation that shall allow to move to the next decommissioning stage.

The duration of operational closure shall be determined by the procedure of SNF evacuation, which depends on the timeline of its acceptance for disposal or further reprocessing.

10.2.4. Final site closure stage for the identified options shall be identical in its pur-

pose, but may differ in terms of duration, as the amount of procedures that shall be completed shall vary. The following general procedures shall be performed at this stage:

- Existing structures and elements potential reusability survey for the new facility;
- Determining measures and options for potential upgrade and/or replacement of certain elements;
- Development of project documentation that shall allow to move to the next decommissioning stage.

No final site closure stage shall be available for Option 4.

10.2.5. Dismantling stage for the identified options shall also be identical in its purpose, but may differ in terms of duration, as the amount of dismantling works that would have to be completed shall vary. In general, dismantling works for CSNFSF structures and elements, as well as handling produced RW shall be performed at this stage.

10.3. RW Management during decommissioning

10.3.1. RW management for RW produced during decommissioning intends for maximal use of designed RW management configuration:

- LRW upon sufficient accumulation shall be transported for further reprocessing to Chornobyl NPP or other facilities within EZ that possess reprocessing capabilities;
- Low-level SRW shall be accumulated in containers and further transported for reprocessing to Chornobyl NPP or Storage and Disposal Facility (SDF);
- It is suggested that containers and specialized transportation vehicles shall be rented from Chornobyl NPP or SDF for the purposes of transportation and reprocessing and/or disposal of intermediate-level SRW (in case intermediate-level SRW shall be produced).

10.3.2. High-level RW production at CSNFSF decommissioning stage is not expected.

11. ENVIRONMENTAL IMPACT ASSESSMENT

Information provided in this Section 11 of the analytical summary is detailed in CSNFSF IFS documentation [23,25-27].

CSNFSF environmental impact assessment (EIA) has been performed by IFS for the most suitable construction site only ("SDF" Site) (see Section 4.7 of this analytical summary).

11.1. Environmental Components and Impact Types analyzed by EIA

11.1.1. An EIA of normal CSNFSF operation conditions and potential emergency situations, that may occur during CSNFSF construction and operation has been performed by IFS. EIA assesses impact on the following environmental components:

- Natural environment;
- Social environment;
- Technogenic Environment.

The following natural environment components were analyzed:

- Geological environment;
- Aerial environment;
- soils;
- ground waters;
- surface waters;
- Plant kingdom (flora);
- Animal kingdom (fauna).

Whereas CSNFSF construction and operation does not have any impact over the intensity of incident solar radiation, temperature, wind speed, humidity, atmospheric inversions, fog intensity or other climatic characteristics, CSNFSF design climatic impact was not assessed by IFS.

Whereas there are no natural reserve areas within Exclusion Zone, CSNFSF impact on such objects was not assessed.

11.1.2. The following direct environmental impact types were studied by IFS during EIA of CSNFSF construction and operation:

- Radiation impact, related with normal CSNFSF construction and operation conditions and potential emergency situations;
- Non-radiation impact:
  - Chemical impact (caused by chemical elements and substances existing in certain waste types (fumes, discharges, dumping or waste);
  - Physical impact (ultrasound, vibration, EMR, noise from operating equipment, vehicles, etc.);

11.1.3. The use of hazardous chemical technologies at CSNFSF is not expected. Ultrasound, vibration, EMR or noise sources, should they exist, are expected to comply with existing limits and regulations on limiting their impact on the environment; this compliance, however, must be substantiated at the general design stage. As a result of qualitative assessment, no detailed quantitative assessments for direct non-radiation impacts were performed by IFS.

11.1.4. Main environmental impact is expected from radioactive waste discharge under normal operation conditions and potential accidents (emergency situations) during CSNFSF construction or operation. Impact sources and their respective discharge amounts for impact sources that were assessed by IFS are summarized in Table 11.1.

Table 11.1. Main sources of radiation environmental impact.

Impact sources	Unit of measure-ment	Radionuclide	Discharge activity
Construction under normal operation conditions			
Pre-development stage, site clearance, railroad stub track construction, access road construction (including deforesta-tion and ground planning)	Bq	^{137}Cs ^{90}Sr α-active TUE	$1{,}4\cdot10^{6}$ $6{,}5\cdot10^{5}$ $3\cdot10^{4}$
Construction Accident			
Forest fire (brush fire)	Bq	^{137}Cs ^{90}Sr α-active TUE	$5{,}4\cdot10^{10}$ $2{,}9\cdot10^{10}$ $5{,}8\cdot10^{8}$
Normal operation			
CSNFSF Normal operation	Bq/year	^{60}Co ^{137}Cs	$1{,}6\cdot10^{7}$ $1{,}9\cdot10^{2}$
Maximum design-based accident			
Reception of MPC-31 fuel can with excessive surface con-tamination	Bq	^{60}Co	$2{,}7\cdot10^{9}$
Beyond-design-basis accident			
MPC-31 leakage with disruption of all fuel elements from unspecified cause)	Bq	^{137}Cs ^{90}Sr α-active TUE	$1{,}9\cdot10^{8}$ $1{,}2\cdot10^{8}$ $5{,}1\cdot10^{5}$

11.2. Site environmental description

11.2.1. As per IFS conclusions, most suitable CSNFSF construction site (“SDF” site) is located within Exclusion Zone (EZ). The site is situated between uninhabited villages of Buryakivka, Chystohalivka and Stechanka, bordering on the west with RW Storage and Disposal Facility (“SDF”, “Vector” Facility. Site location base map is shown in Figure 4.3 above.

11.2.2. Brief surface pattern and geological conditions description for “SDF” site are outlined in Section 4.5 of this Document.

11.2.3. Hydrological conditions of the territories adjacent to CSNFSF construction site are described as follows. The site is located at considerable distance [away] from surface waters, on a watershed plateau between the right bank of Pripyat River and the valleys of its tributaries – Uzh River and Sakhan River. The closest distance to Pripyat River water line is 12km, or 11km and 9km to the water lines of Uzh River and Sakhan River respectively. Site area has no perennial rivers, intermittent watercourses, ponds or marshlands.

Annual moisture balance of the area is positive (+80mm.). Due to high soil permeability and low surface pattern roughness, excessive moisture infiltrates to ground waters, with no evident surface run-off [discharge]. However, localized inclusions of aquiclude may cause marsh formation. CSNFSF site surface pattern has an easy eastern grade (towards Pripyat River valley.

Pripyat River, right tributary of the Dnipro River is the main water artery in the area. Pripyat River is a lowland river with dominant meltwater nourishment, pronounced spring tide and occasional winter and rain runoff discharge floods. Riverbed width within EZ amounts to 160-200 meters, with an average depth of 2,5-4 meters and peak depths of 6-8 meters. Floodplain is ambilateral (except for certain segment near Chornobyl, with an average with of 4-5km, peak floodplain width of up to 7-8 km is observed in the Pripyat City – Krasne segment, as well as in Pliutovische – Ladyzhychi segment. Construction of Chornobyl NPP and its water-blocking infrastructure (erected upon 1986 Chornobyl Accident) has led to the fact that Pripyat riverbed deformation is currently artificial limited. Kiev Reservoir backwater area impact has caused midstream deceleration in the near-mouth segment of Pripyat River with significant sedimental

accumulations. Hydrological characteristics of Pripyat River are listed below:

- Long-term average annual discharge at Chornobyl NPP site - 420 cu.m. per second.
- Maximum annual discharge:
  - with 0,01% exceedance probability – 13000 cubic meters per second;
  - with 0,1% exceedance probability - cubic meters per second;
  - with 1% exceedance probability - 6000 cubic meters per second.
- Minimal average monthly discharge with 97% exceedance probability:
  - Open water period - 61,1 cubic meters per second;
  - Ice cover period - 55,9 cubic meters per second.
- Maximal level at Chornobyl NPP water intake site:
  - with 0,1% exceedance probability - 111,3 m BES;
  - with 1% exceedance probability - 109,9 m BES.
- Minimal daily discharge with 99% exceedance probability:
  - Open water period - 102,20 m BES;
  - Ice cover period - 102,32 m BES.

Floodplain flooding elevation in the segment 5km up/down from Yaniv Rail bridge is above 106,5-106,7 m BES.

Pripyat River Basin includes all other water courses (except Braginka River that flows through Dnipro-Pripyat Interfluve into Kiev Reservoir.

Second most notable (by area) water artery is Uzh River, right tributary of Pripyat River. 20% of its watershed is located within EZ, namely its lower left-bank segment between Polis'ke village and the river mouth. Most notable left-bank tributaries of Uzh River are Hrezlya River and Illya River; right-bank tributaries – Bober River and Veresnya River.

Sakhan River watershed is situated entirely within EZ on the right bank of Pripyat River. Its inflow into Pripyat River is situated near Novoshepelychi village, as well as inflow of Hlynytsa River (river mouth is located near Leliv village). Overall length of Sakhan River perennial streams within EZ amounts to 157km with its watershed area of 113 sq.km.

Chornobyl NPP EZ hydrographic network also includes closed water bodies and low-flow streams.

An artificial cooling pond with the area of 22 sq.km is located in the immediate vicinity of Chornobyl NPP, alongside the right bank of Pripyat River. Artificial water elevation support at 6-7 meters above river water elevation preconditions constant water filtration through reservoir floor and dam with its subsequent flow into Pripyat River as surface discharge via filtration streams and southern drainage channel, as well as via underground flow.

Upon the end of direct radioactive fallout deposition onto water objects in spring and summer of 1986, surface water discharge from the contaminated flood plain area, as well as from contaminated watersheds, currently remains the most significant source of surface water radioactive contamination. Water infiltration from contaminated Chornobyl NPP cooling pond acts as an additional source of contamination for Pripyat River. Major contribution into radioactive contamination is formed by ^{90}Sr and ^{137}Cs. Their respective contaminant concentrations in the surface water bodies is summarized in Table 11.2 below.

11.2.4. Hydrogeological conditions in the CSNFSF construction area are characterized by the following factors. EZ Territory is situated in the selvage part of the north-western slope of Dnipro-Donetsk Artesian Aquifer Basin. Based on aquifer recharge and drainage conditions, washability ratio of the aqueous deposits and chemical composition, ground waters of the surveyed territory belongs to the free water exchange zone.

Table 11.2. ^{90}Sr and ^{137}Cs concentration in the surface waters in the SDF site location area (based on 2001 data).

Monitoring Location	^{137}Cs, kBq/m^3			^{90}Sr, kBq/m^3		
	Min	Max	Avg	Min	Max	avg
Pripyat River (Dovlyady village)	0,04	0,20	0,10	0,02	0,27	0,09
Pripyat River (Chornobyl)	0,03	0,38	0,12	0,10	0,53	0,23
Uzh River (Cherevach village)	0,03	0,22	0,09	0,06	0,53	0,18
Braginka River (Dam №39)	0,21	2,90	1,30	0,73	3,10	1,7
Sakhan River (Novoshepelychi)	0,11	0,65	0,22	0,45	7,40	1,50
Cooling pond (ChNPP)	0,23	7,6	2,10	0,28	3,50	1,50
Hlynytsa River	0,15	0,57	0,31	1,60	7,70	4,60
Semykhody Creek	0,50	1,80	1,30	10	23	16
Pripyat Creek	1050	4,00	2,70	17	37	26
Azbuchyn Lake	6,10	12	9,90	100	120	110
ChNPP Stage 3 Drainage Channel	150	240	190	12	48	38
Polder near Zymovysche village	1,40	7,20	3,90	1,50	43	16
Hlyboke village	2,40	11	7,10	59	96	79

Hydrogeological conditions in the CSNFSF construction area are predefined by the characteristics of aquifer systems and regionally developed aquitards that have the following stratigraphic sequence:

- Quaternary deposits aquifer system;
- Kiev Marl Eocene aquitard deposits (siltstone-marl bed);
- Eocene deposits aquifer system;
- Marl-cretaceous aquitard deposits (Upper Cretaceous Period);
- Cenomanian-Lower Cretaceous aquifer system.

Subsurface waters of the quaternary deposits aquifer system are universally spread. This aquifer system, as a rule, is a free (water-table) aquifer. Aquifer depth may vary between 0,0 meters (in certain subsurface/surface water closure points) and 19-21 meters. Depending on lithological and granulometrical composition of aquiferous stratums, filtration ratio may way widely – between 0,2 and 20-30 meters/day, aquifer transmissivity varies in the range of 100-400 sq.m./day within riverbeds and 40-100 sq.m./day at watershed divides. Aquifer waters are predominantly of calcium-bicarbonate salt composition, rarely of calcium/magnesium bicarbonate type, with water mineralization levels of 0,1-0,8 g TDS per cubic decimeter. Subsurface aquifer water accumulation occurs primarily via precipitation infiltration. First upper subsoil quaternary aquifer system is practically unprotected from radioactive contamination permeation.

Kiev Marl Eocene aquitard deposits have localized spreading. They are comprised primarily from quaternary deposits aquifer systems and mixed (confined/free) aquifer systems in Buchak-Kaniv Eocene deposits. Aquitard waters occur at the depths of 20-30 meters (for riverbed terraces) and up to 90 meters (for river-shed divides). Their stratum depth varies in a wide range from several meters down to 30 meters. Marl depositions are occasionally underwashed, that resulted in formation of sand-loam inclusions. Marl clays filtration ratio varies in the range of $2{,}5 \cdot 10^{-4}$ to $1{,}8 \cdot 10^{-2}$ meters per day.

Eocene deposits aquifer systems have universal spreading and are represented by Buchak and Kaniv aquifers with next to no competent aquitard layers, whereas these aquifers are considered to have merged into a single hydraulic system and are treated as a single aquifer system. Aquifer depth varies from 20 meters in the western part of EZ down to 90 meters in north-eastern direction and under morainic ridges. Aquifer waters are bounded, with 30 to 60 meters waterhead. Water deposition depth ranges from 0,5 meters down to 17 meters. Eocene aquifer waters have calcium-carbohydrate salt composition with water mineralization of up to 0,3 g TDS per cubic decimeter. This aquifer system is the primary source for technical and potable water

supply of State Specialized Facility "Chornobyl NPP".

Marl-cretaceous aquitard deposits (Upper Cretaceous Period) are universally spread. These are represented by a layer of white limestone chalk and chalky marl rocks with the layer thickness of 56-85 meters, gradually increasing from the West to the East, in the general direction of Dnipro-Donets Elevation central graben. Deposition depth ranges between 85 and 145 meters. Filtration ratio is approx. 10^{-6} meters per day.

Cenomanian-Lower Cretaceous aquifer system is universally spread. From lithological perspective, aqueous rock thickness is not seasoned, represented by consertal sands with seldom marl and sandstone inclusions. Thickness of aqueous rock varies from 2 to 40 meters, with a 25-30 meters' average. Aquifer depth levels vary between 150 and 217 meters with gradual increase in eastern direction. The aquifer is bounded. Salt composition primarily of calcium-hydrocarbonate type, rarely of magnesium-carbohydrate type, with general mineralization of 0,5-1,0 g TDS per cubic decimeter. General hardness – 1,9 – 5,6 mgE per cubic decimeter. Formation of aquifer subsurface water deposits occurs outside of surveyed area, water "age" is estimated at 30-70 years. Water discharge occurs primarily due to water intake by water intake facilities. Cenomanian-Lower Cretaceous aquifer system is the major source for centralized potable water supply system of Chornobyl.

Directly at the CSNFSF construction site, at the explored depth of 80-90 meters, there are thick formations of quaternary and Eocene deposits that include quaternary and Buchak-Kaniv aquifers, as well as Upper Cretaceous deposits (lower confining formation of Buchak-Kaniv layer). According to hydrogeological observations data for Buryakivka RWSD, which is located at a 1,1km distance from "SDF" site, annual ground water elevation levels fluctuation amounted to 0,02-0,14 meters. Certain vadose water (perched water) formation is possible in the vadose (aeration) zones in the areas with existing moraine supez soils or fluvioglacial clay soils, significant in their thickness or bed extension. At the time of exploration survey, vadose water was observed in several areas at the depths ranging from 1,4 to 6,8 meters. Moraine or fluvioglacial clay soils layer acts as a confining formation. Filtration ratios for various water-bearing strata may exhibit wide ranges between 0,1 meters per day (clay loam soils) and 20 meters per day (consertial sands). Based on their degree of protection from radioactive and chemical contamination, quaternary aquifer is considered to be unprotected, whereas Buchak-Kaniv aquifer is protected.

Eocene aquifer waters are primarily of calcium-hydrocarbonate, sodium-hydrocarbonate, calcium-sodium, or sodium types, rarely of chloride-calcium-hydrocarbonate type. Water mineralization does not exceed 0,8 g TDS per liter. Aquifer is bounded, piezometric level is typically established at the level, similar to the groundwater levels, occasionally 1 or 2 meters lower. Formation thickness is approx. 35 meters. Filtration ratio for the sands varies in the range of 2 to 20 meters per day (avg. ratio – 3 to 6 meters per day). Aquifer formation bed (aquiclude) comprises of marl-limestone thickness of the Turonian / Santonian age with filtration ratio of 10^{-2} - 10^{-3} meters per day.

Nearby-located potable groundwater intakes, their productivity and distance from CSNFSF construction side are outlined below:

- "Vector" Facility Water Intake – 0,5 km; 150 cu.m. per day;
- Yaniv Water Intake – 10,5 km; 3500 cu.m. per day;
- Novoshepelychi Water Intake – 8 km; 2400 cu.m. per day;
- Shepelychi Water Intake – 7 km; 1500 cu.m. per day.

Subsurface water contamination of Eocene and Cenomanian-Lower Cretaceous aquifers with radionuclides released during Chornobyl Accident can not be reliably verified. 1993 / 2001 data on ^{90}Sr and ^{137}Cs concentration levels in ground waters near CSNFSF construction site (Buryakivka RW SDF monitoring drillholes) are provide in Table 11.3 below.

Table 11.3. ^{90}Sr and ^{137}Cs concentration in ground waters of quaternary aquifer.

Drillhole Number	^{137}Cs, kBq/m^3			^{90}Sr, kBq/m^3		
	Min	Max	Avg	Min	Max	avg
"Buryakivka" RW SDF						
5	0,04	0,06	0,05	0,18	0,72	0,43
14	0,03	0,07	0,05	0,16	0,31	0,24
22	0,04	0,18	0,08	0,17	0,32	0,24
35	0,02	0,08	0,04	0,09	0,44	0,24
53	0,02	0,06	0,04	0,08	0,33	0,18
Average values (for all drill-holes)	0,03	0,09	0,05	0,14	0,42	0,27
1993 Sampling						
Average values (for all drill-holes)	-	-	0,18	-	-	0,33

11.2.5. Climatic conditions for "SDF" site area are as follows: moderate continental climate with positive moisture balance. Winters are soft, summers are hot and humid. Most of precipitation (70%) occurs during frost-free season. Mid-season (spring and autumn) is protracted.

Average annual temperature equals 6,7 ^{0}C, record high temperature (July) - 39,0^{0}C, record low temperature (January) – -35,0 ^{0}C; average monthly low temperature (January) – -6,7 ^{0}C, average monthly high temperature (July) - 19,1 ^{0}C.

Average annual wind speed is 4,2 m/s, highest wind speed observed in winter and spring, lowest – in summer. Average annual lull frequency - 7 %. Average annual number of days with strong winds (15 m/s and higher) - 13, maximal number of gusty days - 38.

Average annual relative humidity is 77 %, partial water vapor pressure – 8,6 hPa. Average annual number of humid days (relative humidity of 80% and higher) – 122; dry days (relative humidity 30% and less) – 19.

Average annual surface evaporation is 524 mm.

Average annual fog duration is over 291 hours. Fog duration during cold season varies from 30 to 69 hours, during warm season - from 2 to 5 hours.

The area belongs to 'rainfall area' type (areas with sufficient moistening). All times of precipitation can be observed. Average annual precipitation amount exceeds annual evaporation. Average annual precipitation amount in long-term observation period is 604 mm, with its high in July (76 mm) and its low in March (37 mm). Annual amount of precipitation in high-water years may go as high as 762 mm, during dry years – may drop down to 301 mm. Absolute daily record – 81 mm of precipitation was observed in May 1983. Daily precipitation high may exceed 100 mm with the probability of once every 100 years.

Average annual number of thunderstorm days - 29, with its record high of up to 45 days.

Hail showers occur twice a year (on the average). In 20% of annual statistical data hail showers were not observed.

Snow cover depth during cold season varies. Average snow cover depth in December is 10 cm (can potentially reach 20 cm), in January - 15 cm, in February – 20 cm. and above. Record high snow depth is 75 cm (occurrence probability of once every 100 years. In 7 % of winters steady snow cover was not observed.

Average number of snowstorms: 11 (average) to 32 (record high); average annual snowstorm duration – 64 hours, average daily snowstorm duration - 5,8 hours.

The area belongs to the territory with moderate icing. Ice thickness (with occurrence probability of once every 5 years) at 10 meters above ground level equals 5 mm, at 200 meters -

35 mm, at 400 meters - 60 mm.

Annual surface inversion frequency for darkness hours is 47, for daytime hours - 3. Average annual night-time inversion layer height is 380 m, daytime inversion layer height – 650 m. Average annual surface inversion intensity (temperature gap) at night is 2,4°, at daytime - 3,6°.

Wind gusts occur during warm season, during the period of high temperature contrasts and heavy air convection. Wind gusts frequency is five times in 10-year period. Wind gusts typically cover small area (local gusts) and last 10 to 60 minutes. Wind gusts speed ranges from 20 to 40 m/s.

Construction area is tornado-safe. Tornados occur approx. 20 times in 100 years. Most of the observed tornados were Class 1 tornados. However, Class 2 and 3 tornados may also occur.

The analysis of long-term ground-layer radiation monitoring shows that EZ exhibits notable aerial aerosol migrations, caused by significant gradients of territorial radioactive contamination, that appeared as a result of 1986 Chornobyl Accident. Ground-level contamination characteristics in the area of CSNFSF construction site are shown in Table 11.4 below.

Table 11.4. Ground level radioactive characteristics in the area of CSNFSF construction site.

Indicator	Units of measurement	Value
^{137}Cs Massic Aerial Activity (MAA):		
- average	Bq/cu.m.	$7,4 \cdot 10^{-5}$
- high	Bq/cu.m.	$5,6 \cdot 10^{-4}$
- ^{137}Cs Massic Aerial Activity Reference level (RL):	Bq/cu.m.	$2,1 \cdot 10^{-4}$
- ^{137}Cs Seasonal Ratio (summer/winter)	units	5,6
MAA (radionuclide (RN) -based)	Bq/cu.m.	$8,5 \cdot 10^{-4}$
Aerial Activity RL (RN-based)	Bq/cu.m.	$3,7 \cdot 10^{-4}$
^{137}Cs atmospheric fallout intensity:		
- average	Bq/(sq.m.*day)	0,51
- high	Bq/(sq.m *day)	3,0
- Seasonal Ratio (summer/winter)	units	1,6

11.2.6. Most commonly observed soil types in the construction site area are linked to joint pine-forest sandy river terraces, that create flat-smooth interfluves that extend themselves for dozens of kilometers. Primary genetic soil type in the area is sod-podzolic soil. It includes concealed podzol, northern semipodzol and mesopodzol sandy and sandy-clay gleyed and non-gleyed soils, that together with meadow (sod) sandy and sandy-clay soils create soil deposits (occupying 54,4% of the territory). Second most commonly observed genetic soil type is sod soil (18,4%). Mud soils together with peat-bog soils and black bog soils occupy 9,6% of the territory.

Sod-concealed podzol, and northern semipodzol sandy and sandy-clay gleysolic and non-gleyed soils were created on sandy ancient alluvial non-carbonated deposits, that predetermines soil impoverishment via finely-divided particles.

Solid body of sandy and sandy-clay soils basically has monomineral composition (95%), which is predominantly represented by chemically inert quartz (SiO_2). These specificities determine their ecologically negative feature – high soil permeability with low sorption capacity (3,4-3,8 mEq per 100g), as well as low fertility values due to low humus and plant nutrients reserves, low moisture capacity and high soil acidity. (pH_{KCL} - 4,6-4,9).

As a result of 1986 Chornobyl Accident, surface soil layer was significantly contaminated, even at significant distances from ChNPP. Technogenic radioactive contamination of soils in EZ is represented by a whole set of radionuclides: ^{90}Sr, ^{137}Cs, ^{154}Eu, $^{238\text{-}241}$Pu and ^{241}Am, that exist in various physicochemical states and proportions. Major active components are however ^{137}Cs and ^{90}Sr.

Spatial distribution of surface contamination within ChNPP EZ and adjacent territories by ^{137}Cs и $^{239-240}Pu$ radionuclides is shown in Figures 11.1 – 11.3. Typical distribution feature is high radionuclide concentration within the nearest 5-km range and pronounced long-span radioactive fallout traces in Western, South-Western and Northern directions.

Vertical radionuclide migration in soil layers occurs via diffusion processes, convective transfer, lessivage and biogenic migration. Currently, 90-95% of gross radioactive activity (geometric cumulative center) are concentrated 5-10 cm. down from the ground surface (including forest leaf litter), where as 85-97 % of TUE deposits are located in the uppermost 0-5cm layer.

11.2.7. "SDF" site and its location is characterized by a set of ecotopes, typical for Ukrainian Polissya (forests, meadows, swamps) and their respective phytocenoses.

EZ land structure is shown in Table 11.5 below. Dominant forestation types are new pine woods (22%) and subors (30%). Relatively fertile sudubrava types occupy 21%, and fertile oak forests occupy just 0,1% of the forestation area. Seizure of melioration system use upon 1986 Chornobyl accident led to gradual soil overmoistening. The size of the area under unseasoned greenwoods and "wet" forest sites is over 11% of the territory, while mesohylile sites occupy nearly 28% of the territory.

Typological features of the territory have predetermined pinewood domination in the general forestation structure (approx. 50% of forest lands, 74% of aggregate forest yield). Second important wood species in forest pathology is birch tree (23% and 12% respectively). Oak forests (4% and 5% respectively) are represented primarily by homogenous stand dating back to 1950es-1960es and natural sprout forest stands with estimated age of 70 to 100 years. Sedge trees are negligible.

Table 11.5. Chornobyl NPP EZ Land Structure (as of 1997).

Land schedule	**Area**	
	hectares	**%**
Forests (incl. protective stand), including	98870	48,5
- Conifer woods (softwoods)	*78700*	*38,6*
- deciduous forests (greenwoods)	*20170*	*9,9*
Misc. forestation (seed plots, forest roads, section lines)	2170	1,1
Total under forests	101040	49,6
Unforested lands, incl.	68050	33,3
- burnt timber (standing snags)	*7185*	*3,5*
- cleared lands upon deforestation	*700*	*0,3*
- Resting lands (after agricultural exploitation)	*60170*	*29,5*
Swamps	4930	2,4
Sands	380	0,2
Water	17360	8,5
Cities, town, villages, roads and specially designated lands	12280	6,0
TOTAL	**204040**	**100**

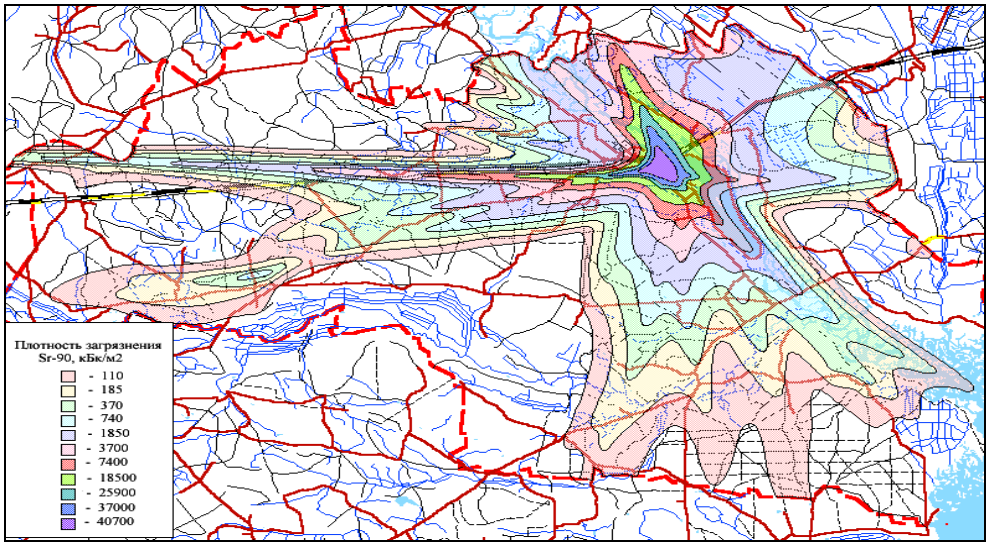

Fig.11.1. Chornobyl NPP EZ – Surface contamination with ^{90}Sr.

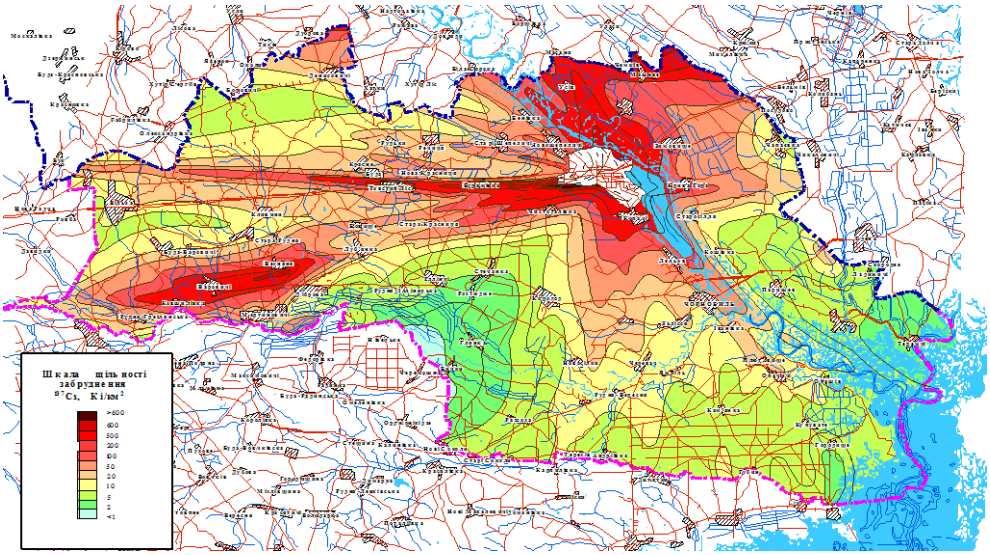

Fig.11.2. Chornobyl NPP EZ – Surface contamination with ^{137}Cs.

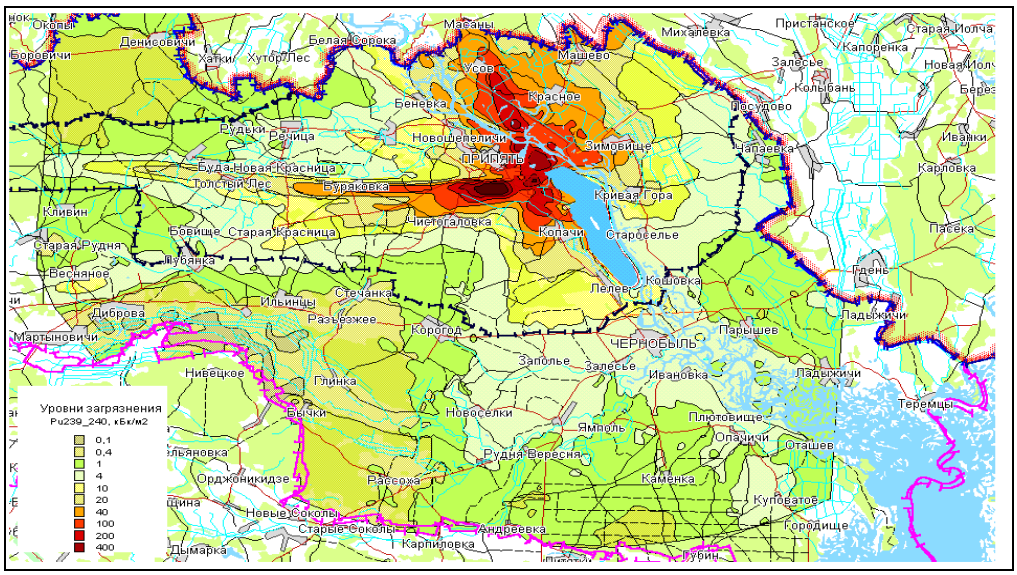

Fig.11.3. Chornobyl NPP EZ – Surface contamination with $^{239+240}Pu$.

11.2.8. Animal kingdom in the area of "SDF" site is represented by faunal associations, typical for wooded areas of the Northern part of Kyiv Polissya physiographical zone. Typical faunal associations were formed during late-glacial period, that have undergone major changes ever since. The newest stage in the development of natural associations in the region was caused by total evacuation of the population and drastic reduction in anthropogenic activities after 1986 Chornobyl Accident. Due to ongoing natural process, faunal structure of the area has begun changing, slowly reverting to its original unrestrained natural state, common to this physiographical zone.

Diversity and tessellation of plant coens, that have been recently established, as well as absence of chemical treatment of plow lands, have primarily enriched and stabilized entomological associations, an increase in rare and pollinating insects is observed. Synanthropic species population (spadgers [*Passer domesticus*], common swallow [*Hirundo rustica*], pigeons [*Columba Livia*], rooks [*Corvus frugilegus*], jackdaws [*Corvus monedula*], white storks [*Ciconia ciconia*], rats, house mice [*mus musculus*], stray cats and dogs) has decreased, while population of woods, shrubs and forests has increased. An increase in population of commercial species (hazel grouse [*Tetrastes bonasia*], black grouse [*Lyrurus tetrix L.*], beaver [*castor fiber L.*], musk beaver [*Ondatra zibethica*], fawn [*Capreolus capreolus*], wild boar [*Sus scrofa*], moose deer [*Alces alces*], red deer [*Cervus elaphus*], wolf [*canis lupus L.*], common red fox [*Vulpes vulpes*], raccoon dog [*Nyctereutes procyonoides*]) has been noted. Certain nearly extinct or rarely observed vulnerable species were occasionally observed (crane [*Grus cinerea*], black stork [*Ciconia nigra*], white-tailed eagle [*Haliaeetus albicilla*], short-toed snake eagle [*Circaetus gallicus*]; lynx [*Lynx lynx*], common otter [*Lutra lutra*], badger [*Meles meles*]). Near-reservation conditions of the EZ area, as well as landscape diversity facilitates preservation of migrating bird species and bats.

A 2002 estimate implied that EZ territory is populated with 399 vertebrate species (proven population of 290 species), which is practically the highest possible number for this physiographical zone. Taxonomic diversity of vertebrates within EZ is shown in Table 11.6 below.

An association of protected species, potentially resident in EZ area, consists of 50 species (proven population for 15 species has been established as of 2002: black stork [*Ciconia nigra*], common goldeneye [*Bucephala clangula*], osprey [*Pandion haliaetus*], red kite [*Milvus milvus*], white-tailed eagle [*Haliaeetus albicilla*], greater and smaller spotted eagles [*Clanga clanga*], short-toed snake eagle [*Circaetus gallicus*], crane [*Grus cinerea*], common pied oystercatcher [*Haematopus ostralegus*], common shrike [*Laniidae*], common otter [*Lutra lutra*], badger [*Meles meles*], lynx [*Lynx lynx*]). Przewalski's horses [Equus ferus przewalskii] were released in EZ area in 1998 as a special conservation effort (species listed in IUCN Red List).

11.2.9. 11 natural reserves were created in the territory of current EZ prior to 1986 Chornobyl Accident, as a recognition of existing plant and animal diversity and the role of the territory in supporting European biocoenotic, populational and trivial interconnections. Those 11 natural reserves are listed in Table 11.7 below.

Table 11.6. Taxonomic diversity of vertebrates within Chornobyl EZ

Taxonomic unit	Cyclo-stomes	Fish	Amphibiae	Reptiles	Birds	Mammals	Total
Orders	1	10	2	2	17	7	39
Families	1	16	6	5	52	20	100
Genera	1	47	6	6	141	45	247
Species	1	65	11	7	245	70	399
Observed species	0	48	11	6	178	47	290

Table 11.7. Ukrainian Natural Reserve Fund Areas within EZ.

№	Name	Distance from CSNFSF, km	Area, hectares
1.	Illinsky National Hydrological Reserve	41	2000
2.	Centennial oaks (Botanical Reserve)	34	12
3.	Prof. Tovstolis Alder Grove (Botanical Reserve, partially destroyed)	12	4,8
4.	"Horodysche" Natural Landmark (General Reserve)	9	5
5.	Scotch pine (Pinus silvestris) Grove (Botanical Reserve)	26	5,8
6.	Oak forest (Botanical Reserve)	9	0,02
7.	Oak Grove (Botanical Reserve, partially destroyed)	26	5,8
8.	Centennial Scotch Pine (Botanical Reserve), (extinct)	34	11
9.	Centennial oaks (Botanical Reserve)	30	14,6
10.	"Zahirya" Natural Boundary (Botanical Reserve)	32	110
11.	Pripyat Black Alder Grove (Botanical Reserve)	14	14,3
Total area under NRF within Exclusion Zone		**-**	**2180**

11.3. Social Environment Description

11.3.1. Social environment in the area of CSNFSF construction is determined by its EZ affiliation, where any and all habitual residence is prohibited [33]. However, due to certain social and economic conditions, a civilian population of 315 (as of 2003), is currently illegally resident in the EZ (self-settlers or "*samosely*").

Distance between "SDF" site to the nearest cities and EZ boundaries is outlined in Table 11.8 below.

11.3.2. Authorized personnel presence within EZ area is stipulated by the necessity of conducting aftermath minimization efforts, efforts, aimed at radioactive carryover prevention, and works related to Chornobyl NPP final decommissioning and transformation of Chornobyl Reactor Shelter into an eco-safe system. EZ personnel count and their personal external exposure monitoring results are provided in Table 11.9 below.

Table 11.8. Distance between "SDF" area and the nearest cities or borders/boundaries.

Location	Geographical direction	Distance from site, km
Chornobyl City	S-E	20
Slavutych City	N-E	58
Chernihiv City	N-E	90
Ivankiv City	S	43
Kyiv City	S	110
State Border of Ukraine	N-W	13
EZ Boundaries	N E S W	13 28 23 39

Table 11.8. EZ Personnel count and their average annual external exposure doses.

Line	Facility / Enterprise	Personnel count	Average annual external exposure dose, mSv
1.	EZ Administration	23	0,75
2.	SE «Kompleks»	326	1,57
3.	SE «SBK »	224	1,03
4.	SE «UBK »	27	1,21

5.	SE «Chornobylservice»	1314	0,84
6.	Chornobyl Water Mains	244	1,26
7.	ДСПКЛП “Chornobyllis” / Chornobyl Forestation Services	614	1,16
8.	State Specialized Scientific-Industrial Enterprise “Chornobyl Radiation Ecology Center” (“ECOCENTER”)	406	1,15
9.	ДСП “РУООД” SE “Regional administrative and technical support department”	261	1,12
10.	ЕПК/ Energy Production (Generation?) Facility	375	1,04
11.	СВАСО / Emergency Response & Rescue Team?	32	1,07
12.	SE "Tekhnocentr"	172	1,04
13.	Chornobylinterinform	24	1,04
14.	Чернобильск. спец. РЕМ Electrical Networks Maintenance / Servicing Unit	67	1,17
15.	Chornobyl NPP Personnel	3463	3,01
16.	Reactor Shelter Personnel	775	3,34
17.	Chornobyl NPP Subcontractors’ Personnel	2236	1,34
18.	Scientific-Technical Center "Shelter" [Ukryttia]	341	2,37
19.	Other enterprises and institutions	2164	0,68

11.4. Technogenic environment description

11.4.1. The list of enterprises currently operating in the EZ is provided in Table 11.9 below. The location of technogenic objects in the vicinity of “SDF” site is shown in Figure 11.4 below.

11.4.2. The territories adjacent to “SDF” site host no active housing and communal objects, as well as no social and cultural objects, no cultural, historical or architectural state-protected landmarks.

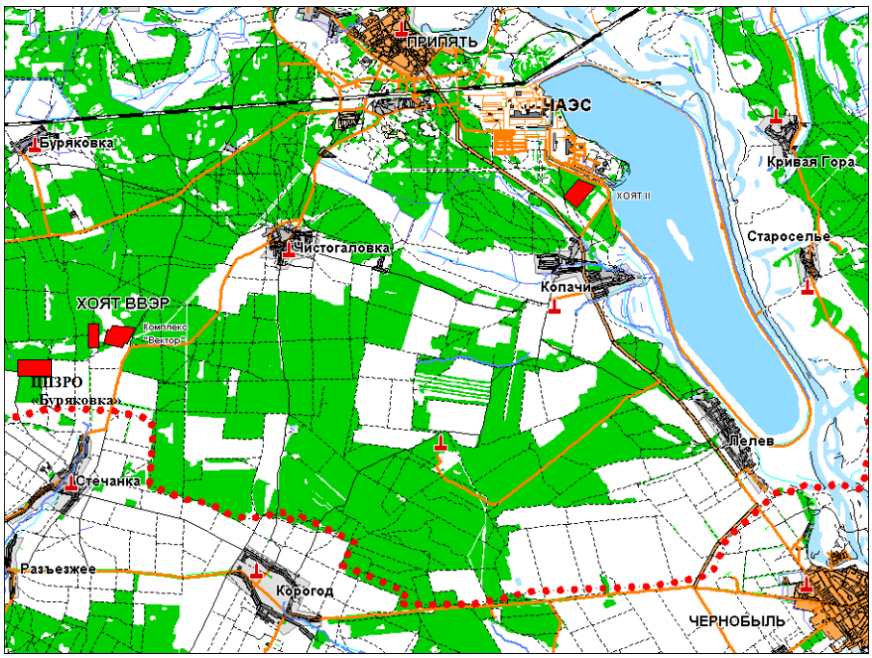

Fig.11.4. location of technogenic objects in the vicinity of “SDF” site.

11.5. Geological environment impact assessment

11.5.1. The following unfavorable natural and man-made exogenic processes are currently being observed in the "SDF" site area:

- Surface erosion (Sheet erosion and denudation);
- atmogenic (Eolic) effects (sandblows);
- swamp formation.

Endogenic processes in the CSNFSF construction area have low manifestations. Modern tectonic movements analysis along with the structural tectonic study of the territory and structural analysis of the Paleogene and quaternary deposits in the geological platform indicate that the site is located outside of the areas of neotectonic dislocations or fractures.

11.5.2. The following measures shall be undertaken to prevent or limit man-made impact on the geological environment during CSNFSF construction:

- Land planning, asphalt paving and integration works shall be performed to eliminate erosion and Eolic processes;
- Backfilled layers in the construction area (if discovered) shall be removed and replaced with well-graded compacted soils;
- Surface drainage system shall be installed.

Considering these efforts, the development of unfavorable natural and man-made exogenic processes in the CSNFSF construction area is not expected.

11.6. Aerial Environment Impact Assessment

11.6.1. According to the assessments made by IFS, peak aerial environment impact manifestation during CSNFSF construction under normal operation conditions is expected at the pre-development stage (land-planning and deforestation works). Maximal aerial radioactive concentration shall be observed in the immediate vicinity of land-planning works. Volumetric aerial contamination under standard meteorological conditions at the nearest EZ boundary (13km S-W) is assessed as follows:

- ^{137}Cs - $\approx 5*10^{-5}$ Bq/cu.m.,
- ^{90}Sr - $\approx 1*10^{-5}$ Bq/cu.m.,
- alpha-emitting TUE - $\approx 6*10^{-7}$ Bq/cu.m.,

which is ten times lower, than the maximum allowable concentration (0,8, 0,2 and $4\cdot 10^{-4}$ Bq/cu.m. respectively).

11.6.2. An accident with the highest assessed aerial radiation impact during CSNFSF construction is ground fire (see Table 11.1). Ground fire impact assessments, conducted by IFS, demonstrate, that the highest volumetric activity of ^{137}Cs, ^{90}Sr and alpha-emitting TUEs in the air shall be observed at a distance of 4-5 away from ground fire location, and will amount to approx. 15, 8 and 2 Bq/cu.m., whereas the concentrations observed at the nearest EZ boundary (13 km S-W) are assessed at 8, 4 and 1 Bq per cu.m. Considering the fact, that potential ground fires in the EZ might not be related to CSNFSF construction, whereas construction planning stipulates for measures to prevent timber and leaf litter cover inflammation, the potential aerial environment impact during CSNFSF construction is assessed by IFS as 'acceptable'.

11.6.3. Under CSNFSF normal operation conditions, potential radioactive impact on the aerial environment is possible as a result of tolerable MPC contamination with radionuclides present in spent fuel pools, due to violation of normal operation conditions. For the purposes of conservative assessment, SFP water contamination exclusively with Co^{60} is admissible due to the following events:

- Short-term Co^{60} discharge from extraction pipe of the reception facility when extracting

MPC from HI-STAR shipping cask;

- Extended term Co^{60} discharge from HI-STORM shipping casks HI-STORM in container storage area.

^{60}Co aerial volumetric activity dependency from the distance from CSNFSF to certain objects is presented in Figures 11.5, 11.6 below. According to the assessment results, peak volumetric concentration of ^{60}Co in the ground layer shall be observed at a distance of several tens to several hundred meters from the contamination source and shall amount to 6 Bq per cu.m. (for short-term discharge) and $6{,}0*10^{-5}$ Bq per cu.m. (extended discharge). ^{60}Co volumetric activity levels observed at the nearest EZ boundary (13 km S-W) are assessed at 0,02 Bq per cu.m. and $8{,}0*10^{-9}$ Bq per cu.m. respectively, which is significantly less than the maximum allowable concentration of 1 Bq per cu.m. [11].

11.6.4. Highest assessed volumetric activity levels in the ground layer as a result of hypothetic MDBA at CSNFSF with subsequent radioactive release is provided in Figure 11.7 below. Peak volumetric concentration of ^{60}Co in the ground layer shall be observed at a distance of 1,1km away from the release source (16 Bq per cu.m.). The assessed concentration observed at the nearest EZ boundary (13 km S-W) shall not exceed 0,5 Bq per cu.m.

Volumetric activity assessment results for certain radionuclides in the ground layer in case of BDBA at CSNFSF (see Table 11.1) are show in Figures 11.8 – 11.10. Peak volumetric concentration shall be observed at a distance of 100 meters away from defective HI-STORM storage container; overall total volumetric activity for all radionuclides shall not exceed 100 Bq per cu.m. value. Overall total volumetric activity levels observed at the nearest EZ boundary (13 km S-W) are assessed at under 0,05 Bq per cu.m., whereas the volumetric activity of the most significant radionuclides shall not exceed allowable limits [11]. As per IFS conclusions, considering extremely low probability of BDBA occurrence, radioactive impact from an emergency release shall be considered ‘acceptable’.

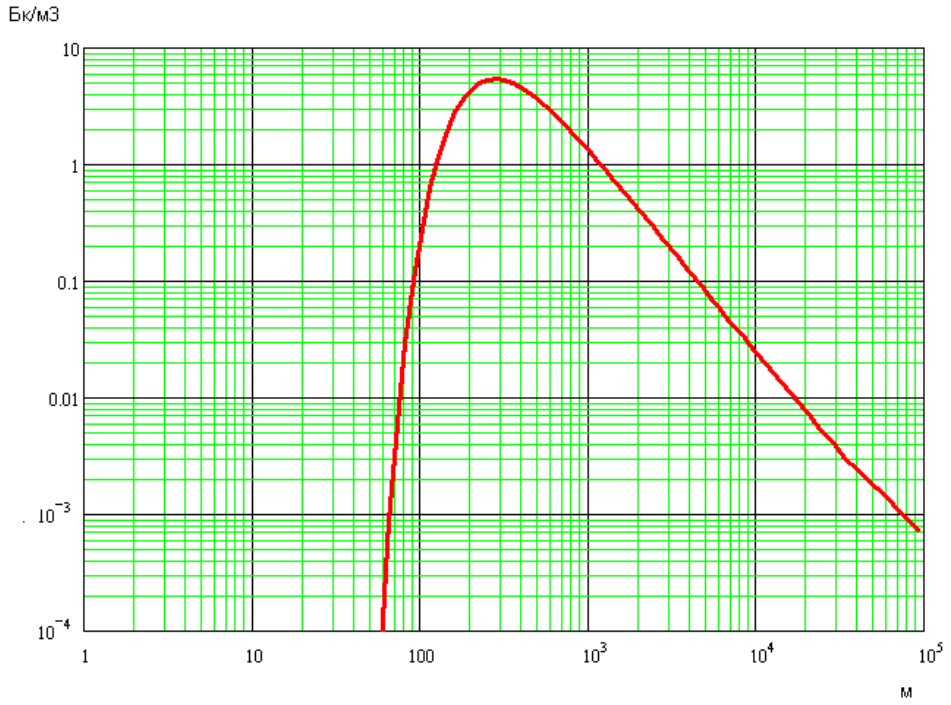

Fig.11.5. ^{60}Co aerial volumetric activity / Distance to CSNFSF Dependency Diagram for normal operation conditions (short-term release from reception facility).

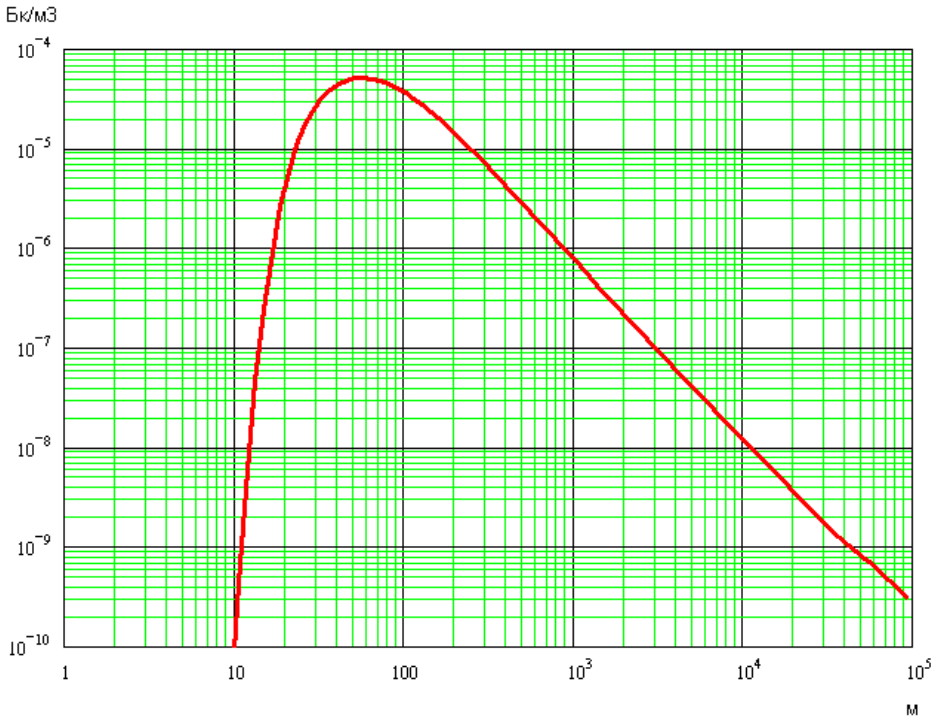

Fig.11.6. ^{60}Co aerial volumetric activity / Distance to CSNFSF Dependency Diagram for normal operation conditions (extended HI-STORM release).

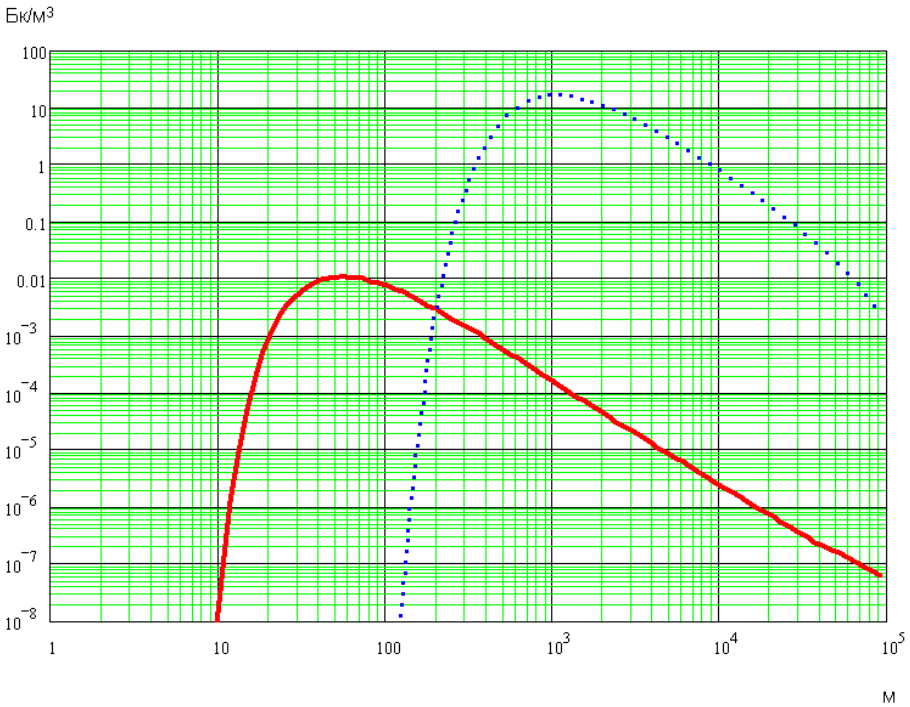

Fig.11.7. ^{60}Co aerial volumetric activity / Distance to CSNFSF Dependency Diagram for MDBA.

extended HI-STORM release (duration of 1 year);

immediate release at reception facility (average volumetric activity for 5 hours).

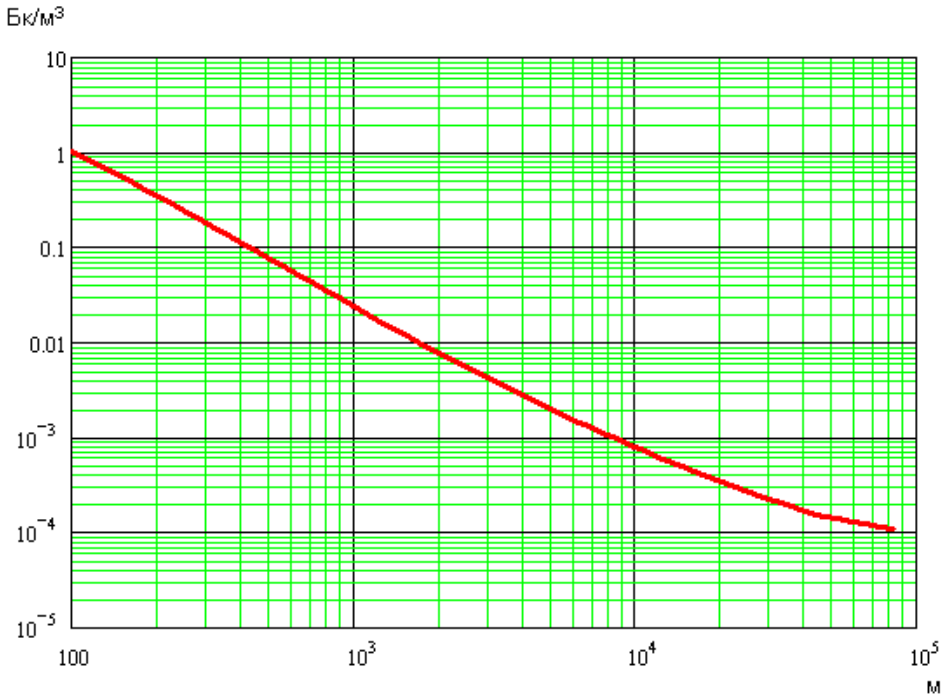

Fig.11.8. ^{137}Cs volumetric activity assessment in case of BDBA at CSNFSF.

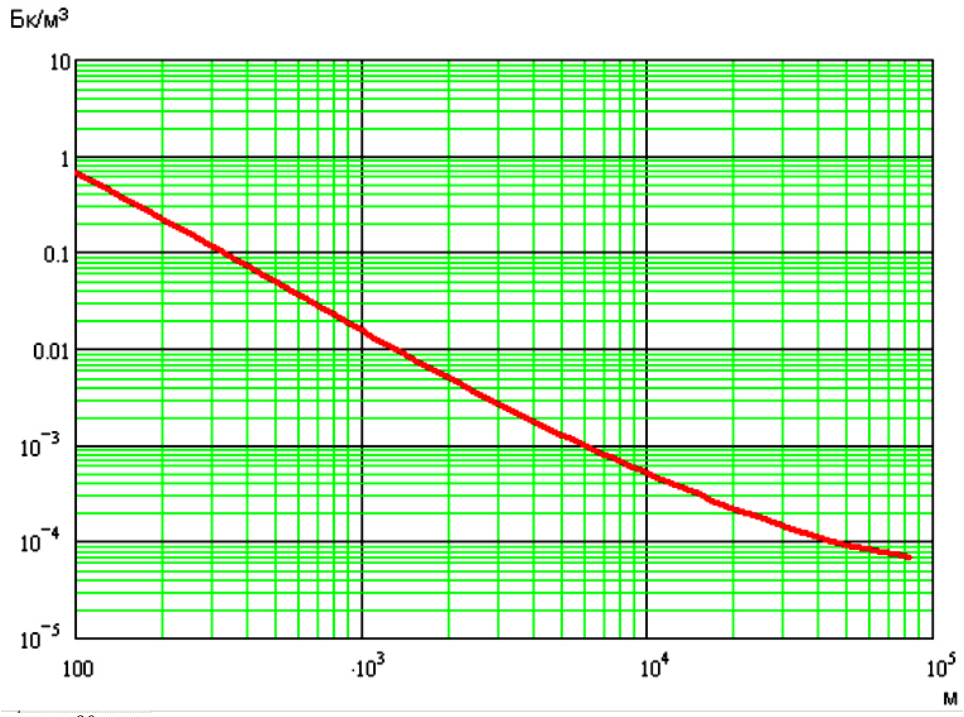

Fig.11.9. ^{90}Sr volumetric activity assessment in case of BDBA at CSNFSF.

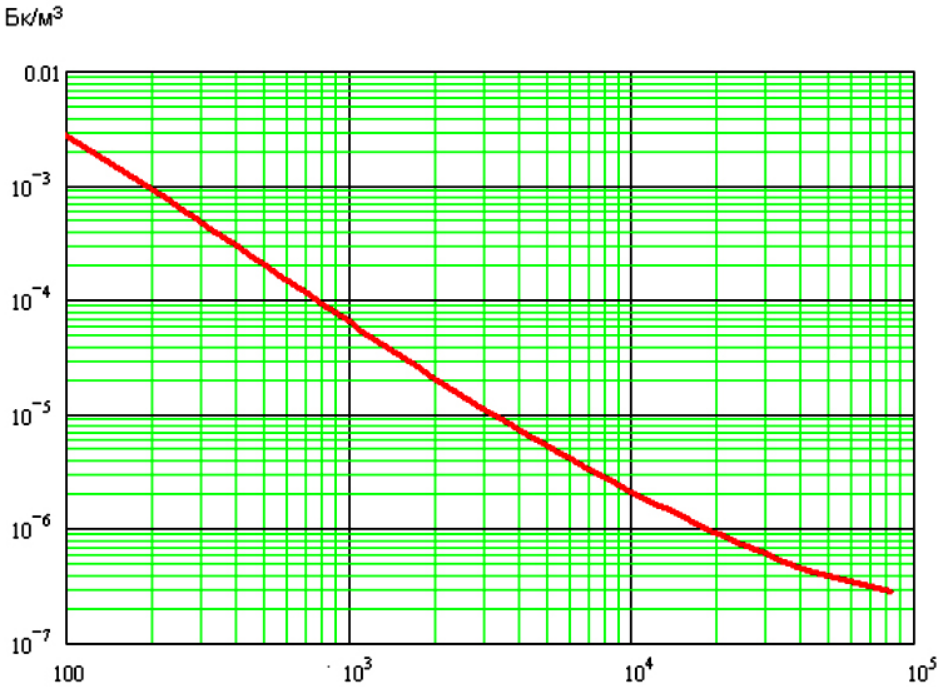

Fig.11.10. TUE volumetric activity assessment in case of BDBA at CSNFSF.

11.7. Open / ground waters impact assessment

11.7.1. According to IFS results, no impact on open waters is expected under CSNFSF normal operation conditions.

In the hypothetical event of an emergency during construction (ground fire), highest open water contamination impact shall be expected from radioactive airborne participates fallout onto the Pripyat River flood plain and water table (at a distance of 12km away from fire location). Additional contamination from ^{137}Cs, ^{90}Sr and TUE, that shall be expected from radioactive airborne participates fallout onto the water table and from flood plain wash-off waters, shall amount to $1{,}11*10^{10}$, $0{,}56*10^{10}$ and $0{,}11*10^{10}$ Bq respectively.

Conservative IFS assessment of hypothetical MDBA aftermath during CSNFSF operation indicates, that Pripyat water surface ^{60}Co fallout in the direction of the waterline of the nearest water surface (at a distance of 13km) shall amount to approx. $5{,}6\cdot10^{6}$ Bq.

Highest possible radiation impact on open waters as a result of BDBA is expected in case of radioactive element fallout onto the Pripyat River delta. Assessment data indicates, that expected fallout along plume centerline is estimated at 7,19 Bq/sqm (^{137}Cs), 4,63 Bq/sqm (^{90}Sr) and 0,019 Bq/sqm of alpha-emitting TUE, whereas aggregate radionuclide fallout over this area shall not exceed $1{,}1\cdot10^{6}$ Bq.

Considering that aggregate annual radioactivity carryover via Pripyat River flow is estimated at up to 10^{13} Bq annually, IFS has determined impact from all types of nuclear accidents on surface waters to be insignificant.

11.7.2. Ground water contamination during CSNFSF construction and operation may arise exclusively from vertical migration of radionuclides that fall onto the ground surface. Whereas ground water levels on site vary from 18 to 21 meter below ground level, and annual vertical migration velocity for radionuclides in soil layers varies in the range of 0,1-1,5 cm, IFS has concluded that impact from additional contamination on ground waters during CSNFSF construction and operation (including potential nuclear accidents listed in Table 11.1) under current radioactive contamination levels in the adjacent areas shall be insignificant.

11.8. Ground surface impact assessment

The territories under CSNFSF construction site and its railroad stub tracks belong to the radioactive contamination area, where any of its impact on surface and soils shall be manifested as a secondary (additional) radioactive contamination, caused by airborne dust on the pre-development stage (during land-planning works). IFS assessments and calculations indicate, that additional ground contamination under CSNFSF normal operation conditions shall be insignificant. Highest possible ^{137}Cs additional contamination in the work zone shall not exceed the value of 7 kBq/sqm under existing level of 7500 kBq/sqm.

11.8.1. According to the calculation results, peak additional ground contamination with ^{137}Cs, ^{90}Sr and TUE in case of construction emergency (ground fire) shall be observed at a distance of approx. 4km from the fire location and shall amount to 200, 90 and 2 Bq/sqm. Additional ground contamination at the nearest EZ boundary (13 km S-W) shall be excepted at 100, 50 and 1 Bq/sqm, which corresponds to 0,1-0,2% from existing contamination levels.

11.8.2. Under CSNFSF normal operation conditions, impact on ground surface shall be insignificant (Fig.11.11). According to IFS results, highest additional contamination from ^{60}Co during CSNFSF 50-year operation period (at a distance of 50-70 meters away from the facility) shall not exceed 600 Bq/sqm, whereas highest additional contamination at EZ boundary shall not exceed - 0,002 Bq/sqm (excluding ^{60}Co decay).

11.8.3. Additional ^{60}Co surface contamination assessment for the territories adjacent to CSNFSF in case of MDBA is outlined in Fig.11.12. Highest radioactive airborne participates fallout from MDBA shall be expected at a distances of up to 1km away from a defective HI-STORM container and shall not exceed 10 kBq/sqm. ^{60}Co surface contamination levels at the nearest EZ boundary (13 km S-W) shall not exceed 7 Bq/sqm.

11.8.4. In case of BDBA, radioactive release shall consist of a gas-aerosol radionuclide combination with highest impact on soils produced by Cs-isotopes (^{134}Cs and ^{137}Cs), ^{90}Sr and alpha-emitting TUEs (Fig.11.13,11.14,11.15). Highest additional surface contamination from these radionuclides shall be observed at a 100m distance away from defective HI-STORM storage container – up to 30 kBq/sqm, 15 kBq/sqm and 60 kBq/sqm respectively, whereas highest additional contamination at EZ boundary shall not exceed - 20 Bq/sqm, 8 Bq/sqm and 0,03 Bq/sqm for Cs, Sr and TUE respectively.

11.8.5. Based on the assessment results, IFS concluded that additional ground surface contamination during CSNFSF construction and operation (for normal operation conditions and for MDBA) shall be insignificant, whereas in case of BDBA it shall be considered acceptable.

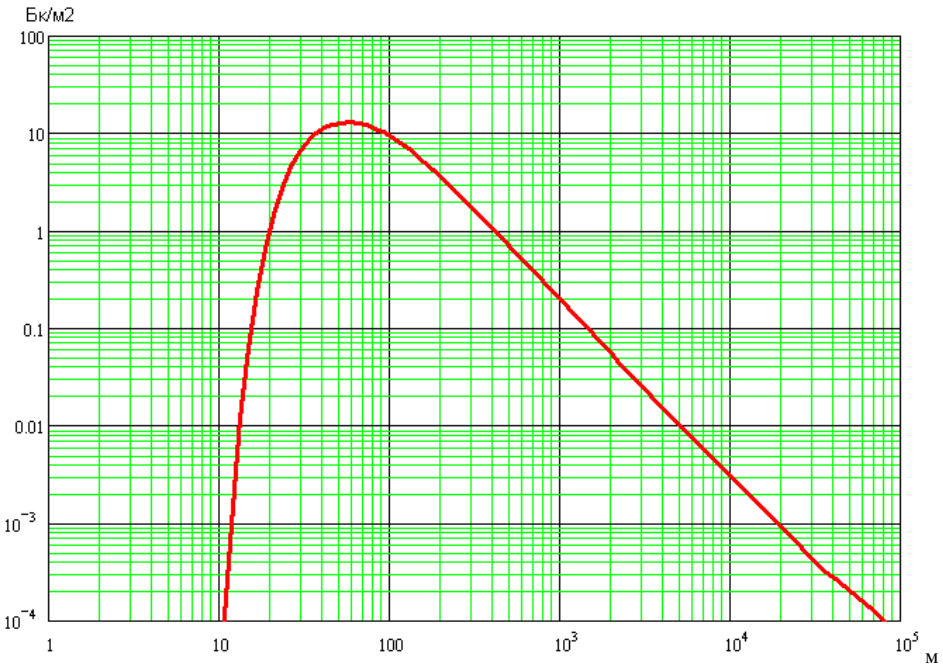

Fig.11.11. ^{60}Co surface contamination density under CSNFSF normal operation (HI-STORM-release during 1 year).

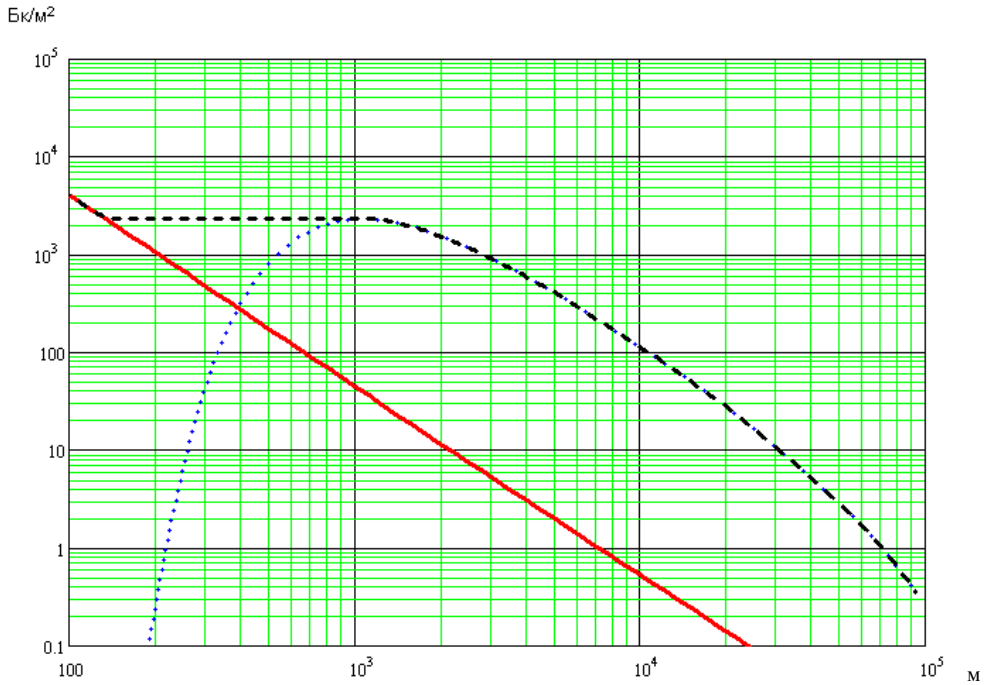

Fig.11.12. ^{60}Co surface contamination density / CSNFSF distance dependency in case of MDBA.

- extended HI-STORM release (during 1 year);
- rapid release from reception facility;
- highest values for all distances [away] from source of release.

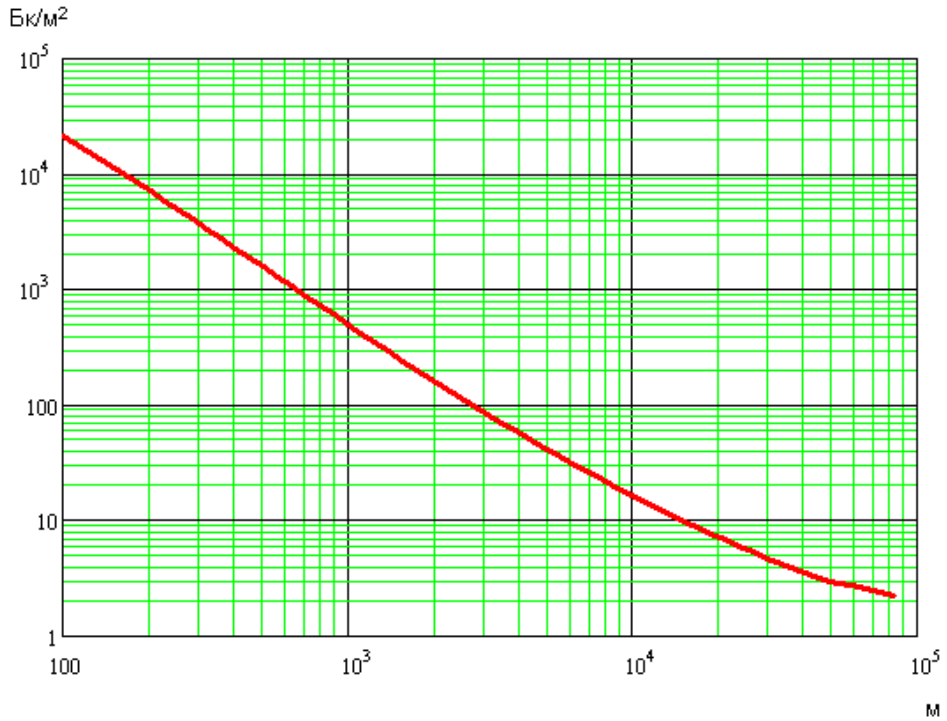

Fig.11.13. Cs-isotopes (^{134}Cs / ^{137}Cs) surface contamination density / CSNFSF distance dependency in case of BDBA.

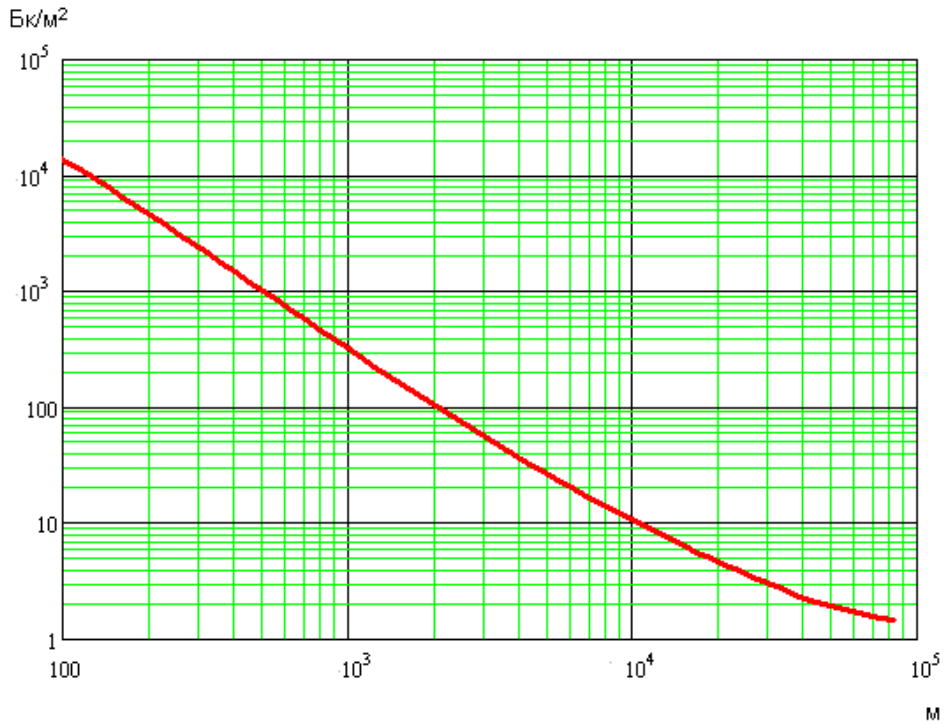

Fig.11.14. ^{90}Sr surface contamination density / CSNFSF distance dependency in case of BDBA.

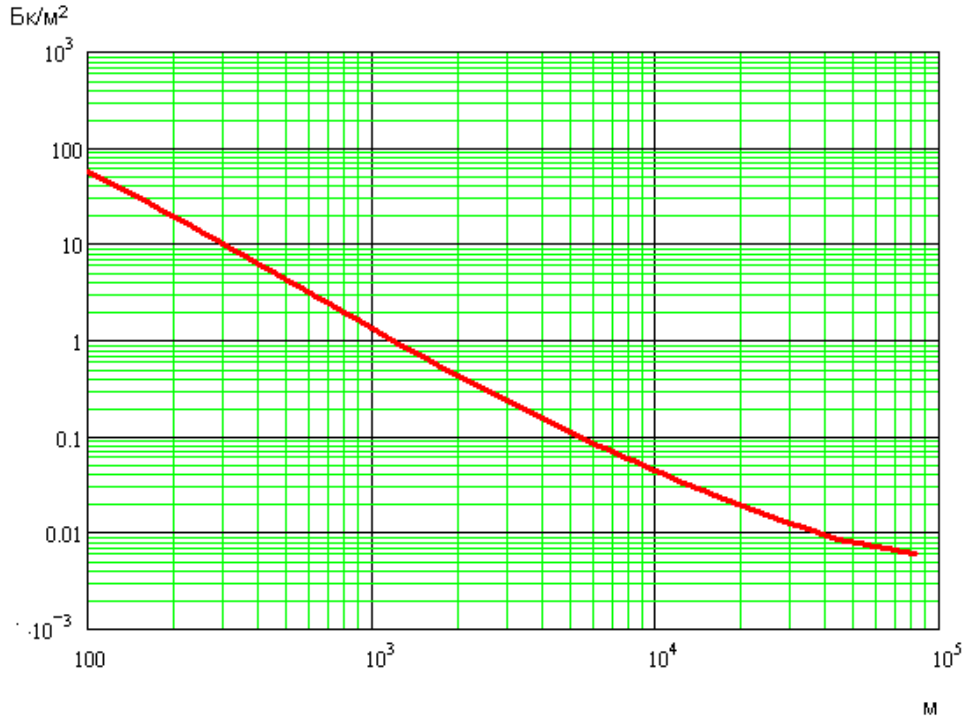

Fig.11.15. TUE surface contamination density / CSNFSF distance dependency in case of BDBA.

11.9. Flora and fauna impact assessment

11.9.1. Radiation impact on ground layer, open water and soils are assessed as insignificant. Whereas no deterioration of environmental conditions for flora and fauna is expected, IFS concluded that radiation impact from CSNFSF construction on flora and fauna under normal operation conditions shall be insignificant.

11.9.2. Major CSNFSF construction impact factor is manifested by on-site deforestation at an area of 11,72 hectares, as well as deforestation during railroad stub track construction (at an area of 7 hectares). However, considering the high density of forestation in the adjacent areas and EZ favorable conditions (similar to natural reserve conditions), IFS does not anticipate significant impact on species diversity of flora, as well as on animal diversity.

11.9.3. Highest additional surface contamination of soils with ^{60}Co shall not exceed 10 kBq/sqm (0,3 Ki/sq.km) at a distance of 1000m away from facility. Considering the fact that background radiation levels of the adjacent territories from gamma-emitting radionuclides (equivalent to ^{60}Co in biological impact) are at least 93 kBq/sqm (2,5 Ki/sq.km), additional impact on flora and fauna as a result of MDBA is considered by IFS to be insignificant.

11.9.4. Most hazardous impact on flora and fauna in case of BDBA shall originate from ^{137}Cs and ^{90}Sr radioactive fallout. Long-term radiation and ecology surveys and observations conducted in the EZ indicate, that no statistically valid change in plant and animal populations shall be observed as a result of expected highest additional contamination (including background radiation levels). On the basis thereof, IFS concluded that radiation impact from BDBA on flora and fauna should be considered acceptable.

11.10. Social environment impact assessment

11.10.1. Additional EZ personnel radiation exposure levels, as well as population radiation exposure levels during CSNFSF construction and operation, assessed in EIA, are outlined in Table 11.10 below.

11.10.2. Plots curves for individual effective exposure doses in population from all ^{60}Co discharge sources upon 30 years of CSNFSF normal operation are shown in Fig.11.16.

Table 11.10. Additional EZ personnel /population radiation exposure levels during CSNFSF construction and operation.

Personnel/ population	Reference levels, mSv/year	Additional exposure load during construction		Additional exposure load during CSNFSF operation		
		Normal conditions, mSv/year	Accident, mSv	Normal conditions, mSv/year	MDBA, mSv	BDBA, mSv
Chornobyl NPP facilities, LRW SDF,SRW MF, SNF Storage Facility #2	17	$3,0*10^{-5}$	0,05	$1,5*10^{-6}$	$3,8\cdot10^{-5}$	$4,0\cdot10^{-4}$
"Vector" Facility	18	$0,7*10^{-1}$	0,08	$6,0*10^{-3}$	$1,2\cdot10^{-3}$	0,2
"Buryakivka" RW SDF	18	$2,7*10^{-3}$	0.01	$7,0*10^{-5}$	$1,2\cdot10^{-3}$	0,6
Enterprises located in Chornobyl	2,3-15	$1,5*10^{-5}$	0,03	$7,0*10^{-7}$	$1,3\cdot10^{-5}$	$2,0\cdot10^{-4}$
Chornobyl Residents	0.04* 1**	$1,5*10^{-5}$	0,03	$7,0*10^{-7}$	$1,3*10^{-5}$	$2,0*10^{-4}$
Population at EZ nearest boundary	0,04* 1**	$4,0*10^{-5}$	0,05	$1,5*10^{-6}$	$3,6*10^{-5}$	$4,0*10^{-4}$

* Annual effective exposure dose limit quota for civilians
** Annual effective exposure dose limit for civilians

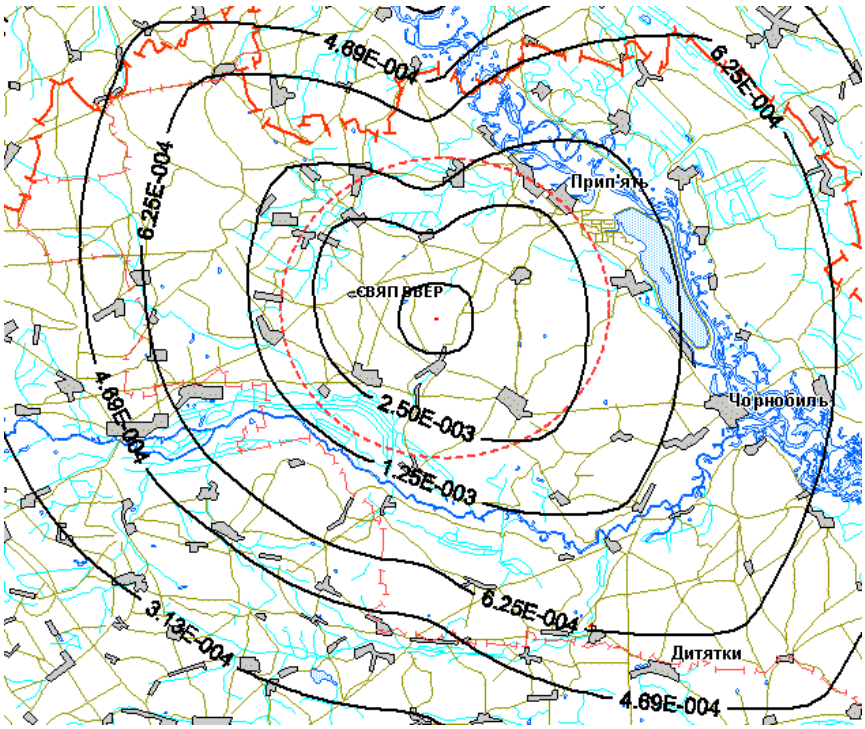

Fig.11.16. Individual effective exposure doses in population from all ^{60}Co discharge sources upon 30 years of CSNFSF normal operation.

11.10.3. IFS demonstrates that additional exposure loads for certain EZ facilities' personnel during CSNFSF construction and operation (including accidents, see Table 11.1), together with existing exposure loads, shall not exceed the reference levels set for such personnel.

11.10.4. IFS demonstrates that additional exposure loads for population during CSNFSF construction and operation (including accidents, see Table 11.1), shall not exceed the reference levels set in [11].

11.10.5. Based on the assessment results, IFS concluded that radiation impact on social environment under normal operation conditions during construction and operation, as well as in case of MDBA at CSNFSF, could be described as insignificant, whereas impact from construction accident or CSNFSF BDBA could be considered acceptable.

11.11. Technogenic environment impact assessment

11.11.1. CSNFSF construction and operation under normal operation conditions and in case of nuclear accidents shall not require any changes in the operation conditions of nearby-located enterprises (Table 11.9). The only factor that impacts technogenic environment is the use of existing infrastructure of "Vector" facility and Chornobyl NPP, and an insignificant increase of exposure loads for the respective personnel, related to CSNFSF operation (Table 11.10).

11.11.2. The territories adjacent to "SDF" site host no active housing and communal objects, as well as no social and cultural objects, no cultural, historical or architectural state-protected landmarks. The area of potential impact has no recreational zones or cultural landmarks. On the basis thereof, no impact on such objects is theoretically possible.

11.12. Environmental Impact Minimization Efforts

11.12.1. IFS stipulates the following measures for the purposes of environmental compliance and minimization of environmental impact from CSNFSF construction and operation:

- Monitoring measures;
- Protective measures;
- Rehabilitation measures;
- Compensatory measures;
- Resource-saving measures.

11.12.2. Monitoring measures stipulated by IFS include:

- Radiation monitoring system organization;
- Physical protection system organization;
- Radioactive material monitoring and inventory system organization;
- Technological process monitoring and control system organization;

11.12.3. Protective measures stipulated by IFS include:

- Contaminated equipment and machinery decontamination;
- Personnel decontamination;
- Construction site protective fencing;
- Security perimeter setup with security checkpoints and onsite round-the-clock guards;
- Organization of fire breaks between interim onsite buildings and structures and sections thereof;
- Laying access roads and fire access routes to all interim onsite buildings and structures;
- Setting up isolated smoking areas;
- Daly removal of combustible construction waste from the construction site;
- Setting up onsite firefighting water supply system;
- Ensuring compliance of electric power supply and lighting systems and electric equipment facilities with regulatory requirements for permanent installations;
- Onsite fire point installations with basic firefighting tools;

- Work sites equipment with powder-type fire extinguishers;
- Provisioning of all buildings, structures and sheds with basic firefighting tools;
- Organization of safe storage and usage of highly-flammable lacquers and varnishes, as well as combustible or hazardous components thereof;
- Ensuring that welding worksites are free from highly-flammable and combustible materials, explosive materials and devices;
- Provisioning personnel with personal protective equipment, hard hats (safety hats) and workwear (protective clothing);
- Occupational and electrical safety trainings and checks for personnel;
- Occupational safety compliant lighting at workplaces;
- Protection of welding equipment from precipitation and mechanical damage;
- Prohibition of equipment installations and vehicular traffic near wedges of failure and/or sliding triangles;
- Installation of banister-equipped pathways for crossings over ditches and trenches;
- Installation of banister-equipped ladders for access to construction pits or wide trenches;
- Construction pits sloped notching (without timbering);
- Storage of significant amounts of material or soils outside of sliding triangles;
- Systematic inspection of edges and curbs;
- Formwork safety inspection for concrete boarding prior to concrete mixture pouring;
- Installation and use of grounded electrovibrators with vibration absorbers for concrete mixture vibration;
- Establishing guidelines for communication with crane operators;
- Proof Load Inspection and Testing prior to operating load-handling devices;
- Two-step load-handling and lifting with load slinging checks at low altitudes.

Protective measures at the time of CSNFSF operation include:

- Security Checkpoints (SC-1 and SC-2) with round-the-clock onsite guards for personnel and vehicular access control (SC-1) and railroad access control (SC-2), equipped by primary anti-ram barrier-equipped gates and secondary mechanical sliding gates;
- Installation of specialized air conditioning system equipped with air purification system capable of removing airborne participates at ventilation filters for transportation-and-utility line corridor of the reception facility and controlled access area locations;
- Performance of all LRW handling operations in stainless steel-plated blocks of the controlled access area;
- Usage of HI-TRAC transfer casks for all SNF handling operations (whereas HI-TRAC design secures standardized protection from gamma and neutron emission exposure);
- Usage of HI-STAR shipping cask for SNF transportation from NPP to CSNFSF (whereas HI-STAR design secures standardized protection from gamma and neutron emission exposure);
- Usage of HI-STORM reinforced concrete storage containers for long-term SNF storage (whereas HI-STORM design secures standardized biohazard protection);
- Usage of specialized protected shipping container that provides standardized protection from gamma and neutron emission exposure for SRW collection and transportation from CSNFSF to “Vector” Facility or to Chornobyl NPP;
- Implementation of fire safety measures (fire prevention, fire protection, fire fighting);
- Implementation of measures aimed at limiting and/or preventing noise impact from CSNFSF equipment (use of equipment in silent operation versions, use of sound absorbing panels, etc.);
- Installation of redundant electric power supply systems for radiation monitoring, radioactive

material accounting and inventory, physical protection and fire alarm systems;
- Category I nuclear and fire safety design and planning for reception facility and container storage area;
- Perimeter fire-belt installation around CSNFSF site area, etc.

11.12.4. Rehabilitation measures stipulated by IFS include:
- Radioactive ground layer excavation stripping and subsequent dumping at RW SDF "Buryakivka";
- Land planning provides for landscape conditions improvement and reduction of exogenic processes in the area of CSNFSF;
- Territory improvement and planting of shrub;
- On-site interpad road construction and asphalt pavement to help prevent or reduce probability of radioactive contamination of soils;
- Installation of rainwater collection system with instrumental radioactive monitoring and subsequent purification;
- Decontamination efforts for the area of 18 hectares (approximate size of construction site) prior or during construction.

11.12.5. The following rules, rights and regulations are considered to have compensatory effect by current legislation:
- Nuclear facility personnel (CSNFSF personnel) has the right for social and economic compensation of hazardous ionizing radiation impact on its health;
- According to legislation in place, individuals whose property or health have suffered from damage, caused by the negative impact of ionizing radiation in the process of nuclear energy use, shall have the right for full compensation of respective damages;
- Nuclear facility personnel is subject to mandatory insurance from the risk of negative impact of ionizing radiation exposure at the cost of licensees.

In addition to mandatory measures, outlined above, IFS stipulates for the implementation of the following additional compensatory measures:
- 3% of the total invested costs shall be spent on construction of social infrastructure (3%);
- additional costs shall be planned at cost estimation stage to compensate for rotational work schedule and harmful labor conditions in Exclusion Zone, as required by the current legislation;
- cost planning at CSNFSF operational cost estimation stage for wage benefits, wage determination and bonuses for standard personnel payroll in accordance with the current legislation of Ukraine;
- Construction of an additional artesian well and reconstruction of "Buryakivka" facility as the compensation for the potential impact on Vector Facility infrastructure.

11.12.6. Resource-saving measures stipulated by IFS include:
- Refusal to use artesian water for indoor temperature regulation in the buildings via the use of electric heating;
- Refusal to use potable water for on-site irrigation and watering purposes via the use of clarified rainwater;
- Use of energy-effective equipment (cranes, ventilation systems, pumping stations that use less electricity under the same performance conditions;
- Storage of maximum-allowed number of spent nuclear fuel assemblies per each MPC in order to reduce energy intensity per each stored spent nuclear fuel assembly);
- Selected CSNFSF construction site landscape pattern does not require back-filling with natural soils in order to achieve required ground water elevation levels;
- Minimization of land works and land planning efforts by via selection of CSNFSF construc-

tion site with optimal grade elevation (138,5m).

11.13. Controlled Access Area Definition. CSNFSF's Permissible Emission Threshold Definition

11.13.1. In accordance with the requirements of Ukrainian health legislation, objects like CSNFSF require the establishment of controlled access area and control area around the site. As per IFS assessment results, radioactive exposure loads for civilian population outside of CSNFSF location from radioactive release are assessed as follows:

11.13.2. Exposure dosage limit quota set by [11] for Category B, related to nuclear facility impact (80 μSv) is not exceeded at a distance of 0,5km away from CSNFSF. However, considering the location of CSNFSF in the Exclusion Zone IFS deemed it practical to match CSNFSF controlled access area boundaries with the boundaries of EZ, where exposure loads for civilian population do not exceed 0,001% of the limit stipulated by [11] (1 mSv/year). The only source of radioactive impact on the environmental is the ionizing radiation from HI-STORM storage containers stored in the CSNFSF container storage area. IFS assessment results indicate that individual effective exposure of 1 mSv from fully-loaded storage facility (design capacity of 458 HI-STORM storage containers) shall not be exceed at a distance of 100 meters away from CSNFSF site area. Therefore, the controlled access area radius has to be 100 meters from existing CSNFSF site borders.

IFS assessed potential impact values from CSNFSF normal operation, as well from MDBA and BDBA. The distance at which exposure quota limits might be exceeded as a result of radionuclide inhalation intake in case of BDBA constitutes 600 meters away from CSNFSF storage area. On the basis thereof, maximum CSNFSF radiation impact range constitutes 600 meters, and a control area radius of 600m around the container storage area is required.

11.13.3. Permissible discharge values for CSNFSF assessed in IFS is based on the assumption of non-exceeding the exposure quota limits from all technological release impact sources, as stipulated by [11] for civilian population (40 μSv/year) amounted to approx. $4*10^{10}$ Bq. Expected discharge from CSNFSF normal operation is assessed by IFS to be by three orders of magnitude less than the abovementioned permissible discharge limit.

11.13.4. Considering the absence of organized pollutants release during CSNFSF construction and operation, permissible pollutant discharge limit for CSNFSF was not assessed by IFS.

11.14. Residual impacts summary. Ecological risks assessment.

11.14.1. Residual impacts summaries for CSNFSF normal operation conditions and in case of potential accidents are outlined in Tables 11.11, 11.12.

11.14.2. According to IFS conclusions, should the regulatory values for impact types during CSNFSF construction and operation be met, the ecological risk thereof shall be deemed acceptable.

11.14.3. Based on IFS results, ecological risk in case of accidents during CSNFSF construction might be related to potential [ground] fires. Should the prescribed fire protection measures be duly executed, the ecological risk from any such fire shall be deemed accessible.

CSNFSF BDBA probability assessment, performed by IFS in accordance with the provisions of [13], estimates BDBA probability as 'negligible' (less than 10^{-7} $years^{-1}$).

11.15. Environmental Impact Assessment in its Transboundary Context

11.15.1. The closest bordering states that might be subject to impact from CSNFSF are

Republic of Belarus and the Russian Federation. Based on the fact, that the shortest distance from CSNFSF site to the Russian border constitutes 220 km, and the fact that the Convention on Environmental Impact Assessment in a Transboundary Context [4] is not ratified by Russian Federation, potential impact on the territory of this state shall not be considered by IFS.

11.15.2. The shortest distance from CSNFSF location to the Belarussian border constitutes 13km North (uninhabited community Khutor Lis). The closest permanently populated locations are located 31km North-West from CSNFSF (Oleksandrivka village) and 31km East (Gden village).

11.15.3. Impacts on the areas of Republic of Belarus, indicated in Section 11.15.2 above are assessed by the IFS for the following construction and operation conditions of CSNFSF:

- Normal construction conditions;
- CSNFSF normal operation conditions;
- MDBA at CSNFSF;
- BDBA at CSNFSF.

Whereas for the purposes of impact assessment a construction accident is deemed to be a potential forest fire, and any such fire would not be treated as a direct consequence of the CSNFSF construction, impact from CSNFSF construction accident on the territory of the Republic of Belarus is not considered by the IFS.

Table 11.11. Residual impacts summary for CSNFSF normal operation conditions.

Type / source of impact	Discharge / Release Conditions	Impact Description for different Environments					
		Aerial Environment	Water Environment	Soils	Flora & Fauna	Technogenic Environment	Social Environment
Normal construction conditions							
Dust lift-off at construction site pre-development or during actual construction	$2{,}1 \cdot 10^6$ Bq released into the air, incl.: $1{,}4 \cdot 10^6$ Bq ^{137}Cs, $6{,}5 \cdot 10^5$ Bq ^{90}Sr, $3{,}0 \cdot 10^4$ Bq α-emitting TUE.	Highest assessed concentrations of ^{137}Cs, ^{90}Sr, are 10^3 – 10^4 times lower that the highest permissible concentrations; α-emitting TUE concentration is 10^3 times below the limit.	Volumetric radionuclide concentration in open waters (distance to Uzh River – 6-8 km, Sakhan River – 7km, Pripyat River – 12km) caused by CSNFSF shall be below detectable concentrations	Highest soil contamination levels immediately near the work sites shall amount to 0,2-0,3% of existing soil contamination levels. Contamination levels at EZ boundary shall not exceed 0,01% of existing contamination.	Expected deforestation of certain areas shall not significantly impact species diversity of flora in the adjacent districts. No quantitative impact or impact on diversity of animal species is expected.	Highest expected additional exposure loads are assessed for Vector Facility personnel – 0,07 mSv/year, which is under 1% of the current reference levels (incl. existing background radiation).	Assessed exposure loads for civilian population outside EZ shall not exceed 0,001% of the limit stipulated by НРБУ-97 (1 mSv/year)
Normal operation conditions							
Release of airborne radioactive effluents into the atmosphere via the ventilation exhaust duct of the reception facility caused by surface contamination of the rail platform or acceptable surface contamination of MPC.	Cs release shall amount to 190 Bq/year, ^{60}Co - $1{,}61 \cdot 10^7$ Bq/year. Other RN release (^{90}Sr, TUE, etc.) constitutes a negligible amount.	Highest assessed concentration of ^{60}Co – 6,0 Bq/cu.m. shall be observed at a distance of 250-300 meters away from the source; concentration levels at nearest EZ boundary – 0,02 Bq/cu.m., which is significantly lower than permissible values.	No negative radiation impact is expected for ground water elevation levels of over 10 meters below ground and an average vertical migration velocity through aeration layer of 10^{-2}-10^{-4} m/day.	No negative radiation impact is expected upon installing selected ventilation solutions.	No reason to expect any changes in the natural population structure, caused by radioactive impact from CSNFSF discharges, that shall constitute less that 0,1% of existing contamination density in the territory.	Maximal expected additional exposure loads are assessed for Vector Facility personnel – 0,006 mSv/year, which is under 0,08% of the current reference levels.	Assessed exposure loads for civilian population outside EZ shall not exceed 0,0004% of the limit stipulated by НРБУ-97 (1 mSv/year)

Type / source of impact	Discharge / Release Conditions	Impact Description for different Environments					
		Aerial Environment	**Water Environment**	**Soils**	**Flora & Fauna**	**Technogenic Environment**	**Social Environment**
Release of airborne radioactive effluents into the atmosphere via the HI-STORM ventilation exhaust ducts caused by acceptable surface contamination of MPC	^{60}Co release shall amount to $1{,}61 \cdot 10^{7}$ Bq/year. Other RN release (^{90}Sr, TUE, etc.) constitutes a negligible amount.	Highest possible activity of 60Co – 6,0 · 10-5 Bq/cu.m., shall be observed at a distance of 50-70m away from container storage area, which constitutes less than 17% of the aggregate RN radiation exposure reference Levels for EZ; highest activity at the nearest EZ boundary shall constitute less than 0,2% of reference levels.	No negative radiation impact is expected for ground water elevation levels of over 10 meters below ground and an average vertical migration velocity through aeration layer of 10^{-2}-10^{-4} m/day.	Highest ^{60}Co soil contamination over 50-year period shall be observed at a distance of 50-70m (600 Bq/sqm or 12% of existing level). Contamination levels at ChNPP EZ boundary shall not exceed 0,0025 Bq/sqm, which corresponds to 0,0005% of existing soil contamination levels.	No reason to expect any changes in the natural population structure, caused by radioactive impact from CSNFSF discharges, that shall constitute less that 0,1% of existing contamination density in the territory.	Maximal expected additional exposure loads are assessed for Vector Facility personnel – 0,006 mSv/year, which is under 0,08% of the current reference levels.	Assessed exposure loads for civilian population outside EZ shall not exceed 0,0004% of the limit stipulated by НРБУ-97 (1 mSv/year)
Residual impacts summary under normal operation conditions		**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**

Table 11.12. Residual impacts summaries in case of potential accidents at CSNFSF.

Type / source of impact	Discharge / Release Conditions	Impact Description for different Environments					
		Aerial Environment	Water Environment	Soils	Flora & Fauna	Technogenic Environment	Social Environment
Impact in case of construction accident							
Forest (ground) fire	Expected release activity (Bq): ^{137}Cs – $5,4x10^{10}$; ^{90}Sr – $2,9x10^{10}$; α-emitting TUE – $5,8x10^{8}$	Expected release activity for ^{134}Cs, ^{90}Sr isotopes and α-emitting TUE in the air shall be observed at distances of 4-5 km away from fire location and shall constitute 15 Bq / cu.m., 8 Bq / cu.m. and 2 Bq/cu.m. respectively	Additional ^{137}Cs, ^{90}Sr and TUE contamination that shall fall out directly onto water table shall constitute 0,30, 0,15 and 0,03 Ki, respectively, which is way below the annual Pripyat River run-off carry-over (314-165 Ki/year)	^{137}Cs, ^{90}Sr and α-emitting TUE contamination of soils at the nearest EZ boundary (13km S-W) shall not exceed 0,1-0,2% of background contamination	Highest accident contamination of ground and floral layers shall be observed at a distance of 4000m away from the fire location. It shall not exceed 0,1-0,2% of background contamination	Highest expected additional exposure loads are assessed for Vector Facility personnel – 0,08 mSv/year, which is under 1,2% of the current reference levels.	Additional exposure loads for civilian population shall not exceed the limit stipulated by НРБУ-97
Impact in case of operation accident							
MDBA	Expected release activity (Bq): ^{60}Co-$2,67 \cdot 10^{9}$	Highest ^{60}Co volumetric activity in the air (16 Bq/cu.m) shall be observed at a distance of 1,1km away from the source. Volumetric activity at EZ boundary is assessed at 0,5 Bq/cu.m., which is significantly lower than permissible values.	Pripyat River water-table radiation fallout shall constitute approx. $5,6x10^{6}$ Bq, which is significantly lower, which is way below the annual Pripyat River run-off carry-over (below 10^{13} Bq)	Soil contamination shall not exceed 10 kBq/sqm at a distance of 1,1km away from storage area. Contamination at nearest EZ boundary – 0,007 Bq/sqm. All values constitute 10% or less of the current soil contamination.	^{60}Co ground layer contamination shall not exceed 10 kBq/sqm at a distance of 1,1km away from storage area, which is significantly lower than background radiation levels in the adjacent territories from gamma-emitting radionuclides (equivalent to ^{60}Co in biological impact) are at least 93 kBq/sqm	Highest expected additional exposure loads are assessed for Vector Facility personnel – 10 mSv/year, which is under 10% of the current reference levels (incl. existing background radiation).	Effective radiation exposure dosage from all ^{60}Co impact sources at EZ boundary - $1,5 \cdot 10^{-3}$ mSv/year, which is significantly lower than the limit, stipulated for civilian population by НРБУ-97.

Type / source of impact	Discharge / Release Conditions	Impact Description for different Environments					
		Aerial Environment	**Water Environment**	**Soils**	**Flora & Fauna**	**Technogenic Environment**	**Social Environment**
BDBA	^{137}Cs-1,896·10^{8} Bq ^{90}Sr –1,22·10^{8} Bq α-active TUE – 5,072·10^{5} Bq	Maximum total volumetric activity levels shall not exceed 258,3 Bq/cu.m at a distance of 33,5 m away from a leaking HI-STORM container. Activity levels at EZ boundary shall not exceed 0,053 Bq/cu.m and therefore shall not exceed the permissible limits.	Pripyat River water-table fallout shall amount to 4,4·10^{10} Bq, incl. ^{137}Cs - 2·10^{3} Bq/sqm, ^{90}Sr - 40 Bq/sqm and α-emitting TUE – 10 Bq/sqm, which is 2000 times less than the annual Pripyat River carry-over	Additional surface contamination at 100m distance shall not exceed 30 kBq/sqm for Cs-isotopes, 15 kBq/sqm for ^{90}Sr and 60 Bq/sqm for TUE. Contamination at EZ boundary shall not exceed 20 kBq/sqm for Cs-isotopes, 8 kBq/sqm for ^{90}Sr and 0,03 Bq/sqm for TUE, which is insignificant	Considering that no significant aerial, soil or groundwater contamination is expected, flora and fauna impact shall be deemed acceptable	Maximum additional exposure doses (30 days' aggregate) shall be expected for Vector Facility – 0,6 μSv, which is below reference levels.	EZ Boundary exposure levels shall be expected at 0,358 μSv (30 days' aggregate), which is below the exposure limit quota for civilian population, stipulated by НРБУ-97 (40 μSv).
Residual impacts summary for accident conditions		**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**	**Impact levels do not exceed permissible levels**

11.15.4. Whereas radiation impacts are the primary types of impact generated by CSNFSF, environmental impact on the territory of the Republic of Belarus is assessed by the following general factors:

- Aerial radiation contamination;
- Soils radiation contamination;
- Additional civilian population exposure.

11.15.5. Aerial radiation contamination levels assessed by IFS for the territories of Republic of Belarus specified in 11.5.2, for different CSNFSF construction and operation conditions are summarized in Table 11.13.

11.15.6. Soils radiation contamination levels assessed by IFS for the same territories is summarized in Table 11.14.

11.15.7. Assessed additional civilian population exposure levels are outlined in Table 11.15.

11.15.8. Based on the assessment results, obtained by IFS, the following conclusions were made with regard to CSNFSF impact on the environment of the Republic of Belarus:

- CSNFSF construction and operation shall not cause any significant negative impact on the aerial, surface (soils) or social environment of the bordering territories of Republic of Belarus for the whole duration of CSNFSF existence (100 years).
- Aerial contamination, surface contamination and additional civilian population exposure levels for the bordering territories of Republic of Belarus in case of maximum design-based accident in the process of CSNFSF operation shall be insignificant due to considerable distance between SNF storage facility and said territories;
- Aerial contamination, surface contamination and additional civilian population exposure levels for the bordering territories of Republic of Belarus in case of beyond-design-based accident shall not cause any significant changes to the radiation situation, which is, considering low accident probability, acceptable.

Table 11.13. Volumetric aerial radionuclide activity during CSNFSF construction and operation (Bq/cu.m).

	NOC - Construction		**NOC - Operation**		**CSNFSF MDBA**		**CSNFSF BDBA**	
	13 km	31 km	13 km	31 km	13 km	31 km	13 km	31 km
^{60}Co	-	-	$8*10^{-9}$	$2*10^{-9}$	$1,5*10^{-6}$	$3*10^{-7}$	-	-
^{137}Cs	$4,0*10^{-5}$	$1,3*10^{-5}$	-	-	-	-	$6,0*10^{-4}$	$2,0*10^{-4}$
^{90}Sr	$9,0*10^{-6}$	$3,0*10^{-6}$	-	-	-	-	$4,0*10^{-4}$	$1,3*10^{-4}$
TUE	$5,0*10^{-7}$	$1,5*10^{-7}$	-	-	-	-	$1,4*10^{-6}$	$6,0*10^{-7}$

Table 11.14. Surface radiation contamination density during CSNFSF construction and operation (Bq/sqm).

	NOC - Construction		**NOC - Operation**		**CSNFSF MDBA**		**CSNFSF BDBA**	
	13 km	31 km	13 km	31 km	13 km	31 km	13 km	31 km
^{60}Co	-	-	$2*10^{-3}$	$5*10^{-3}$	68	10	-	-
^{137}Cs	*	*	-	-	-	-	12	7
^{90}Sr	*	*	-	-	-	-	8	3
TUE	*	*	-	-	-	-	0,03	0,015

* Negligible values were not provided by IFS.

Table 11.15. Additional civilian population radiation exposure during CSNFSF construction and operation.

	NOC - Construc-tion		**NOC - Operation**		**CSNFSF MDBA**		**CSNFSF BDBA**	
	13 km	31 km	13 km	31 km	13 km	31 km	13 km	31 km
mSv/year	*	*	$9{,}4 \cdot 10^{-7}$	$6{,}3 \cdot 10^{-7}$	-	-	-	-
mSv	-	-	-	-	$3{,}6 \cdot 10^{-5}$	$5{,}3 \cdot 10^{-6}$	$4{,}0 \cdot 10^{-4}$	$1{,}5 \cdot 10^{-4}$

* Negligible values were not provided by IFS.;
** from inhaling ^{60}Co;
*** from inhaling radionuclide mixture (30 days' aggregate values).

12. CONCLUSIONS

A number of calculations, assessments and substantiations made by IFS allowed for the following general conclusions, detailed in IFS documentation [23]:

- CSNFSF for WWER-type reactors spent nuclear fuel complies with the general principles of the state nuclear use policy and ensures uninterruptible operation of Ukrainian NPPs in the long run before final decision on SNF end-of-life management technology shall be approved.
- IFS has performed substantiation and project economics analyses for CSNFSF construction vs. existing SNF management routine that stipulates for SNF export, storage and reprocessing at the facilities in Russian Federation with subsequent return of HLRW, produced from SNF reprocessing, back to Ukraine.
- IFS has analyzed potential SNF storage solutions and identified solutions most suitable for Ukraine, as well as described the selection process for CSNFSF construction solution and the results of international turnkey bidding procedure for CSNFSF construction.
- IFS has provided cost estimate assessments for SNF storage at CSNFSF, including cost accumulation for CSNFSF decommissioning and SNF handling upon long-term storage expiration date.
- Based on the analysis of potential CSNFSF construction site locations, IFS has substantiated the choice of optimal location, that is situated within Chornobyl NPP Exclusion Zone, immediately adjacent to the centralized RW storage and disposal facility (RW SDF) ("SDF" site).
- Environmental Impact Assessment conducted by IFS for CSNFSF construction and operation exhibited low impact levels and compliance with current legislation requirements.
- IFS has drafted preliminary CSNFSF deployment timeline, including efforts required at predesign stage, project design stage, documentation stage and CSNFSF construction and operation licensing stage. Preliminary duration of CSNFSF start-up facility construction was estimated at 36 months from the commencement of construction.
- Technical and economic performance indicators, provided by IFS, as well as technology solutions, deployment timeline, EIA values and other IFS assessment results are subject to further refinement and rectification at the general design stage.
- Immediate subsequent steps for CSNFSF construction include IFS appraisal, public consultations, as stipulated by law, and law-drafting procedure for 'CSNFSF Construction Law'.

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Appendix C3

EnergoAtom. 2009. Translation of the Feasibility Study for Creation of the Spent Fuel Storage Facility of Rivne, Khmelnitsky, and South-Ukrainian NPP (FS CSFSF).

TRANSLATION
OF THE FEASIBILITY STUDY FOR CREATION OF THE SPENT FUEL STORAGE FACILITY OF RIVNE, KHMELNITSKY, AND SOUTH-UKRAINIAN NPP (FS CSFSF)

Explanatory Note

Ukraine has in operation 13 WWER-1000 power units and 2 WWER-440 power units at 4 NPP.

Spent nuclear fuel (SNF) from Zaporizhzhya NPP after preliminary decay storage in reactor cooling pools is sent to dry-type Interim Storage Facility (ISF) located at the Zaporizhzhya NPP site, which was put into operation in 2001.

SNF from Rivne, Khmelnitsky and South-Ukrainian NPP preliminary decay storage in reactor cooling pools is consigned for storage and subsequent reprocessing to Russia. Radioactive waste produced during reprocessing is to be returned back to Ukraine.

In 2003 NNEGC "Energoatom" signed a contract with the publicly traded company "Kievenergoproject" (KIEP) on development of a feasibility study (FS) for construction of a centralized SFSF for WWER nuclear power plants of Ukraine. The developed Feasibility Study includes selection and substantiation of a site for CSFSF construction, a substantiation of expediency of CSFSF construction and environmental impact assessment for the recommended CSFSF site..

In the Feasibility Study the following conclusions were made:

- preferable site is the site adjacent to the "Vector" Complex site at the ChNPP exclusion area;
- the expediency of CSFSF construction is provided as for a modern price level on SNF acceptance in Russia, and for the perspective prices in view of SNF final disposal in Ukraine;
- potential radiological impact of CSFSF is not distributed beyond the boundaries of exclusion area of the territory, undergone to radioactive contamination caused by the Chernobyl accident.

In 2003 NNEGC "Energoatom" announced the tender on designing and construction of CSFSF on a "turn-key" basis. As a result of the tender in 2004 the winner company "Holtec International" with technology of storage HI-STORM was declared.

The CSFSF Feasibility Study consists of the following volumes and their sections:

Volume 1. Section 1	Input data for implementation and justification of the necessity and reasonability of CSFSF construction.
Volume 1. Section 2	Analysis and assessment of alternative technologies of SNF management.
Volume 1. Section 3	Main technical decisions.
Volume 1. Section 4	Nuclear and radiation safety.
Volume 1. Section 5	Selection and comparison of sites for CSFSF construction.

Volume 1. Section 6	General layout and transportation.
Volume 1. Section 7	Main decisions on construction management.
Volume 1. Section 8	Technical and economical indicators CSFSF
Volume 2	Summary cost report
Volume 3 Section 1	Environmental impact assessment. Characteristics of the site and region of CSFSF location.
Volume 3 Section 2	Environmental impact assessment. Sources of CSFSF impact on the environment. Assessment of CSFSF impact on the environment.
Volume 4.	Draft Declaration of the environmental consequences.

Translation of materials of the Feasibility Study of CSFSF conceptually describing the CSFSF design contains the information of Volume 1, parts 1-4 of the Feasibility Study.

Translation of materials of Feasibility Study of CSFSF describing potential radiological impact CSFSF on the environment contains the information of Volume 1, part 5; Volume 3 parts 1, 2 and Volume 4 of the Feasibility Study.

Declaration
on Ecological Consequences of Construction and Operation of the Centralized Spent Fuel Storage Facility at Rivne, Khmelnitsky and South-Ukrainian NPPs
SE NNEGC "Energoatom"

Nuclear energy is within the top of the Ukrainian's economics. 15 WWER power units of four operating nuclear power plants (NPPs) generate the half of electric energy of the country having only 26,6% of the total installed capacity. Within the Energy market, a part of electric energy generated at NPPs continues to be high every year. Thus, for example, in 2000 it constituted 45,3% and in 2005 and 2006 – 52,3% and 50,0% correspondingly.

In accordance with the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the State Enterprise "National Nuclear Energy Generating Company "Energoatom"" (NNEGC "Energoatom") was entrusted with functions of the operating organization who is responsible for safety of the operating NPPs.

Increase of electric energy power generation at NPPs due to continuous increase of their safety level and assurance of stable operation conditions was and remained to be the main task of the NNEGC "Energoatom".

The problem of NPP spent nuclear fuel management is one of such challenges. Spent nuclear fuel (SNF) is an inherent consequence of power generation at NPPs. The scheme for SNF management, arranged in USSR times and for USSR objectives, lied in yearly removal of WWER spent fuel from NPPs for processing. Today, the abovementioned scheme of SNF management for Ukrainian NPPs is not economically sound, moreover, provokes the problem related to return of radioactive waste resulted from SNF processing back to Ukraine.

To solve the problem associated with WWER spent nuclear fuel management of Ukrainian NPP, the Verkhovna Rada of Ukraine, the President of Ukraine, the Cabinet of the Ministers of Ukraine made decisions on creation of conditions for Ukrainian NPP SNF long-term storage in Ukraine. The set forth decisions have been partially implemented at Zaporizhzhya NPP, where in 2001 the SNF plant storage facility was constructed. It is planned to construct a common storage facility for Rivne, Khmelnitsky and South-Ukrainian NPPs – a centralized spent nuclear fuel storage facility (CSFSF) that will receipt SNF from these NPPs for storage.

Data on planned activities, objectives and ways for their execution

Spent nuclear fuel of the three aforementioned NPPs generated during their operation time will come gradually at the CSFSF. The CSFSF maximum planned operation life is up to 100 years. The CSFSF capacity will be increased up to the planned capacity according to the construction turn.

To store spent nuclear fuel in the CSFSF, the technology will be used proposed by the Holtec International (USA), that has to design the CSFSF and construct its first turn. This technology is applied at NPPs of the USA and other countries. This technology provides for use of a multi-purpose canister with two containment shells that is applied for both SNF transfer and storage. Shells separate reliably from the environment the inner volume of the canister filled with the inert gas where SNF is loaded. Such a canister is filled with SNF and sealed by welding at the NPP, and the sealed MPC is transferred to the CSFSF in a special

transport overpack with two containment barriers. In CSFSF the multi-purpose canister is transferred in the storage overpack where it is stored during the design lifetime. These overpacks along with the multi-purpose canister ensure the necessary environment protection against SNF impact.

In accordance with the requirements of the State Construction Standards of Ukraine, the feasibility study (FS) for the CSFSF construction has been carried out, as well as environment impact assessment (EIA) during the CSFSF construction and operation. The EIA has been implemented for conditions of the construction site, proposed in the FS as an optimal, and the aforesaid SNF storage technology considered in the FS.

The publicity traded company "Kyiv Research and Development Institute "Energoproject" (PTC KIEP) has performed the FS for CSFSF construction.

In the FS for CSFSF construction the following is provided for, in particular:

- The site for the CSFSF construction has been selected in accordance with the legislative requirements by comparing a set of sites according to certain criteria and indicators. The site located within the territory of the exclusion area and the mandatory resettlement area (hereinafter – EA and MRA) suffered from radiation contamination owning to the Chernobyl disaster, at a distance of 12 km from the south-west of the Chernobyl NPP has been determined as an optimal one.
  In accordance with the legislation, the Verkhovna Rada of Ukraine will make the final decision on the CSFSF siting;
- The CSFSF main technical decisions and technical and economical indicators have been specified;
- CSFSF safety (nuclear, radiation and ecological) has been substantiated in accordance with the design stage taking into account the SNF storage technology examined in the FS.

The EIA in the CSFSF construction and operation has been implemented by the PC KIEP with the assistance of the Institute of NPP Safety Problems (NPP SPI) of the National Academy of Sciences of Ukraine in accordance with the requirements of the Construction Standards "Content and Structure of Environment Impact Assessment Materials) in Design and Construction of Enterprises, Buildings and Structures" DBN A.2.2-1-2003".

As regards the CSFSF FS and EIA, a comprehensive state review with ecological and nuclear and radiation safety reviews inclusive will be provided for, as well as an additional (non-state) review with the participation of the foreign experts.

Factors that affect or may affect the environment state considering possible initiation of emergency ecological situations

In assessing environment impacts of the planned activities:

- the existing environment state has been examined at the facility construction site, proposed in the IFS, and at the adjacent territories;
- all the possible environment impact sources of the facility have been specified;
- the impact on all the environment components has been assessed.

The environment impact assessment has shown the following:

Noise, vibration and electromagnetic field impacts will be limited by CSFSF rooms and will not exceed the permissible values.

Thermal pollutions and evaporations as well as the use of chemical substances that could impact the environment are not provided for during the CSFSF construction and operation.

The planned activities do not impact on the solar radiation intensity, temperature, wind speed, humidity, atmospheric inversions, duration of fogs and other environmental characteristics.

Man-made impacts on the geological medium due to the planned activities during the CSFSF construction and operation are not envisaged.

Environment impacts of the planned activities are stipulated by radiation factors only.

From the EIA (Environment Impact Assessment) performed, one may conclude on the possibility of certain impacts (including mediated) on the following environment components:

- air;
- water;
- soil;
- plant and animal life;
- man-made environment;
- social environment (public who lives within the exclusion area (EA) and MRA).

Possible impacts were estimated for normal operation conditions and for both design basis and beyond design basis (hypothetical) accidents.

A ground forest fire is considered an accident involving maximum consequences during construction. The arrival of the multi-purpose canister (MPC) contaminated with radionuclides above the permissible boundaries during its loading with spent fuel at the NPP is considered an accident involving maximum consequences during operation.

As the beyond design basis accident during the CSFSF operation, the EIA considers the MPC seal failure and fuel destruction causing radioactive substances to release into the environment.

Permissibility of impacts has been determined based on terms of non-exceeding of the current regulatory sanitary and health criteria resulted from such an impact.

Indicators of ecological risk levels and safety for public vital activity during the planned activities. Measures ensuring implementation of the activity in accordance with the ecological standards and regulations.

The assessment did not define essential impacts on the environment components that could lead to exceeding of the permissible levels because the process decisions made in the FS exclude practically significant impacts in construction and operation.

The assessment results of the planned activity impacts demonstrated:

1. Air impacts:

- in construction:

  - under normal conditions – thousands times lower than the permissible ones;

  - in design basis accident involving maximum consequences (ground forest fire), short-term exceeding of reference levels within EA and MRA is possible. Beyond the EA and MRA – lower than the permissible. Ground fire at the CSFSF site (up to removal of plants) will be prevented by using organizational and technical measures;

- in operation, at the EA and MRA nearest boundary to CSFSF:
  - under normal operation – dozens of times lower than the permissible;
  - in design basis accident involving maximum consequences – lower than the permissible;
  - in beyond design basis accident – lower than the permissible.

2. Aquatic environment impacts:
- in construction – absent practically;
- in operation:
  - under normal operation – there are no process contaminated discharges, additional process discharges are practically absent;
  - in accidents – do not lead to exceeding of the established standards.

3. Soil impacts:
- in construction – practically absent;
- in operation:
  - under normal operation conditions – practically absent;
  - in design basis accident involving maximum consequences – insignificant impacts that do not impact practically on the existing state of soils;
  - in beyond design basis accident – insignificant impact that causes additional contamination hundreds times less than the existing state of soils.

4. Impacts on plant and animal life – practical impacts have not been detected.

5. Man-made environment impacts – do not exceed the reference levels for the personnel of the adjacent facilities within the exclusion area.

6. Social environment impacts:
- in construction:
  - significantly lower than the established standard;
- in operation:
  - under normal conditions – significantly lower than the established dose quota;
  - in design basis accident – significantly lower than the established levels;
  - in beyond design basis accident – lower than the established levels.

Ecological risk total assessment

Under normal operation conditions of the planned activity, impacts on the environment and public do not lead to exceeding of the current sanitary and health standards established by the Radiation Safety Standards of Ukraine (NRBU-97);

In the design basis accident involving maximum consequences, the ecological risk is acceptable by all constituents because they do not exceed indicators of the existing environment state and the current health and safety standards;

In the beyond design basis (hypothetical) accident involving heavy conditions – considering low probability of such an accident, the risk is assessed as such that may be ignored (in accordance with NRBU-97/D-2000).

Assessment results relative to transboundary impact demonstrate that there are no practically the CSFSF construction and operation negative consequences for the near frontier area of the Belarus Republic, adjacent to the CSFSF site.

Assessment of dimensions for control and observation areas

The width of the controlled area (CA) and observation area (OA) assessed in EIA around CSFSF during its operation constitutes 100 meters and 600 meters correspondingly.

Finally, the CSFSF CA and OA dimensions will be calculated in its draft and will be concurred and approved in accordance with the legislation.

CSFSF will be provided with the necessary infrastructure for the planned activity taking into account safety ensuring requirements and the qualified personnel whose level of knowledge, in particular, in radiation and ecological safety will be periodically checked and improved.

Radiation monitoring will be provided for at the facility and within its controlled and radiation and ecological monitoring – at the observation area that will ensure monitoring of personnel, technological processes and the environment state.

A physical protection system will be arranged at the facility that will exclude unauthorized access to SNF storage areas.

Protective, restorative, compensative and resource-saving measures identified in the FS will be performed in the CSFSF construction and operation.

List of residual effects

In the CSFSF construction and operation impacts of the abovementioned activities on air and water environments, natural and animal life, man-made and social environments are practically absent.

Consequences of accidents during the CSFSF construction and operation do not produce impacts on air and water environments, natural and animal life, man-made and social environments that lead to exceeding of the established permissible levels.

Public participation

Having respect for constitutional rights of every person, introducing a policy of transparency of decisions in providing nuclear, radiation and ecological safety, SE NNEGC "Energoatom" under the planned activity related to CSFSF will take all the appropriate measures as regards ensuring of rights of citizens and their unions in nuclear energy use, ensuring of ecological and radiation safety resulted from the requirements of the current legislation of Ukraine, in particular, from:

- Law of Ukraine "On Nuclear Energy Use and Radiation Safety".
- Law of Ukraine "On Procedure for Decision –Making as Regards Arrangement, Design, Construction of Nuclear Facilities and Objects Designed for Radioactive Waste Management that are of General State Importance".
- Convention on Environment Assessment Impact within Transboundary Scope Ratified by the Verkhovna Rada of Ukraine (Law of Ukraine No. 534-XIV of 19 March 1999).
- Procedure for Conducting Public Hearings Regarding Nuclear and Radiation Safety Issues Approved by the Cabinet of the Ministers of Ukraine No. 1122 of 18 July 2007.

Client engagements as regards implementation of the accepted decisions

The Client assumes the obligations to accomplish in full scope all the technical, organizational, financial and other decisions provided for by the Feasibility Study of investments, as well as to observe operating regulations, incur material and financial expenses and, thereby, to ensure implementation of ecological requirements during the CSFSF operation lifetime.

The CSFSF personnel arrangements will provide for appropriate officials who will be responsible for fulfillment of the operating regulation and design decisions as regards the CSFSF safe operation and environment protection.

For Client:	**For General Developer:**
President of SE "National Nuclear Energy Generating Company "Energoatom"	Head of Direction of the PC "Kyiv Research and Development Institute" "Energoproject"
_____ A. Derkach	**_____ Yu. Malakhov**

CSFSF FOR UKRAINIAN WWER NPPs

FEASIBILITY STUDY OF INVESTMENTS

VOLUME 1
PART 1

Input data and substantiation for a need and reasonability of CSFSF construction

Introduction

This document is an integral part (volume 1, part 1) of the Feasibility Study (FS) carried out in accordance with the Terms of Reference on agreement No. 1039/08 of 25 November 2002 "Development of Feasibility Study of Investments for Construction of a Centralized Spent Fuel Storage Facility for Ukrainian WWER NPPs" with the NNEGC "Energoatom" Amendment No. 4 of 20 January 2006 (Appendix A to the current document).

The objective of this document is to submit the main input data used in the FS development and substantiate expediency and reasonability of CSFSF construction.

The main input data are presented as follows:

- Data on the existing schemes and the SNF management technologies at the Ukrainian NPPs;
- Data on SF inventory to be stored in CSFSF;
- Data to estimate expenses for SNF transportation;
- Data to determine the required infrastructure;
- Data confirming a possibility to apply the infrastructure of the adjacent facilities;
- Data to estimate operation costs;
- Notes and decisions made during the FS development;

The organizations submitted the input data used in the document are:

- NNEGC "Energoatom";
- SSE "Man-made Waste Processing and Disposing Center "Tekhnocenter"";
- SSE "Chernobylservis";
- SE "Capital Construction Department";
- State rail transport administration of Ukraine "Ukrzaliznycya";
- SSE "Chernobyl NPP".

The information submitted in the current part of this FS on the use of the infrastructure is of preliminary character, with taking into consideration the design stage, namely, the FS. Subsequent design stages will require technical conditions to be connected to the infrastructure after specification of technical decisions on the selected technology.

Expediency and reasonability for constructing the CSFSF is justified on the basis of CSFSF cost data obtained during development of the current FS and the cost data recommended in the international documents for different stages of the nuclear-fuel cycle.

Abbreviations

RC	-	Reactor Core
NPP	-	Nuclear Power Plant
CP	-	Cooling Pool
HLW	-	High-Level Waste
WWER	-	Water-cooled Water-moderated Energy Reactor
EB	-	Engineered Barrier
LLW	-	Low Level Waste
SAA	-	Spent Additional Absorber
SFA	-	Spent Fuel Assembly
SNF	-	Spent Nuclear Fuel
OECD/ NEA	-	Organization for Economic Cooperation and Development / Nuclear Energy Agency
RAW	-	Radioactive Waste
RBMK[1]	-	High-Power Channel-Type Reactor
RF	-	Reactor Facility
RF	-	Russian Federation
MLW	-	Medium-level Waste
FE	-	Fuel Element
FA	-	Fuel Assembly
SC	-	Shipping Cask
HM	-	Heavy Metal
FS	-	Feasibility Study
CSFSF	-	Centralized Spent Fuel Storage Facility
NF	-	Nuclear Fuel
NFC	-	Nuclear Fuel Cycle

[1] transliterated

List of terms and definitions

Long-term storage	-	In this document the term means interim storage of spent nuclear fuel within the design storage life of more than 30 years.
Capital costs	-	Any investor's expenses on independent manufacturing, construction, purchase or improvement of the capital assets and intangible assets of the SNF storage facility, which book value will be amortized after commissioning in the established order through its step-by-step transfer to the cost of SNF reception and storage services. Depending on the execution time, capital costs for the storage startup complex and current capital costs of the reporting (planned) period are appropriated including expenses for purchase (construction) of the capital assets and intangible assets for the projected extension of the storage facility productive capacity.
Capital assets	-	Material values applied by a taxpayer in its business activity during the period that exceeds 365 calendar days from the date of beginning use of such material values and which value gradually decreases due to physical or moral ageing.
Storage facility productive capacity	-	Maximum designed number of places to locate storage means on the site.
Expenses of passive period	-	Any permanent expenses of the storage facility operating organization in any reporting (planned) period following the last period of SNF reception for interim long-term storage. Expenses of passive period are determined by a period between a year in which SNF reception for storage is completed and a year in which the storage design lifetime is completed.
SNF storage means	-	A unit of equipment, constructively designed, manufactured and certified to provide SNF long-term interim storage in compliance with safety standards and requirements during the service life.
t (kg) HM	-	Heavy metal ton (kilogram) – the weight of isotopes contained in SFA, which is normalized to the weight of uranium.
Fuel assembly	-	A special rigid structure which must not be dismantled during the service life, designed to provide technical capability to use NF energy potential in the reactor core to generate energy in compliance with safety standards and regulations.
SNF storage facility	-	A nuclear facility comprising a complex of fixed assets (buildings, structures, access roads, SFA storage capacities, machinery and equipment, computer engineering and I&C etc.), which operational operability for SNF long-term interim storage reception according to the approved technology in compliance with safety requirements and standards is confirmed by an appropriate permission (license) of the state regulatory authority.
Operational costs	-	Any permanent expenses of the storage facility operating organization in the reporting (planned) period including maintaining the operated buildings, structures, machinery, equipment and other capital assets of the facility in the "ready" status, assurance of compliance with safety standards and

	requirements during its operation, as well as management of operating activities.
Spent nuclear fuel	- Nuclear fuel irradiated in the reactor core and finally removed from there (NP 306.2.105-2004).
Nuclear fuel cycle (NFS)	- A set of process operations comprising: uranium ore extraction, uranium concentrate manufacturing, enrichment; fuel fabrication for nuclear facilities; its burn-up in reactors in order to generate thermal and electrical power; spent nuclear fuel (SNF) storage, SNF disposal / processing, and radioactive waste management.

1 MAIN APPROACHES AT FS DEVELOPMENT

The current revision of the FS is developed in accordance with DBN A.2.2-3-2004 "Composition and Procedure for Development, Agreement and Approval of the Design Documentation for Construction".

Tasks to be accomplished within the current FS are:

- substantiate a need and relevancy for CSFSF construction;
- determine a composition for CSFSF construction;
- identify overall dimensions of the CSFSF site;
- determine a CSFSF required infrastructure;
- select a CSFSF preferred siting;
- assess CSFSF impact on the environment;
- estimate CSFSF construction costs;
- assess radiation impact on SFSF personnel;
- state main decisions and deadlines on CSFSF construction;
- identify main decisions on a general layout, assess preliminary grade levels and determine on-site transport schemes;
- assess SNF delivery routs from NPP to the CSFSF and recommend a most preferred delivery option;
- estimate costs for CSFSF startup complex;
- define technical and economic indicators for CSFSF design capacity and the capacity of the CSFSF startup complex;
- state main stages for CSFSF construction;
- make conclusions and recommendations regarding CSFSF, determine residual uncertainties and substantiate a preliminary plan for CSFSF implementation.

FS does not cover the following tasks:

- selection of a technology for SNF management (storage or processing) – it is determined by strategic decisions being made now;
- selection of a nuclear fuel cycle of Ukraine – it is determined by strategic decisions being made now;
- selection of an option for SNF transportation from NPP to the CSFSF – it is determined by the existing method, availability of the required equipment and gained experience;
- selection of a technology for SNF dry storage – it has been determined in the course of a tender.

To fulfill these tasks the input data presented in the subsequent sections of this document were used.

Approaches accepted during FS development:

- consider the main FS decisions and indicators for the case of HI-STORM 100S SNF (Holtec, the USA) storage technology - selected based on the international tender results for CSFSF "turnkey" construction;
- develop EIA within the FS for WWER SNF according to the data on initial events of accidents submitted by the Holtec International;
- taking into account that the CSFSF preferred site is located within the ChNPP exclusion area, the main EIA task is to assess the CSFSF contribution to the existing situation within the ChNPP exclusion area;

- assess within the FS a need and reasonability for SNFSF construction taking into account the cost data obtained within FS, the Client's current (present and planned in the next future) data on SNF delivery costs to Russia and considering the Holtec data about the CSFSF basic equipment costs;
- determine within the FS the main CSFSF technical and economic indicators for the SNF storage technology identified by the tender results;
- during FS development it is supposed that the automated radiation monitoring system of the ChNPP exclusion area is available and, as a result, a separate system of the meteorological station is not provided for in the sanitary-protection area and the CSFSF area under monitoring.

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2 INPUT DATA FOR FS DEVELOPMENT

2.1 SNF storage volumes

The following characteristics and requirements for storage are accepted as input data for FS:

- storage facility is considered only for WWER SNF storage;
- storage facility operation design lifetime is not less than 100 years;
- storage facility volume capacity should ensure storage of the whole fuel from RNPP-1-4, KhNPP-1-2 and SU NPP-1-3 (i.e. design loading of the cooling pond, fuel loaded in reactors and fuel to be generated in operation);
- possibility of storage facility extension was considered in determination of storage facility overall dimensions;
- storage technology should ensure compliance with the existing SNF management technology and NPP equipment for SNF management and shipment;
- CSFSF design capacity should ensure location and storage of 12500 WWER-1000 SFA and 4000 WWER-440 SFA during 100 years. CSFSF capacity should ensure location and storage of WWER SNF generated at Ukrainian NPPs during industrial operation by step-by-step increase of storage volume. At the same time, the initial storage facility capacity – the startup complex should constitute not less that 2500 WWER-1000 SFA and 1080 WWER-440 SFA;
- SNF shipment to the Russian Federation (RF) is stopped in a year before CSFSF commissioning.
- uranium/heavy metal mass in SFA of any burnup in assessing the CSFSF costs parameters was accepted equal to the mass of uranium isotope mixture in SFA with zero burnup:
  - 402 kg – in FA-M of WWER-1000;
  - 432 kg – in FA-A of WWER-1000;
  - 120 kg – in SFA of WWER-440 (for FA and RK[2]).
- uranium amount assumed to be stored in CSFSF constitutes 5647,794 t;
- CSFSF should ensure the possibility to prepare for storage not less than 504 WWER-1000 SFA and 192 WWER-440 SFA per year;
- time, required for SFSF loading with nuclear fuel from the operating NPPs, constitutes 45-50 years.

2.2 Input data on SNF shipment

The following input data on SNF transportation from NPP to the CSFSF site in the exclusion area near the "Vector" complex ("CDF" site) were accepted in implementation of this FS:

- SNF are delivered from NPP to the CSFSF by railway transport;
- shipment is performed with the help of a special train (rail car train) consisting of ten cars:
  - five rail cars with SNF;
  - one rail car for a HI-TRAC transfer cask;
  - one platform for welding and auxiliary equipment;
  - one convoy car;
  - two escort cars.
- the existing main-line railways of Ukraine can ensure SNF transfer from NPP to the "CDF" site by two directions:
  - "Western" – Ovruch-Vilcha-Shepelichi-Yanov;

[2] Transliterated. RK is a so-called "working cassette", which for WWER-440 means a common fuel assembly, and "FA" is a fuel follower of a control roads assembly (translator's note).

- "Eastern" –Chernigov-Nedanchichi-Yanov.

- "Western" direction was accepted (Appendix B to this report) to determine the SNF route remoteness from NPP to the "CDF" site in compliance with the answer of the Ministry of Transport of Ukraine;
- distance between NPP and the "CDF" site along the railway is given in Table 2.1.

Table 2.1 – Transfer remoteness, km

NPP	**Distance from NPP to CSFSF site - "CDF", km**
KhNPP	240
RNPP	250
SU NPP	670

- number of routes from NPP to CSFSF is accepted as equal to the operated units, considering annual reactor reloading:
  - Khmelnitskiy NPP – 2 routes per year;
  - Rivne NPP – 4 routes per year;
  - South-Ukraine NPP – 3 routes per year.
- the Client's data on SNF shipment costs in Ukraine are used to determine shipment costs (see Appendix B). Shipment costs do not depend on the number of cars and weight of transferred loads and are determined by:
  - cost of 1 train-km of the empty train;
  - cost of 1 train-km of the loaded train;
  - cost of insurance and guard services;

Thus, 1 train-km costs 480,09 hrn./km;

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2.3 Input data on SNF management technology

In accordance with the first stage of the contract on CSFSF startup complex "turnkey" construction, the Holtec International presented the following input data:

- on process:
  - sequence of operations for receiving MPC, HI-STAR and HI-TRAC at NPP, preparation for loading, for welding and MPC confinement monitoring in the NPP reactor compartment;
  - characteristics of the main equipment;
  - description and characteristics of systems being created for loading technology;
  - characteristics of NPP systems to be required for SFA loading to MPC;
  - description of the technology for HI-STORM overpacks production and installation at the CSFSF industrial site;
  - requirements for a site general layout in use of the HI-STORM 100S technology;
  - brief description of auxiliary facilities at the CSFSF industrial site;
  - requirements for structures of CSFSF building and facilities;
  - functional assignment of buildings and structures at the CSFSF industrial site indicating the main systems assumed in the building;
  - use of mediums, expected discharges for the active and passive operation periods;
  - expected annual amount of LRW and SRW;
  - description of the radiation monitoring system;
  - description of the ventilation system in restricted access area rooms;

- description of procedures on storage facility maintenance;
- CSFSF design annual productivity;

- to substantiate the necessity and reasonability for CSFSF construction:
  - data on operation costs for CSFSF active period;
  - data on operation costs for CSFSF passive period;
  - annual capital costs after CSFSF commissioning (are determined by a number of casks accepted for storage per year);
  - recommended order of construction after the startup complex;
- on construction:
  - requirements for building walls from the viewpoint of biological protection;
  - requirements for a baseplate for a cask storage site;
  - requirements for on-site roads, including specific load of the loaded crawler;
- on electricity:
  - decoding of the main electric power consumers (related to SNF management technology) indicating power and reliability of electric power supply by PUE;
- on water supply:
  - number of personnel in the maximum shift within the restricted access area for changing room calculation;
  - requirements for water quality for technical needs;
- on construction arrangement:
  - description of activities on a construction preparation period within the Holtec work scope;
  - description of decisions on CSFSF construction proposed by Holtec;
- for summary estimated calculation:
  - list of the main equipment and materials indicating the cost;
  - list of auxiliary equipment and materials to be delivered by a Supplier determined by Holtec International;
  - list and costs of equipment for radiation and temperature monitoring systems;
- for Environment Impact Assessment:
  - description and characteristics of CSFSF releases in normal operation;
  - substantiation for selecting maximum design-basis and beyond design-basis accidents;
  - description of the maximum design-basis accident during CSFSF operation based on the HI-STORM 100S technology;
  - description of the maximum beyond design-basis accident during CSFSF operation according to the HI-STORM 100S process;
- to present data on nuclear and radiation safety:
  - description of nuclear and radiation safety criteria that constituting the basis of the technology;
  - description of measures on nuclear and radiation safety during SFA loading, shipment and storage;
  - list of initial events for the storage facility to be considered in design;
  - dose rate on surfaces of HI-STORM 100S, HI-STAR , HI-TRAC overpacks and at the distance of 1m from the surface.

2.4 Input data on infrastructure and operational costs

In order to determine a set of structures and costs for the CSFSF structure, the “Tekhnocenter” data have been used as regards capabilities of the “Vector” complex infrastructure. The “Vector” complex capabilities have been assessed to make decisions for CSFSF regarding:

- capability to provide with drinking water;
- capability to provide with water for production needs;
- capability to provide with electric power;
- capability to receive CSFSF consumer, production and rain waters for treatment;
- capability to rent a tank truck for LRW shipment;
- capability to receive RAW by the CSFSF;
- capability to use a fire station for CSFSF service;
- necessity to construct civil defense structures for CSFSF personnel;
- necessity to create the required powers for the CSFSF construction.

In response to the "Vector" complex capabilities assessment, the following main decision for the CSFSF design have been identified:

- "Vector" complex will submit the required quantity of drinking water and water for production needs at the limit of their capabilities to the CSFSF;
- structures of the "Vector" complex are able to receive the CSFSF effluents, domestic, rain and production waters for treatment without detriment to the "Vector" complex consumers, therefore, it is provided for within the CSFSF only collection, monitoring and shipment to the "Vector" complex structures;
- "Vector" complex will rent a specialized tank truck for LRW shipment with $5m^3$ capacity, therefore, tank trucks for LRW shipment are not provided for within the CSFSF;
- the required costs and storage facilities are not available to receive RAW at the CSFSF within the "Vector" complex stage I, therefore, LRW and SRW shipment to the SSE ChNPP enterprises is provided for within CSFSF;
- there are no civil defense structures within the "Vector" complex stage I, therefore, civil defense structures are provided for within CSFSF;
- the existing "Vector" complex powers are insufficient to construct the CSFSF, therefore, the required temporary structures for the CSFSF construction are provided for within CSFSF (a concrete plant, storehouses, etc.);
- to reduce the CSFSF impact on the "Vector" complex infrastructure, an additional artesian well is provided for at the territory of the "Vector" complex water intake structures;
- to reduce the CSFSF impact on the "Vector" complex infrastructure, it s provided for to reconstruct the "Buryakovka" substation supplying consumers of the "Vector" complex.

Holtec International data have been accepted as a basis to determine a volume of expendable consumed materials.

The following provisions have been accepted in determining costs for personnel maintenance:

- the number of personnel has been determined based on the preliminary staff list stated in volume 1, part 3 of the current FS;
- annual 5% turnover of staff is provided for in the CSFSF operation;
- the CSFSF operation, based on operation readiness, is accepted as one-shift operation;
- a part of personnel that monitors the SNF storage and CSFSF physical protection works around the clock, that is in three shifts;
- a part of personnel works by shifts (two weeks-works, two weeks-rests), other personnel works by the schedule of 4/3 (4 days-works, 3 days-rests);
- considering that CSFSF is located within the ChNPP exclusion area, rises in wages determined by the current Ukrainian legislation has been taken into account in the CSFSF personnel remuneration.

ChNPP data prepared for the ChNPP Decommissioning Concept are used in determining costs for LRW reception at ChNPP:

- LRW reception for processing - 11,8 thousand UAH/m^3.

"Tekhnocenter" data are used in determining costs for RAW reception at the "Vector" complex (in commissioning of stage I):

- SRW reception – 2,64 thousand UAH/m^3.

3 THE EXISTING SNF MANAGEMENT SCHEME OF UKRAINIAN WWER NPPs

Designs of operating NPPs with WWER were performed in 70-th and provided for the following spent fuel management scheme:

- nuclear fuel (NF) spent in the reactor (achieving of the design burnup depth) is reloaded to the sub-reactor cooling pond (CP) where it is cooled not less than 3 years to reduce radioactivity and residual heat release with time;
- after WWER-440 fuel is cooled in cooling ponds, it is transferred for processing to plant RT-1 (FGUP* "Majak") to Russia. At that, a rail car train for SNF transportation belongs to RT-1;
- in accordance with the current agreement and the contract with Russia, WWER-440 nuclear fuel is processed at RT-1 and high-level vitrified waste is to be transferred back to Ukraine not later than in 20 years after acceptance for processing;
- in accordance with the contract for WWER-440 SNF processing, Ukraine pays for services that include SNF shipment from NPP to RT-1, directly processing (including process cooling) and storage of RW generated in processing. The current contract does not include costs for RW return after SNF processing;
- after WWER-1000 fuel is cooled in cooling ponds, it is transferred for processing to the FGUP "KGKhK*" (RT-2) to Russia. At that, the rail car train for SNF transportation belongs to RT-2;
- in accordance with the current contract, SNF should be cooled, processed at RT-2 and the solidified high-level processing products and SNF costly processing products should be returned to Ukraine after routine storage. At present, SNF are only cooled at RT-2 because processing powers are absent;
- in accordance with the contract for WWER-1000 SNF processing, Ukraine pays for services that include SNF shipment from NPP to RT-2, technological cooling, and direct processing. The current contract does not include costs for returning RW generated from processing of SNF and costly products.

3.1 NPPs with WWER-1000

13 units with WWER-1000 are operated in Ukraine. The main components of SNF management system (storage and transportation) for these units are:

- cooling pond;
- shipping cask TK-13 designed for 12 SFA;
- rail car train;
- for SE ZNPP – additionally dry-type SFSF at the NPP site.

Fuel in the reactor is reloaded once a year, at that, about 1/3 of the reactor core in "3-years campaigns" or ¼ of core in "4-years campaigns" is replaced. Procedure for reloading, transfer, and replacement of assemblies is specified based on the active core cartogram and the information on fuel burnup received during reactor operation. The reactor core consists of 163 fuel assemblies.

SFA reloaded from the reactor core are stored in CP racks. Prior to storage, SFA should be tested for FE cladding confinement in accordance with the current NPP regulation. Depending on test results, SFA is installed whether into a cooling pond rack cell or into a tight canister.

Number of cartridges installed into racks is identified by presence of fuel compact storage racks (FCSR) (613-687 cells) or their absence – 392-465 cells. Cooling pool capacity should ensure: storage

* transliterated

places for leak-tight canisters – 25 pcs, one place for a cluster and four canisters of SODS* system, empty cells for core emergency reloading, and cells for SFA storage. Capacity of SFA storage racks ensures their cooling for not less than three years after their reloading from the core but not more than 9 years.

SFA is reloaded to shipping cask TK-13 by means of standard lifting mechanisms of the reactor compartment under water layer in the cooling pond. The shipping cask is prepared at the service mark of the reactor compartment central hall. The procedure for cask preparation provides for its decontamination, drying, vacuuming, filling with cooling liquid of neutron protection cladding, and containment.

The shipping cask prepared for transportation is lowered at the railway platform in the transfer tube of the reactor compartment, is turned over into a horizontal position by means of standard lifting mechanisms.

Average time for operations of the rail car train preparation for transportation to RT-1 is 7 days, in average, one day - for one rail car train.

3.2 NPPs with WWER-440

Two RNPP units (1 and 2) with WWER-440 are operated in Ukraine. Reactors operation started in 1980 - 1981.

The main components of SNF management system (storage and transportation) for these units are:

- cooling pond;
- shipping cask TK-6 designed for 30 SFA;
- rail car train.

Fuel in the reactor is reloaded once a year, at that, about 1/4 of the reactor core in "4-years campaigns" is replaced. Procedure for reloading, transfer, and replacement of assemblies is specified based on the active core cartogram and the data on fuel burnup received during reactor operation. Reactor core consists of 313 (RNPP-1) and 349 (RNPP-2) fuel assemblies.

SFA reloaded from the reactor core are stored in CP racks. Prior to storage, SFA should be tested for FE cladding confinement in accordance with the current NPP regulation. Depending on test results, SFA is installed whether into a cooling pond rack cell or into a tight canister.

The spent fuel storage system is intended to withdraw activity and residual heat releases from spent cartridges reloaded from the reactor core to the permissible values for temporary storage of ARK cartridges extensions and cartridges-shields (unit 1) as well as to ensure biological protection of NPP personnel staying in the RC CH. Spend fuel is cooled in the RC CP not less than 3 years.

Free space has to be ensured in the unit CP to reload one full core at any moment of operation. Having considered that unit 1 and 2 have one common RC CH and there is a possibility to transfer SNF from the CP of one unit to the CP of the other unit at any moment, it is required to ensure not less than 110 free cells in each of the CP and additionally 386 free cells in both cooling ponds of two units (Technical decision No. 43 – NSR-TD) before fuel reloading. Moreover, it is planned now to reconstruct unit 2 cooling pond and install there SNF compact storage racks produced by Skoda. After the reconstruction of unit 2 CP, total number of cells in both cooling ponds makes up 1706 SFA.

SFA is reloaded to shipping cask TK-6 by standard lifting mechanisms of the reactor compartment in the cooling pond under water layer. A shipping cask is prepared for transfer at the attended mark of the reactor compartment central hall. The procedure for preparing a cask provides for its decontamination, drying, vacuuming, and sealing.

A shipping cask prepared for transfer by standard lifting mechanisms of the reactor compartment is put down at the railway platform in the reactor compartment transfer tube and is turned over to a horizontal position.

* transliterated for System of Detection of Leaky Fuel Assemblies

An average time required to prepare a rail car train for shipment to RT-2 is 7 days, on average, one day is required for one rail car train.

The design of a railway aggregate to transfer TK-13 and TK-6 casks is similar. TK-6 shipping casks are absent in Ukraine.

3.3 Long-term dry-type SFSF at Zaporizhzhya NPP

At present, the spent nuclear fuel dry storage facility is in operation at the Zaporizhzhya NPP based on the DE&S International technology (VKKh[*]-WWER-1000) that supposes to use a one-purpose (only for storage) metal-concrete ventilation cask for SNF interim long-term storage. A protective transfer cask and an on-site crawler are applied to reload SNF from the cooling pond to the storage cask and to transfer and store the cask from the reactor compartment to the storage site.

Handling equipment available at the ZNPP reactor compartments is used (almost in full) in SFA loading to VKKh-WWER.

The storage facility is intended to store 380 VKKh-WWER-1000 casks or store 9120 WWER-1000 SFA. The storage facility is an open site where VKKh-WWER-1000 casks are installed at the interval of 4.5 m. The site is located within the ZNPP industrial site and is equipped with an independent physical protection barrier.

The SNF storage design term in a cask is 50 years. The issue on further management of SNF and casks after long-term storage is not identified at present.

3.4 State of SNF transfer to Russia

The fuel cycle completion option with processing is actually being implemented in Ukraine, for that, SNF has been transferred till present for interim storage and treatment to the Russian Federation after necessary cooling in subreactor ponds.

[*] transliterated

4 CSFSF DESIGN DECISIONS

4.1 Project description

In accordance with the Terms of Reference the design of a Spent Nuclear Fuel Storage Facility (CSFSF) for Ukrainian WWER NPPs is intended to house and store for a long-term period (not less than 100 years) WWER-type spent nuclear fuel:

- 12500 SFA of WWER-1000;
- 4000 SFA of WWER-440.

Considering the current state of SFA availability in NPPs units and NNEGC "Energoatom" prospects for shipment of SFA to Russia as well extension of power units operation life up to 2030, the CSFSF design capacity will constitute:

- 12010 SFA of WWER-1000;
- 4519 SFA of WWER-440.

CSFSF capacity provides for emplacement and storage of WWER SNF generated at Rivne NPP Units 1-4, Khmelnitsky NPP Units 1-2 and South-Ukrainian NPP Units 1-3 (that means the CP design load, the fuel loaded in reactor cores and the spent fuel to be accumulated during operation of power units) by the step-by-step increase of storage volume.

Under this project it is planned to apply the SNF dry storage technology that provides for SNF storage in the inert atmosphere with natural air-cooling. SNF management technology considered in this FS has been developed by the American company Holtec and applied at NPPs in the USA.

Under this FS the CSFSF includes the following:

- areas for loading SFA in MPC and preparing HI-STAR overpacks for transportation at every power unit of WWER NPP;
- transportation of the HI-STAR packages with SFA from NPP to CSFSF;
- a receiving building at the CSFSF site;
- a site to store the HI-STORM overpacks with SFA;
- an on-site transport system.

Areas to load SFA in the MPC and to prepare the HI-STAR overpacks for transportation are located in reactor departments of Khmelnitsky, Rivne and South-Ukrainian NPPs power units. In the reactor hall the SFA (after being kept in the cooling pond not less than 5 years) are loaded into MPCs, dehydrated and dried, MPCs are pressurized and filled up with helium. MPC two confining barriers provide for non-release of SFA radioactive substances into the environment. The HI-TRAC transfer cask and HI-STAR transport overpack are used to ensure biological shielding of the personnel during reloading.

MPC with SFA are transported from NPP to CSFSF in the HI-STAR transport overpacks designed in accordance with the USA safety requirements. These casks will be certified in Ukraine as type B (U) packages in accordance with the PBTRM*-2006 [21] requirements.

A receiving building is designed for reloading MPC with SFA from the HI-STAR transport overpack into a HI-STORM long-term storage overpack. MPC with SFA are reloaded in the receiving box by means of the HI-TRAC transfer cask.

A storage site for SFA casks is a passive storage system for HI-STORM overpacks with two confining barriers as MPC and HI-STORM cask bio-shielding barrier.

The current FS, volume 1, part 3 describes the main technological decisions regarding the SNF management technology.

The following buildings and structures have been determined during composition of a general layout:

- MPC receiving and reloading building, including "dirty" workshops, a changing room, and a CSFSF central control room;
- a storage site for HI-STORM casks;
- a maintenance building with MPC storage facility, including roofing for concreting HI-STORM shells;
- a garage for holding and maintenance of a track-type transport;
- a garage for four cars, including workshops for minor repair and a decontamination unit;
- a covered site for maintenance and repair of one rail car and an open site for holding one escort car;
- a building for electrical devices;
- a filling station including two underground capacities for two types of fuel;
- an office building, including offices, an assembly hall, a dining-room, a civil defense structure;
- a check-point at the railway entry;
- holding railways for a rail car train composed of five rail cars, one rail for a HI-TRAC transfer cask, one platform for welding and auxiliary equipment, one support car and two escort cars;
- a pump-house for drainage water;
- a pumphouse for fire water supply;
- fire extinguishing water supply capacities;
- rainwater storage capacities;
- a guard building.

Overall size of the fenced site is 644x182 m. Two roads from the south and the north sides and one railway entry are designed for the site.

A parcel of land (11,72 hectares) is provided for within the ChNPP exlusion area to construct a CSFSF and a 6,4 km access railway.

FS provides for creation of a NNEGC "Energoatom" separate subdivision with all the required infrastructures and staff to ensure operation of a nuclear facility – CSFSF.

CSFSF has to provide a possibility to prepare for storage not less than 504 WWER-1000 SFA and 192 WWER-420 SFA per year. A period of time required to fill up SNFSF with nuclear fuel of operating NPPs is from 45 to 50 years.

On this basis two main stages for CSFSF operation have been determined:

- **active period** (45-50 years) – a period when MPC with SFA are delivered and handled and HI-STORM are emplaced for long-term storage;
- **passive period** (50-55 years) – a period when MPC with SFA are stored in HI-STORM metal-concrete casks, CSFSF systems are operated until making a decision on a further SNF management technology in Ukraine.

In accordance with the Client's task order, a startup complex and subsequent construction stages have been identified within the CSFSF.

All the aforesaid buildings and structures are included in the CSFSF startup complex, as well as holding and maneuvering railways in full scope.

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4.2 Preliminary operation program

In assessing design quantitative parameters of the production program, the following provisions have been taken into account:

1) At a period before the CSFSF commissioning, SNF transportation to the RF is provided for within minimum scopes. Transportation is planned in a case, if a number of free cells in the cooling pond does not allow emergency discharge of the reactor core.

2) Duration of the use of productive capacities of the CSFSF startup complex and its subsequent stages has been determined prior to filling of HI-STORM foundations included in the construction stage.

3) To determine a book value of HI-STORM with MPC for SFA storage, the data have been accepted for equipment purchasing and mounting presented in prices for 2006. The average annual value of HI-STORM with MPC (has been identified based on the condition that they are manufactured, delivered at the CSFSF and are entered at book values gradually in the course of year in a quantity equivalent to the quarterly part of the delivery annual scope.

4) To estimate annual discharge of SFA from the reactor to the cooling pond, the following parameters have been accepted: for power units with WWER-440 – 84 (72) SFA, for power units with WWER-1000, in use of regular FA the annual discharge constitutes 48 pcs, in use of FA-A ("TVSA") –42 pcs. The given volumes of discharge have been accepted conditionally for the FS goals.

5) The time required for loading the CSFSF with nuclear fuel of the operating NPPs constitutes from 45 to 50 years.

6) All period of the CSFSF operation is conditionally divided into two stages: active operation period (50 years) and passive operation period (50 years).

7) An active operation period is specified by SFA coming for storage.

8) A passive operation period is specified only by storage of SNF, as well as maintenance and repair of the CSFSF structures and systems.

About 5,65 thousand tons of fuel materials (FM) will be transferred for interim storage from the operating power units of the Ukrainian NPPs from 2011 to 2056.

Duration of use of storage facility stages is determined by SFA arrival scopes from the operating power units of the Ukrainian NPPs and constitutes, approximately, for the startup complex – 6 years, for stage 2 – 11 years, for stage 3 – 10 years and for stage 4 – 19 years. SNF coming to the CSFSF on the stages and types of power units is given in Table 4.2.1.

Table 4.2.1- Timing and quantitative characteristics for SFSF loading

Name, period	**WWER-1000**		**WWER-440**		**Total**	
	SFA, pcs	**tFM**	**SFA, pcs**	**tFM**	**SFA, pcs**	**tFM**
Startup complex (2011-2016)	2697	1135,866	850	102	3547	1237,866
Second stage (2017-2027)	3348	1446,336	1955	234,6	5303	1680,936
Third stage (2028-2037)	3342	1430,352	1714	205,68	5056	1636,032
Fourth stage (2038-2056)	2623	1092,960	–	–	2623	1092,96
Total	12010	5 105,514	4519	542,28	16529	5647,794

Figure 4.2.1 demonstrates SFA generation dynamics during the CSFSF operation active period, and Figure 4.2.2 shows dynamics of heavy metals incoming to the CSFSF.

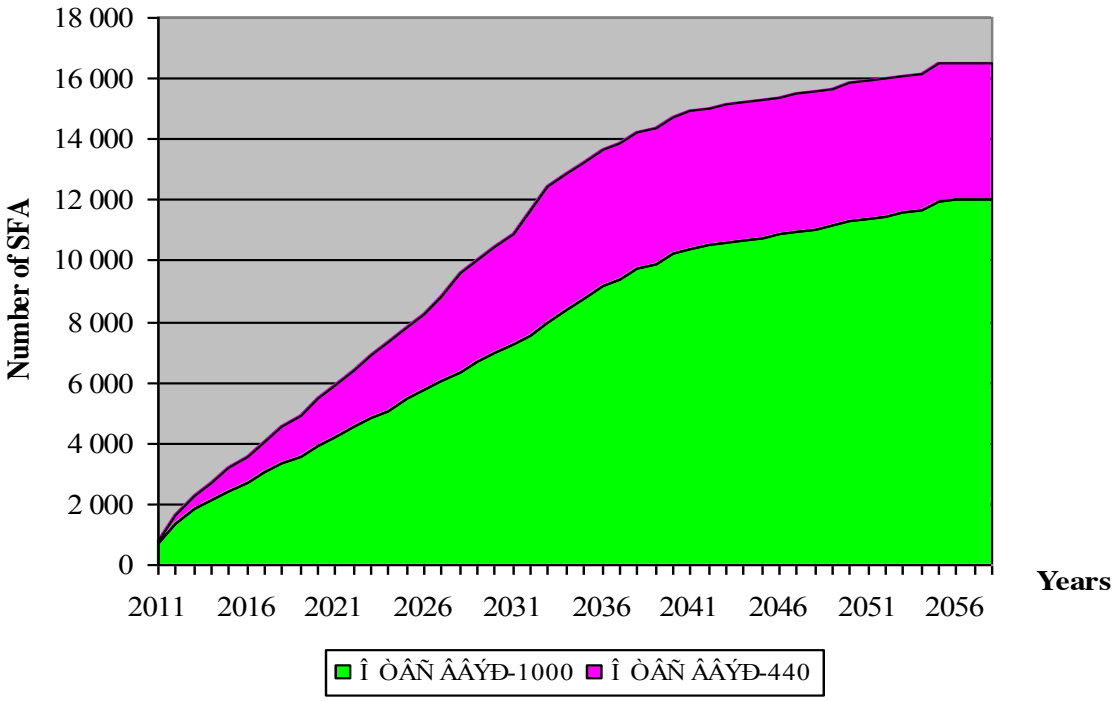

Figure 4.2.1- SFA generation dynamics in the CSFSF

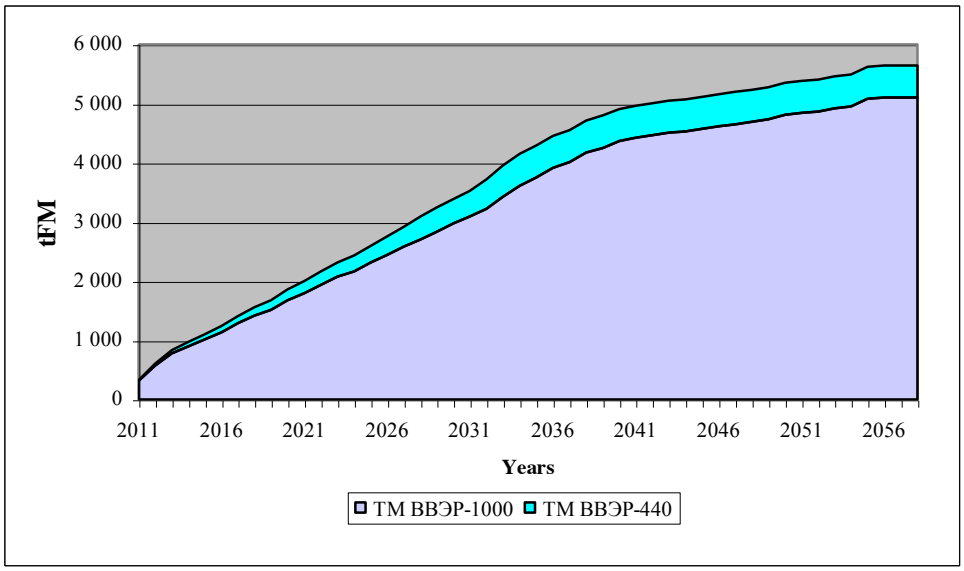

Diagram 4.2.2 – Dynamics of heavy metal incoming to the SFSF

In total for one period 5 647 794 kg of irradiated nuclear fuel in conversions to heavy metal, including 5 105 514 kg (90%) from WWER-1000 reactors, will income to the SFSF. The most active incoming of spent fuel to be stored in the CSFSF is supposed during the first years – on average about 169 thousand tons per year. This is specified by the necessity to provide with a standard reserve of free shells in the CP occupied in a period before the CSFSF construction and commissioning. Correspondingly, the most costs for the CSFSF decommissioning and final stage of SNF management should be formed just in this period.

On average, during the latter part of the CSFSF operation active period, about 86,7 tFM per year will income for storage up to 2056 inclusive.

List of the applied sources

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CENTRALIZED SPENT FUEL STORAGE FACILITY FOR UKRAINIAN WWER NPPs

FEASIBILITY STUDY OF INVESTMENTS

VOLUME 1
PART 2

Analysis and Assessment of SNF Management Alternative Technologies

Introduction

SNF management within this document means SNF management after its removing from the reactor and cooling in the reactor fuel cooling pond.

SNF Management includes:

- SNF transfer;
- SNF storage;
- SNF processing or disposal.

The objective of this Section 2 is to:

- analyze the world practice of SNF management systems;
- analyze the available data on the existing world SNF transfer and storage technologies;
- develop recommendations on the options of SNF management technologies most acceptable for Ukraine.

This document does not cover selection of a SNF storage technology for Ukrainian NPPs with WWER.

During the development of this document the materials have been applied of the activities carried out earlier:

- The Kyiv Research and Design Institute "Energoproject" document "Feasibility Study of Options for SNF Interim Storage of Ukrainian WWER NPPs" developed in the framework of Contract No. 57-006 with NNEGC "Energoatom";
- The NPP OSI document "Definition and Substantiation of Requirements for the Unified Design of Spent Nuclear Fuel Interim Storage System for RNPP, KhNPP and SUNPP" developed in the framework of Contract No. 1 with NNEGC "Energoatom";
- .

List of abbreviations

NPP	-	Nuclear Power Plant
FCP	-	Fuel Cooling Pool
VCC	-	Ventilated Concrete Cask
WWER	-	Water-cooled Water-moderated Energy Reactor
BWR	-	Boling Water Reactor
MIC	-	Mining Industrial Complex
EB	-	Engineered Barrier
MIA	-	Ministry of Internal Affairs
MPC	-	Multi-purpose Canister
MT	-	Ministry of Transport
SAA	-	Spent Auxiliary Absorber
SFA	-	Spent Fuel Assembly
SNF	-	Spent Nuclear Fuel
RAW	-	Radioactive Waste
RBMK	-	Light Water Cooled Graphite Moderated Reactor
RF	-	Russian Federation
PWR	-	Pressurized Water Reactor
FFDS	-	Fuel failure detection system
USSR	-	Union of Soviet Socialist Republics
FE	-	Fuel Element
TC	-	Transfer cask
FS	-	Feasibility Study
ISF	-	Interim Storage Facility
CSFSF	-	Centralized Spent Fuel Storage Facility

List of terms

Extended storage	-	As used in this document, this term means the intermediate storage of spent nuclear fuel with design storage time period of more than 30 years.
Spent Fuel Assembly (SFA)	-	A fuel assembly spent in nuclear reactor whose subsequent use is not envisaged (RD 306.08.02/2.067-2003).
Spent Nuclear Fuel (SNF)	-	Separate FEs or FAs (with absorber or without it) irradiated in nuclear reactor, and with no envisaged subsequent use (RD 306.08.02/2.067-2003).
Fuel Element (FE)	-	A separate assembly unit with nuclear fuel arranged in the reactor core that ensures heat energy generation, accumulation of fission products and secondary nuclear fuel (PBYa RU AS-89).
Packaging for Spent Nuclear Fuel	-	A set of means used at spent nuclear fuel transfer and storage that ensure fuel safe keeping, prevention of radioactive substance release into the environment, as well as nuclear and radiation safety (PNAE G-14-029-91)
Interim Storage Facility	-	As used in this document, the term means a nuclear facility which consists of a set of buildings, systems, equipment and elements designed for spent nuclear fuel loading, unloading, transfer, preparation to storage, storage, monitoring and control of storage conditions and also for spent nuclear fuel removal from a storage site.

1 GENERAL DATA ON SNF MANAGEMENT TECHNOLOGY

1.1 Properties of a nuclear fuel cycle

1.2 World experience of SNF management

1.2.1 SNF management in France

1.2.2 SNF management in Germany

1.2.3 SNF management in Bulgaria

1.2.4 SNF management in Sweden

1.2.5 SNF management in USA

1.2.6 SNF management in Spain

1.2.7 SNF management in Switzerland

1.2.8 SNF management in Canada

1.2.9 SNF management in Russia

1.2.9.1 SNF management at IC "Mayak"

1.2.9.2 SNF management at Krasnoyarsk Mining-Industrial Complex

1.2.9.3 Prospects for SNF management in Russia

Assessment of the international service market on SNF management, carried out by the Minatom, stipulates that it is possible to obtain about 21 milliards of USA dollars for import of 20 thousand tons of foreign SNF to Russia, for the period from 2000 up to 2010.

The existing RT[1]-1 capacities are not enough due to increase of incoming SNF, moreover, RT-1 receives specific type of SNF only, i.e. it is problematically to receive foreign SNF (not from former republics of USSR). After RT-2 commissioning, Russia can process considerably large amount of SNF – up to 1940 tons a year, including foreign SNF. The Minatom makes plans to provide storage services on terms of preliminarily payment (100%); prior to fuel processing there shall take place storage during 40-60 years. Intermediate storage will facilitate SNF processing, since the most of dangerous radioactive elements will undergo decay during 50 years.

Prior to realization of RT-2 processing capacity, the Minatom supposes to increase the capacity of RT-2 and RT-1 SNF storages by 23,6 thousand of tons. At the same time it is stipulated to increase capacity of a “wet” storage facility in Krasnoyarsk from 6 up to 9 thousand of tons and to construct a new dry-type storage facility for 9 thousand of tons and to increase IC “Mayak” storage capacity by 1,6 thousand of tons. It is supposed as well to construct a cask- type dry storage facility with the volume of 10 thousand of tons.

1.2.10 SNF management in Great Britain

1.2.11 SNF management in Japan

[1] transliterated

1.2.12 SNF management in India

1.2.13 Recommendations on SNF management in Ukraine

2 GENERAL DATA ON SNF TRANSPORTATION IN THE WORLD

2.1 SNF transportation by railway

2.2 SNF transportation by water transport

2.3 Experience of SNF transportation by motor transport

2.4 World experience in SNF transportation

2.5 SNF transportation within the former USSR countries

3 GENERAL DATA ON THE EXISTING SNF STORAGE TECHNOLOGIES

3.1 General data on storage technologies

3.1.1 Pool-type storage facilities

3.1.2 Dry-type storage facilities

3.2 World experience in SNF storage

3.2.1 SNF storage experience in France

3.2.2 SNF storage experience in Germany

3.2.3 SNF storage experience in Lithuania

3.2.4 SNF storage experience in Czechia

3.2.5 SNF storage experience in Hungary

3.2.6 SNF storage experience in USA

3.2.7 SNF storage experience in Russia

4 DESCRIPTION OF THE MAIN TYPES OF SNF CAVE (VAULT) STORAGE FACILITIES

4.1 CASCAD cave storage facility

4.2 MVDS concrete-module storage facility

4.3 FUELSTOR concrete-module storage facility

4.4 MACSTOR concrete-module storage facilities

5 DESCRIPTION OF THE MAIN TYPES OF SNF CASK STORAGE FACILITIES

5.1 TN-family casks

5.2 HDC-type casks

5.3 VSC (VKKh[2]-WWER) cask

5.4 TEPCO International cask

5.5 TK[3]-type casks

5.6 NAC-family casks

5.7 CASTOR and CONSTOR casks

5.8 "Westinghouse" Company casks

5.9 TranStore System for SNF storage and transportation

5.10 Holtec cask storage system

The system, developed by Holtec International [37-38] consists of the following main components:

- Multi-Purpose Canisters (MPC);
- Metal-concrete overpack (HI-STORM);
- Transport overpack (HI-STAR);
- Steel transfer cask (HI-TRAC).

The Holtec cask storage system is given in Figure 5.12.

In 1999 HOLTEC INTERNATIONAL obtained the license on MPC and HI-STAR from the Nuclear Regulatory Commission (NRC). In 2000 Holtec obtained the license on the unified storage complex from the USA Nuclear Regulatory Commission (NRC). Now, HOLTEC overpacks are applied in the USA, Great Britain, South Korea, Taiwan and Brazil.

The HOLTEC cask system main characteristics are presented in Table 5.13.

[2] transliterated
[3] transliterated

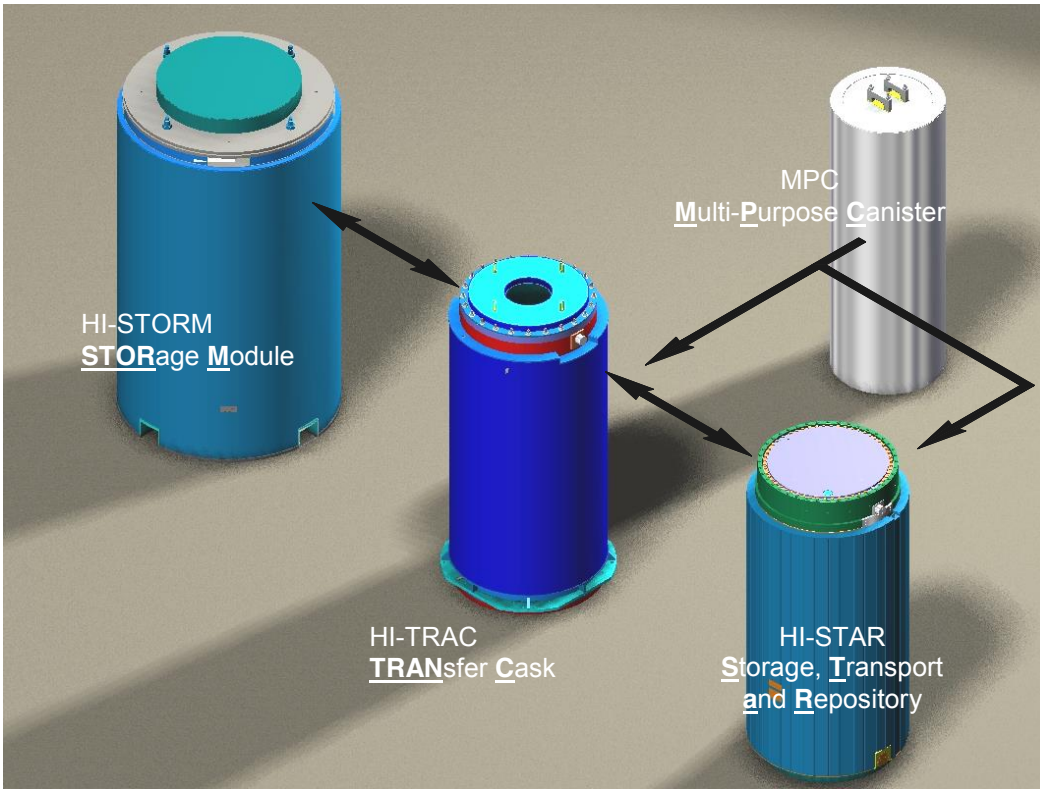


Figure 5.12 – General View of HOLTEC Cask System

Multi-Purpose Canister (MPC) is a stainless steel cylinder containing of two sealed lids. Each cylinder contains cells for each SFA. The basket inner side consists of a solid set of honeycomb stainless steel plates, where cells are welded along the whole length. The Boral plates, where necessary, are placed between stainless steel plates in accordance with the patented technology that the Holtec together with UST&Dwhich possess. A high-accuracy computerized facility with a hydraulic drive and a set of fixing devices along the whole length of a section is applied for an assembly. In order to prevent a stainless steel deformation under the welding temperature, a longitudinal welding is carried out when fixing devices hold a section. The welding process is patented as well; it is conducted by using the unique guiding system that gives a possibility to make welds quickly and with high accuracy. After MPC filling, water and air are removed from it and MPC is refilled with helium. Then, the MPC may be placed either into a storage cask made of concrete and steel or in a steel shipping cask; with this purpose a steel transfer cask is used.

HI-STORM overpack. A carbon steel high-strength outer shell designed taking into account the requirements of the American Society of Mechanical Engineers (ASME) (Section III, Subsection NF). This enclosure meets the requirements as well, established for equipment of nuclear power plants. Two concentric enclosures serve as a protection mass that preserves shell properties under irradiation. This minimizes a possibility of the shell contamination and allows reusing this shell. Tight steel welded outer enclosure protects a concrete structure from external impacts and prevents worsening of state and prosperities of concrete that may be resulted from weather conditions. A specific geometry of inlet and outlet vent ports prevents radiation flow. Inner protection shell decreases the concrete shield operating temperature and preserves container efficiency. Earthquake-proof properties ensure cask stability on sites that are specified by high seismic activity.

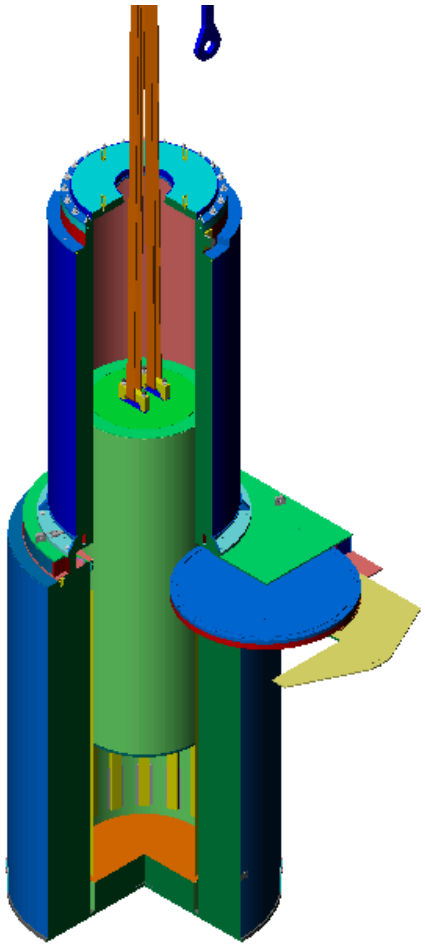
HI-STAR overpack. An overpack is a cylindrical vessel designed for MPC housing. The HI-STAR overpack performs radiation protection functions (walls are sufficiently thick for gamma-radiation protection) and MPC physical protection from external impacts in normal operation conditions and at design basis accidents during the storage period and transportation. The HI-STAR

overpack includes a neutron shield. Holtite-A neutron absorber (that belongs to Holtec) passed the radiation and thermal tests at the temperature that exceeds greatly the maximal temperature under which this absorber is operated. The main cutoff point between an overpack and a lid is confined by a bolt joint and is sealed with two gaskets. For transfer operations a container is equipped with lifting trunnions. Being a transfer cask, the HI-STAR meets all the requirements of the international standards.

HI-TRAC overpack. An overpack is designed for MPC vertical transfer from HI-STAR overpack to HI-STORM metal-concrete overpack. For this purpose, the transfer overpack is equipped with a shutter and special biological shielding means. An overpack enclosure is made of metal and is designed for biological shielding of personnel who is involved in MPC transfer. HI-TRAC overpack utilization diagram is presented on Drawing 5.13.

There are the following distinctive features of the HOLTEC cask system:

- MPC manufacture high labor-output ratio and high requirements for personnel qualification;
- MPC diameter is universal for any type of SFA;
- SFA heat removal system is optimized;
- use of a multi-purpose sealed basket allows loading SFA both at NPP unit and at a storage facility;
- a flexible system that allows to apply different options of SFA loading;
- a storage cask is metal-concrete;
- basket transfer cask and shipping casks are metal;
- an overpack system ensures multi-purpose functions (transfer, transportation and storage);
- storage overpack is ventilated due to natural convection;
- an adaptation will be required for WWER-1000 and WWER-440 SFA.



Drawing 5.13 – HI-TRAC overpack utilization diagram

Table 5.13 – Main characteristics of HOLTEC cask system

Developer	HOLTEC International, Inc., USA
License status	The USA License
Storage type	Metal-concrete casks
Purpose	Storage and transportation
Fuel type	PWR, BWR
Cask capacity	24-32 SFAs of PWR, 68 – BWR reactors
Material	Stainless steel, carbon steel, Boral
Inner environment	Helium
Specific cost	No data

6 RECOMMENDATIONS ON SNF STORAGE TECHNOLOGIES IN UKRAINE

6.1 Vault storage facilities

6.2 Module storage facilities

6.3 Metal casks

6.4 Metal-concrete casks

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CSFSF FOR UKRAINIAN WWER NPPs

FEASIBILITY STUDY OF INVESTMENTS

VOLUME 1
PART 3
Main Technical Decisions

Content

INTRODUCTION 7

GENERAL PART 8

ABBREVIATIONS 12

1 PROCESS PART 14

1.1 ASSIGNMENT AND DESIGN BASIS 14
1.2 HANDLING OPERATIONS AT NPP SITES 17
1.2.1 Preparation for Loading 17
1.2.2 Fuel Loading in MPC 17
1.2.3 Removal of HI-TRAC with MPC from the Cooling Pond 21
1.2.4 MPC Confinement 24
1.2.5 MPC Transfer in the HI-STAR Transport Overpack 27
1.2.6 Required Time for Loading Operations 30
1.3 SNF OUTSIDE TRANSPORTATION 33
1.3.1 General Principles 33
1.3.2 Shipping of Canisters with SFA from NPPs to the CSFSF Site 34
1.3.3 Shipment of the Empty Rail Car Train 35
1.3.4 Maneuvering with the Rail car Train within the CSFSF Site 37
1.4 OPERATIONS ON SNF RECEPTION TO THE CSFSF 37
1.4.1 General Principles 37
1.4.2 General Layout of the Receiving Building for HI-STAR Casks 38
1.4.3 Reception of the HI-STAR Transport Overpack in the Receiving Building 41
1.4.4 Preparation for MPC Transfer 47
1.4.5 MPC Transfer 49
1.4.6 Transfer of the HI-STORM at the Storage Area 49
1.4.7 Preparation of the HI-STAR Overpack for Reuse 55
1.5 CASK STORAGE AREA 55
1.5.1 Assignment and Main Design Principles 55
1.5.2 Description of the HI-STORM Overpack Storage Area 56
1.5.3 Handling with Damaged MPC 60
1.5.4 Handling with Damaged SFA 60
1.6 DESCRIPTION OF THE MAIN EQUIPMENT 62
1.6.1 MPC Multi-Purpose Canister 62
1.6.2 HI-TRAC Transfer Cask 69
1.6.3 HI-STAR Transport Overpack 74
1.6.4 HI-STORM Storage Overpack 79
1.6.5 Special Auxiliary Equipment 86
1.6.6 Maintenance of HI-STAR, HI-STORM and HI-TRAC Overpacks 87
1.7 ON-SITE TRANSFER 88
1.8 MAINTENANCE BUILDING WITH THE MPC STORAGE 90

2 MAIN DECISIONS ON MONITORING AND CONTROL SYSTEM 92

2.1 GENERAL STRUCTURE OF CONTROL AND MONITORING 92
2.1.1 Acceptance Monitoring System of Shipping Casks and SFA 93
2.1.2 Storage Process Monitoring System 94
2.1.3 System of Monitoring and Accounting of Fission Materials 94
2.1.4 Radiation Monitoring System 96
2.1.5 Monitoring and Control System of Special Sewages 96

2.1.6 Monitoring and Control System of Shower Water 96
2.1.7 Monitoring and Control System of Ventilation Installations 96
2.1.8 Compressed air Monitoring and Control System 96
2.1.9 Fire Safety Ensuring System 96
2.1.10 Monitoring and Control System of Rain Drains 96
2.1.11 SPS Monitoring and Control System 96
2.1.12 Water Supply Monitoring and Control System 97
2.2 RADIATION MONITORING SYSTEM 97
2.2.1 Design Decisions of the Radiation Monitoring System 97
2.2.2 Subsystem of Radiation Process Monitoring (RPM) 98
2.2.3 Subsystem of Radiation Dosimetric Monitoring (RDM) 98
2.2.4 Subsystem of Radiation Monitoring for Non-Spreading of Radioactive Contamination 98
2.2.5 Subsystem of Individual Dosimetric Monitoring (IDM) 99
2.2.6 Subsystem of Environment Radiation Monitoring (ERM) 99
2.2.7 Technical Means of the Radiation Monitoring System 99
2.2.8 Main Characteristics of Radiation Monitoring Technical Means 100
3 PHYSICAL PROTECTION ENGINEERED BARRIER 103
3.1 DETERMINATION OF PROTECTION OBJECTIVES 103
3.2 PRINCIPLES OF PROTECTIVE MEASURES 103
3.3 PHYSICAL PROTECTION ENGINEERED BARRIERS 103
3.3.1 Access Control System 103
3.3.2 Intrusion Detection System 103
3.3.3 TV Monitoring System 103
3.3.4 Communication, Warning and Alarm System 103
3.3.5 Power Supply System 103
3.3.6 Guard Lighting System 103
3.3.7 Restricted Access Area, Module Site and Access Control Point Engineered Barriers 103
3.3.8 Physical Protection Control Panel 103
4 BASIC ARCHITECTURAL AND CONSTRUCTIONAL DECISIONS 104
4.1 BASIC ARCHITECTURAL DECISIONS 104
4.1.1 Receiving Building 104
4.1.2 Maintenance Building with MPC Storehouse 104
4.1.3 Administrative Building 105
4.1.3.1 Civil Defense Rooms (Blockhouse) 105
4.1.4 Electrical Device Building 106
4.1.5 Garage for Crawler 106
4.1.6 Garage for Four Automobiles 106
4.1.7 Pump Station for Fire Water Supply 106
4.1.8 Guard Building 107
4.1.9 Access Control Point, ACP-1 107
4.1.10 Access Control Point, ACP-2 107
4.2 BASIC CONSTRUCTION DECISIONS 107
4.2.1 Design Criteria 107
4.2.2 External Input Data 108
4.2.3 Loads and Their Combinations 110
4.2.3.1 Normal Operation Loads 110
4.2.3.2 Extreme (Design) Loads 111
4.2.3.3 Construction Load Combinations 111
4.2.4 Receiving Building 113

4.2.4.1 Description of Structures 113
4.2.4.2 Corrosion Prevention Measures 115
4.2.4.3 Settlements and Lists 115
4.2.5 Cask Storage Site 116
4.2.5.1 Description of Structures 116
4.2.6 Maintenance Building with MPC Storehouse 117
4.2.7 Administrative Building 118
4.2.8 Electrical Device Building 118
4.2.9 Garage for Crawler 118
4.2.10 Garage for Four Autos 118
4.2.11 Rail Car Maintenance Building 119
4.2.12 Gasoline Station 119
4.2.13 Pump Station for Fire Water Supply 119
4.2.14 Tanks for Fire Water Supply 119
4.2.15 Residential Waste Water Collecting Pump House 120
4.2.16 Rain Waste Water Retaining Tanks 120
4.2.17 Guard Building 120
4.2.18 Access Control Point, ACP-1 121
4.2.19 Access Control Point, ACP-2 121

5 BASIC DECISIONS ON WATER SUPPLY, DRAIN SYSTEM AND FIRE EXTINGUISHING 122

5.1 WATER SUPPLY SYSTEMS 122
5.1.1 Drinking and Utility Water Supply 122
5.1.2 Fire Water Supply 124
5.1.3 Watering Pipeline 126
5.2 DRAIN SYSTEM 126
5.2.1 House Drain System 129
5.2.2 Rainwater Drain System 129
5.2.3 Drains Polluted by Petroleum Products 131

6 MAIN DECISIONS ON POWER SUPPLY 133

6.1 CHARACTERISTICS OF POWER CUSTOMERS 133
6.2 POWER SUPPLY OF ELECTRICAL CONSUMERS 135
6.2.1 Decisions with Regards to Electric Circuit Diagram 135
6.2.2 Decisions with Regards to Layout 136
6.3 LIGHTING 139
6.4 LIGHTNING PROTECTION AND EXTERNAL GROUND 140
6.5 OUTER POWER SUPPLY FOR CONSTRUCTION AND OPERATION PERIOD 140
6.6 COMMUNICATION NETWORKS 140

7 MAIN DECISIONS ON FIRE SAFETY ENSURING 142

7.1 FIRE SAFETY SYSTEM PURPOSE AND FUNCTIONS 142
7.2 FACILITY BRIEF CHARACTERISTIC 143
7.3 ARCHITECTURAL AND CONSTRUCTIONAL PART 143
7.3.1 Decisions on Fire Prevention Decisions on General Layout 143
7.3.2 Classification of Buildings, Fire Resistance Characteristics 144
7.4 ELECTRICAL PART 145
7.4.1 Fire Safety of Electrical Installations 145
7.4.2 Fire Protection System Power Supply 146
7.4.3 Evacuation Lightning 146
7.4.4 Characteristic of Lightning Protection for Buildings and Structures and External Ground of Electric Equipment and Buildings 146

7.5 VENTILATION SYSTEM 147
7.6 FIRE WATER SUPPLY 147
7.6.1 External Fire Water Pipeline 147
7.6.1.1 Characteristics of Water Sources and Fire Water Pipeline External Mains 147
7.6.1.2 Inside and Outside Fire Suppression Water Flow and Head Calculation 148
7.6.1.3 Fire Water Reserve Calculation 148
7.6.2 Internal Fire Water Pipeline 149
7.7 FIRE DETECTION AUTOMATICS 149
7.7.1 Automatic Fire Alarm 149
7.7.2 Automatic Fire Extinguishing Facilities 151
7.7.2.1 Automatic Water-Type Fire Extinguishing Facilities of the Receiving Building Cable Vaults 151
7.7.2.2 Automatic Powder Fire Extinguishing Facility of the Diesel Station ... 151
7.7.3 Smoke Protection Systems 152
7.7.4 Fire Alarm System 152
7.8 TECHNICAL AND ORGANIZATIONAL MEASURES 152

8 MAIN DECISIONS ON HEATING, VENTILATION AND CONDITIONING ... 154

8.1 GENERAL PROVISIONS 154
8.2 INPUT DATA 154
8.3 BASIC PROVISIONS OF VENTILATION AND CONDITIONING 156
8.3.1 Receiving Building 156
8.3.1.1 Principle Decisions on Ventilation, Heating and Conditioning System 156
8.3.1.2 Description of Ventilation System Operation 157
8.3.1.3 Heating, Heat Supply and Hot Water Supply 160
8.3.2 Maintenance Building with MPC Storage 166
8.3.3 Building of Electrotechnical Devices 166
8.3.4 Administrative Building 166
8.3.5 Garage for Crawler 166
8.3.6 Garage for Four Automobiles 167
8.3.7 Pump Station of Fire Water Supply 167
8.3.8 Sewage Pump Station 167
8.3.9 Guard Building 167
8.3.10 Access Control-Point 1 and Access Control Point-2 167
8.4 MAIN INDICATORS ON VENTILATION AND HEATING 167

9 RADIOACTIVE WASTE MANAGEMENT 169

9.1 LIQUID RADIOACTIVE WASTE (LRW) MANAGEMENT 169
9.1.1 Assignment and Design Basis 169
9.1.2 LRW Generation Sources 169
9.1.3 LRW Management in Operation 172
9.2 SOLID RADIOACTIVE WASTE (SRW) MANAGEMENT 172
9.2.1 Assignment and Design Basis 172
9.2.2 Sources of SRW Generation 172
9.2.3 SRW Management 173
9.3 RAW MANAGEMENT IN PASSIVE PERIOD ..... **ОШИБКА! ЗАКЛАДКА НЕ ОПРЕДЕЛЕНА.**~~174~~
9.4 RAW MANAGEMENT IN PASSIVE OPERATION PERIOD 174

10 ARRANGEMENT OF OPERATION 175

10.1 OPERATION STAGES 175

10.2 OPERATION READINESS 175
10.2.1 Transfer in Power Unit Reactor Compartment 175
10.2.2 Transfer of Loaded Canister from NPP to CSFSF Site 175
10.3 STAFF 178
11 LABOR PROTECTION 183
11.1 INDUSTRIAL SAFETY 183
11.2 INDUSTRIAL SANITATION 185
12 DECOMMISSIONING 187
12.1 DECOMMISSIONING GENERAL WORK PLAN 187
12.2 MAIN PRINCIPLES 187
12.3 DECOMMISSIONING STRATEGY 187
12.4 SAFETY ENSURING MEASURES IN DECOMMISSIONING 188
12.5 RAW MANAGEMENT IN DECOMMISSIONING 189
LIST OF REFERENCE REGULATIONS AND LITERATURE. 190
APPENDIX A 192
APPENDIX B 193

Introduction

A goal of this document is to present the main decisions on the SNF dry-type storage facility technology during 100 years for Ukrainian WWER SFA NPPs.

The main technical decisions have been selected and reviewed as follows:

- decisions on the SFA management technology beginning with spent fuel loading in overpacks at NPP up to arrival at the CSFSF and installation for a long-term storage;
- decisions on arrangement of CSFSF monitoring and control, including nuclear material radiation monitoring and accounting;
- decisions on power supply arrangement for CSFSF users;
- decisions on water supply and sewage system arrangement;
- decisions on arrangement of heating and ventilation for buildings and structures;
- decisions on arrangement of liquid radioactive and solid waste management;
- decisions on arrangement of CSFSF physical protection;
- design criteria and main decisions on architectural issues;
- main decisions on fire and general industrial safety ensuring;
- main decision on arrangement of CSFSF operation, including personnel and operational readiness;
- main provisions on the CSFSF decommissioning.

The development level of the technical decisions submitted in the current part of FSI corresponds to the FS design stage. In this case, the Holtec International technology was accepted, which was determined by the tender results, and the input data received from the technology developer were used. This technology includes the following stages:

- transfer operations on spent nuclear fuel loading in the overpack at the NPP power unit;
- SNF shipment at the CSFSF by means of transport overpacks using a special rail car;
- transfer operations with the spent nuclear fuel overpack within the CSFSF;
- SFA storage in accordance with the Holtec International dry-type storage technology.

The technical decisions may be clarified at the subsequent design stages (firstly, at the stage “Design”).

General Part

A design of spent nuclear fuel storage facility for Ukrainian WWER NPPs (CSFSF) is intended to house and store WWER spent nuclear fuel for a long-term period (not less than 100 years):

12500 SFA of WWER-1000;

4000 SFA of WWER-440.

CSFSF capacity provides for housing and storing of WWER SNF generated at Rivne NPP-1-4, Khmelnitsky NPP-1-2 and South-Ukrainian NPP-1-3 (that is the CP design load, fuel loaded in reactors and that will be generated during operation of power units) using step-by-step increasing of storage volume.

In carrying out the FSI, the Holtec International (the winner of the CSFSF "turnkey" construction tender) technology is being considered.

The system developed by the Holtec International consists of the following main components:

universal multi-purpose canister (MPC);

metal concrete storage overpack (HI-STORM);

transport overpack (HI-STAR);

steel transfer cask (HI-TRAC).

In 1999 Holtec International received the Certificate for the HI-STAR transport overpack with use of a set of MPC modifications from the USA Nuclear Regulatory Commission (NRC). In 2000 the Holtec International obtained the license for a unified storage complex from the USA Nuclear Regulatory Commission (NRC). Now, Holtec overpacks are applied in the USA, Great Britain, South Korea, Taiwan and Brazil.

The SFA technology within this FS covers:

- MPC loading at NPPs power units using the HI-TRAC transfer cask;
- drying, filling with inert gas (helium) and welding of MPC two containment barriers at NPPs power units;
- control of containment and quality of MPC lids welding at NPPs power units;
- reloading of the prepared MPC in the HI-STAR transport overpack by means of the HI-TRAC transfer cask;
- transportation of a rail car train with HI-STAR overpacks loaded with MPC at the CSFSF;
- receipt of a rail car train at the CSFSF on holding and maneuvering tracks;
- MPC reloading from the HI-STAR transport overpack in the HI-STORM storage overpack in the receipt building;
- transportation of HI-STORM overpack with MPC to the storage site by means of the on-site crawler;
- long-term storage of HI-STORM overpacks with SFA.

SNF operations, carried out at NPPs, are similar to the operations carrying out now at NPPs during SNF shipment for treatment and/or storage in Russia.

The spent nuclear fuel (SNF) storage system is completely passive and performs the following three functions:

safe confinement of radioactive fission materials using two static barriers of MPC preventing radionuclide leakage from SFA in the environment;

MPC safe long-term storage in the shielded structure (HI-STORM storage overpack) that prevents direct impact of ionizing radiation, generated by SFA, on personnel and the environment;

SFA protection against extreme nature and man-made impacts during their storage in the HI-STORM.

The main purposes of CSFSF are:

receive MPC with SFA of WWER-440 or WWER-1000 received in the HI-STAR transport overpack;
house MPC in the HI-STORM;
transport the HI-STORM to their storage site;
store MPC with SFA in the HI-STORM for a long-term period;
collect and transport liquid and solid radioactive waste for treatment/disposal;
protect SFA against external extreme nature and man-made impacts;
protect personnel and the environment against ionizing radiation impact;
ensure physical protection and accounting of nuclear materials.

Total number of HI-STORM overpacks, required to ensure the SFSF design capacity, constitutes 458 pcs. Such a number of overpacks will ensure storage of 12500 WWER-1000 SFA and 4000 WWER-440 SFA, taking into account that 5% will be leaky involving a consequent decrease of SFA number in the WWER-1000 MPC up to 24 pcs and 3 % of WWER-440 SFA will be leaky involving a consequent decrease of SFA number in the WWER-440 MPC up to 78 pcs.

Within the CSFSF, a start-up complex was provided for that includes all structures at the SFSF site and overpacks to store not less than 2500 WWER-1000 SFA and 1080 WWER-440 SFA.

The following buildings and structures were determined during composition of a general layout:

- MPC receiving and reloading building, including “dirty” workshops, a changing room and a CSFSF central control room;
- HI-STORM overpacks storage site;
- maintenance building with MPC storehouse, including roofing for concreting HI-STORM shells;
- garage for holding and maintenance of a crawler;
- garage for four autos, including workshops for minor repair and a decontamination unit;
- covered roofing area for maintenance and repair of one rail car and an open area for holding one rail escort car;
- building for electrical devices;
- gasoline station including two patrol pumps with two underground capacities for two types of fuel;
- administrative building, including offices, an assembly hall, a dining-room, a civil defense building;
- access control point (ACP) at the motor entry;
- access control point (ACP) at the railway entry;
- holding tracks for a rail car train composed of five rail cars, one rail car for HI-TRAC transfer cask, one platform for welding and auxiliary equipment, one support rail car and two escort rail cars;
- drainage water pump;
- fire water supply pump;
- fire extinguishing water supply capacities;
- rainwater storage capacities;
- guard building.

Overall size of the enclosed industrial site constitutes 644x182 m. Two road trains from the south and the north and one railway entry are designed for the site.

MPC with SFA are transported from NPP to the CSFSF by a special railway train in the HI-STAR transport overpacks designed in accordance with the USA safety requirements. These overpacks will be certified in Ukraine as a overpack of type B (U) in accordance with the PBTRM -2006[2] requirements.

The HI-STAR overpack with MPC loaded with SFA is received from a railway track and MPC is transferred in the HI-STORM in the receipt building located in the south of the site and according to the technology requirements is equipped with a railway entry and a caterpillar entry.

The receiving building is designed for transfer of MPC with SFA from the HI-STAR transport overpacks into the HI-STORM long-term storage overpack. MPC with SFA are reloaded in the reception box by the HI-TRAC transfer cask.

The placement of the receiving building on the site ensures the shortest rout for the loaded crawler to get to the cask storage area. . The garage for crawler holding and repair is interlocked with a garage for four autos and is placed taking into account a crawler traffic diagram in the immediate vicinity of the western receiving building elevation.

A storage area for SNF overpacks is a passive storage system for the HI-STORM overpacks having two MPC confining barriers and the HI-STORM overpack bio-protection barrier. In this connection, other auxiliary on-site systems are not required to ensure nuclear and radiation safety during SFA storage.

Empty HI-STORM overpacks and MPC are delivered to the CSFSF by the railway transport. For this purpose, it is provided for that holding tracks of the maintenance building with the MPC storage be adjoined to the railway dead-end line in the south of the site. Here, there is roofing for concreting the HI-STORM overpacks and the cask storage area ready to be loaded.

Empty HI-STORM overpacks are delivered to the receiving building for loading by an on-site crawler.

A water-supply building and rainwater storage capacities are assembled in one site and are located in the southwest of the site.

A guard building is located the southward of the area for water-supply buildings near the main entrance to the site. Here, the design provides for a building of electrical devices and an administrative building. The design provides for blocking of an administrative building with a deepened auxiliary building, arranging of two exits at the surface from different sides of the building.

Along the whole site perimeter, there are double barriers provided for by devices included in the site physical protection system. This system includes also a guard building and two access control points for transport and personnel.

In the technical decisions, a storage site inside the CSFSF protected perimeter has been determined as a particularly significant area – where an access is prohibited for the personnel with no permission.

Transport accesses and hard surface areas are designed for in accordance with the process and SNiP II-89-80 [13], Section 3 requirements for assuring of access roads for fire transport to get to buildings and structures.

In determining components for a start-up complex construction, the decision has been taken as a basis to perform in full scope the physical protection system and engineered barriers of this facility, because holding and maneuver tracks of the special train are located within the industrial site barriers and the physical protection system has to function in the full scope when this special train arrives.

Therefore, the CSFSF start-up complex includes all the abovementioned buildings and structures and holding and maneuvering tracks entirely.

Prospective expansion of the site is possible in the north, approximately by 350 m and in the west by 300 m provided that HVL 110 kV (high-voltage line) is transferred.

In order to arrange construction work, the design provides for a construction area. It is located in the southeast of the CSFSF industrial side. At the construction area, in addition to the temporary structures and sites operating within the construction stage only, the design provides for construction of a concrete-mixing plant designed to provide with concrete of the required quality during the CSFSF construction and to concrete the HI-STORM shells during CSFSF operation.

Abbreviations

AB	-	Administrative Building
GS	-	Gasoline station
ARMS	-	Automated Radiation Monitoring System
NPP	-	Nuclear Power Plant
WWER	-	Water-Moderated Water-Cooled Reactor
HVL	-	High-Voltage (Transmission) Line
HVDS-750	-	High-Voltage Distribution Substation;
SNRCU	-	State Nuclear Regulatory Committee of Ukraine
SFA	-	State Forestry Administration
CD	-	Civil Defense
SSE ChNPP	-	State Specialized Enterprise "Chernobyl NPP"
PR	-	Permissible Release
DGS	-	Diesel-Generator Station
PE	-	Permissible Effluent
RCPP	-	Reinforced Concrete Plant Production
LRTF	-	Liquid Radioactive Waste Treatment Facility
SRTF	-	Solid Radioactive Waster Treatment Facility
RAA		Restricted Access Area
SFSA	-	Spent Fuel Storage Area
LRW	-	Liquid Radioactive Waste
EB	-	Engineered Barrier
PTC KIEP	-	Publicity Traded Company Kyiv Research and Development Institute "Energoproject"
SPS		Sewage Pump Station
ACP	-	Access Control Point
MIA	-	Ministry of Internal Affairs of Ukraine
MDBA	-	Maximum Design Basis Accident
SSE	-	Safe Shutdown Earthquake
MPC	-	Multi-Purpose Overpack
ME	-	Ministry of Emergencies of Ukraine
HI-STAR	-	Transport overpack
HI-STORM	-	Storage Overpack
HI-TRAC	-	Transfer Cask
RD	-	Regulatory Documentation
VNO		Violation of Normal Operation
NRBU	-	Radiation Safety Standards of Ukraine NRBU-97 (2000)
RTD	-	Regulatory and Technical Documentation
NO		Normal Operation
OS	-	Outdoor Switchgear
SFA	-	Spent Fuel Assembly
OS	-	"Shelter" Object
SNF	-	Spent Nuclear Fuel
DL	-	Dose Limit
OBE	-	Operating Basis Earthquake
RWDF	-	Radioactive Waste Disposal Facility
ICSRM	-	Industrial Complex for Solid Radwaste Management
RAW	-	Radioactive Waste
RM		Radioactive Materials
RR	-	Radiation Release

SSS		Special Sewage System
RMS		Radiation Monitoring System
FE	-	Fuel Element
SRW	-	Solid Radioactive Waste
FS	-	Feasibility Study
KhNPP	-	Khmelnitsky Nuclear Power Plant
CSFSF	-	Centralized Spent Fuel Storage Facility
CDF	-	Central Disposal Facility

1 Process Part

1.1 Assignment and Design Basis

In accordance with the Law of Ukraine on nuclear energy use and radiation safety [3], CSFSF is a nuclear facility.

CSFSF should be designed, constructed and operated in accordance with the Ukrainian Laws and other legislative acts that regulate relations in nuclear energy use and radioactive waste management.

The main requirements provided for by the appropriate standards and rules on nuclear and radiation safety in force in Ukraine have to be applied to any activity at the CSFSF (design, construction, operation, etc.).

The requirements of the following documents were taken into account in development of the CSFSF FS:

- International agreements ratified in Ukraine;
- Laws of Ukraine;
- Decrees of the President and Ordinances of the Verkhovna Rada and the Cabinet of the Ministers of Ukraine;
- Regulatory documents of Ukraine on nuclear and radiation safety;
- Health and Sanitary standards in force within the ChNPP exclusion area.

The CSFSF is a facility for WWER spent nuclear fuel safe storage.

The nuclear fuel management system (reloading, transportation and storage) is a safety-related system and refers to the safety class II in accordance with [4] and to the seismic resistance category I in accordance with [8].

SNF management means a set of activities for SNF loading at NPP, transportation at the CSFSF site, receipt of transport overpacks to the CSFSF and reloading of MPC in storage overpacks, SNF transportation and storage on the CSFSF site, MPC reloading from storage overpacks in transport overpacks in the CSFSF and shipment to NPPs. It also includes operations on ensuring a possibility to unseal and repack MPC at NPP, manufacturing storage overpacks and MPC in Ukraine, as well as all the auxiliary functions (control, monitoring, testing, safety ensuring etc.) related to fulfillment of the above operations.

The HI-STORM is an independent system that ensures confinement of SNF and radioactive materials, radiation shielding, keeps subcriticality of fuel and passive heat rejection capability independently of other systems, structures or components. The required scope for HI-STORM research and maintenance is minimal, because the system is completely passive. The main component of the proposed system is the vertical ventilated HI-STORM whose special design provides SNF physical protection and radiation protection of personnel, public and the environment in the immediate vicinity of the storage system.

Design technical decisions considering the SNF dry storage specificity in the CSFSF were proposed to ensure nuclear safety in SNF loading. The main component of the Holtec storage technology is a multi-purpose cask (MPC) whose design ensures nuclear safety in SNF storage.

In accordance with the requirements of regulatory documents [2, 21], the CSFSF nuclear safety is provided by:

- limitation of SA arrangement interval in the MPC;
- limitation of mass of nuclear fission materials in one MPC;
- use of heterogeneous absorbers by Metamic arrangement and fixation in MPC;
- MPC design features;
- monitoring of process parameters of a set of nuclear fuel storage and management systems.

The following operating areas have been determined during composition of a general layout:

- MPC receiving and reloading building;
- a cask storage area;
- a maintenance building with MPC storage;
- a building and a structure for the crawler and motor transport storage and maintenance;
- a building for electrical devices;
- water supply and sewage structures;
- buildings and structures for technical protection means;
- an administrative building;
- railway holding and maneuvering tracks.

Overall size of the enclosed industrial site constitutes 644x182 m. Two road trains from the south and the north and one railway entry in the north are designed for the site.

The rail car train with HI-STAR transport overpacks is received from NPP and shunting operations on separation of each rail car are carried out on holding and maneuvering tracks on the CSFSF site.

The rail car with HI-STAR is discharged, MPC is reloaded from the HI-STAR in the HI-STORM in the receipt building that is located in the south of the site and has a railway entry and a crawler entry.

The placement of the receiving building on the site ensures the shortest rout for the crawler with HI-STORM loaded with SNF to get to the cask storage area and excludes crossing of personnel and crawler movements.

The garage for crawler holding and repair is interlocked with a garage for four autos and is placed taking into account a crawler traffic diagram in the immediate vicinity of the western receiving building elevation.

The main part of the CSFSF industrial site occupies the cask storage area. This is a rectangular site extended from the north to the south. Along the site the eastern part there are railway holding and maneuvering tracks.

It is supposed that effective reserve of HI-STORM overpacks and MPC be stored and HI-STORM shells be concreted in the maintenance building with MPC storage located in the south of the CSFSF industrial site. Empty HI-STORM overpacks and MPC are delivered to the CSFSF by the railway transport. For this purpose, it is provided for that holding tracks of the maintenance building with the MPC storage be adjoined to the railway dead-end line in the south of the site.

Technical decisions ensuring solution of these tasks are described below. These safety-ensuring measures are considered independently for each of the main components of the CSFSF.

In describing technical decisions and nuclear safety assessments, the data are identified for MPC-32 designed for SNF of pressurized water reactors in the USA. It is justified to apply the data on the USA fuel at this stage because of the following reasons:

- fuel element active part length of pressurized water reactors fuel in the USA constitutes 365,76 cm, that is similar to the length of WWER-1000 fuel elements – 355 cm;
- mass of uranium in MPC-32 is 15855 kg, and mass of uranium in MPC-31 containing 31 SFA is 13485 kg;
- burnup degree of fuel loaded in MPC-32 accepted in licensing of MPC in the USA – 55,000 MW/tU, average WWER-1000 SFA burnup constitutes – 45,000-50,000 MW/tU;
- initial enrichment degree considered in MPC-32 licensing in the USA is – 4,2 – 4,8 % ^{235}U, WWER-1000 NF initial enrichment degree is – 4,2 – 4,4 % ^{235}U

It is proposed to use the Holtec International HI-STAR transport overpack for transportation of WWER fuel from the Ukrainian nuclear power plants to the CSFSF, and HI-STORM storage system – for storage.

In accordance with this approach, spent nuclear fuel is loaded in the multi-purpose canister (MPC-31 for WWER-1000 fuel and MPC-85 for WWER-440 fuel at NPP power unit in the fuel-cooling pool reloading well. The HI-TRAC transfer cask is applied for loading and transfer of MPC. Operations on MPC loading with fuel at NPP power unit are very similar to

those performing for TK-6 and TK-13 canisters with one difference only consisting in the fact that the HI-STAR transport overpack is not located in the SNF cooling pool and does not undergo contaminations.

MPC are welded and prepared to final disposal at the NPP power unit. Then, the HI-STAR with MPCs is transferred to CSFSF where MPC are reloaded in the HI-STORM.

On arrival at CSFSF, HI-STAR transport overpacks are discharged from the rail car train and MPC located inside them are reloaded in the HI-STORM overpacks without repackaging of fuel assemblies.

This method has five main advantages:

1) The HI-STAR transport overpack does not undergo radioactive contamination, because it is not installed in the spent fuel cooling pool. Spread of contamination in the CSFSF is practically absent.

2) The transport overpack is very solid and tight owning to four independent barriers preventing leakages in it (two all-welded barriers in MPC and two in the HI-STAR). NPP spent fuel will arrive at the centralized spent fuel storage facility as the "SNF packaging" ready for storage.

3) MPC handling in the CSFSF is very simple; handling operations directly with SFA at the CSFSF are not required.

4) Number of railway transportations is minimal due to large capacity of the HI-STAR (one MPC with 31 WWER SFA or 85 WWER-440 SFA). Yearly, it will be required to transport 20 HI-STAR overpacks only, in order to transfer the necessary number of SFA as compared to 50 TK canisters applied in Ukraine.

5) Due to MPC large capacity, 60% less HI-STARs (as compared to TK canisters) will be required to remove SFA from the NPP unit in its shutdown. This means that it will be required 33% less of time. The fact that a number of canisters will be loaded allows reducing radiation exposure dose for the plant personnel as well.

Access to the CSFSF complex is monitored in the same way as at the operating nuclear power plant. Access to the controlled area (CA), which includes all the CSFSF components, is limited by two access control points, two motor transport entries and one railway entry.

The storage system is completely passive, where the natural convection is applied for cooling. The storage system does not lead to radioactive contamination and radioactive waste generation in CSFSF both in normal operation and in design basis accidents, as well as facilitates decommissioning of the Facility on completion of the storage period.

- According to the technical specification, the CSFSF design annual output should provide for a possibility to receive and install MPC for storage within the HI-STORM not less than 504 WWER-1000 SFA and 192 WWER-440 SFA per year.

The minimum design output is 544 WWER-1000 SFA per year (17 MPC) and 255 WWER-440 SFA per year (three MPC). In total 20 MPC are loaded in the HI-STAR overpacks.

Under complete fill-up, the CSFSF will include 548 HI-STORM storage systems required to store all WWER spent fuel of the Ukrainian nuclear power plants: 12500 assemblies of WWER-1000 and 4000 assemblies of WWER-440.

A general layout of the CSFSF complex, presented in Appendix A, is demonstrated in the storage facility design.

- Holtec International supplies the following:
- Equipment for a storage and transportation system, pcs.:
- - HI-STAR transport overpack …….…….5;
- - HI-STORM storage overpack…...……...94;
- - MPC-31 multi-purpose canister. ……81;
- - MPC-85 multi-purpose canister ..……13;
- - HI-TRAC transfer cask…….……1;
- Auxiliary equipment:
- - equipment applied in MPC loading at NPPs;

- - railway car combined with the HI-STAR, pcs……...…….....5;
- - platform for the HI-TRAC transportation, pcs…….1;
- - device for MPC unsealing, set……..……1.

Practically all the equipment (possibly, except for the canister cross-arm) will be included in the CSFSF and will be transported from the unit to the unit.

It is supposed that a train will be composed of not more than five loaded HI-STAR overpacks installed on the railway platforms, a flat-car with the auxiliary equipment, a car with the HI-TRAC transfer canister, two cover (guard) cars and one provision car. Transportations will be carried out in accordance with the Ukrainian requirements on transportation of dangerous loads.

1.2 Handling Operations at NPP Sites

SFA are loaded in MPC at NPPs power units similar to the existing scheme for SNF reloading, MPC with SFA are installed in the HI-STAR transport overpack using the HI-TRAC transfer cask.

A Holtec International dual-purpose HI-STAR intended for SNF storage and transfer will be applied for shipment. In using the HI-STAR, fuel is loaded in MPC housed in HI-TRAC transfer casks, in the NPP power unit cooling pool. A welded sealed MPC with SNF is arranged at a power unit of every nuclear plant in the inert gas atmosphere.

Prior to handling operations at NPP, the empty MPC transferred from the CSFSF and its lid are inspected, MPC is installed in a vertical position and lid adjustment is checked as well.

1.2.1 Preparation for Loading

A preparatory process for a container loading begins when an empty HI-TRAC transfer cask is installed under a bridged crane by means of a cross-arm. The HI-TRAC transfer cask is craned in the reactor hall by using the existing circular electric crane and a cross-arm.

The empty MPC is cleaning, checking and preparing to be housed in the HI-TRAC transfer cask. Sling devices on the inner surface of the MPC ensure attachment of load handling devices and a place to fit a MPC lid. MPC is lifted by using a circle electric crane and installed inside the HI-TRAC transfer cask. MPC is lowed and turned to select a right position in installing and, then, it is installed in the HI-TRAC transfer cask. At that, any washers or other gaskets are not applied. Marks are made on sides of the HI-TRAC and MPC to check installation accuracy. Sling devices are detached from the MPC.

A circular gap (between the HI-TRAC inner shell and outer sides of the MPC) is filled with chemically demineralized water. An inflatable sealed plug pumped up with air is installed between the MPC and the HI-TRAC in the upper part of the gap. An inflatable gasket shuts the small circular gap by itself, owning to this, the clean water is not mixed with the “dirty” water from the fuel cooling pool.

The HI-TRAC transfer cask cross-arm is used again; the HI-TRAC is lifted and is adjusted to be installed in a fuel feeding well – a CP well (Figure 1.2.1). After the HI-TRAC with the MPC is lowed and installed in the spent fuel pool feeding well, the cross-arm is detached from the HI-TRAC transfer cask by using a remotely controlled pneumatic system.

1.2.2 Fuel Loading in MPC

SFA are loaded in MPC at power units by using a fuel-handing machine similar to the existing scheme for SNF transportation.

SFA, cooled in the fuel cooling pool not less than 5 years, are loaded in the MPC, MPC is dehydrated and dried, sealed and filled up with helium in the reactor compartment central hall.

MPC provides for two confinement barriers against spread of radioactive materials from SFA into the environment.

In order to ensure nuclear safety in SNF reloading, the design decisions have been proposed, taking into account a specificity of the SNF storage technology in the CSFSF.

Previously selected SFA are loaded in the MPC housed in the HI-TRAC by using the gripping devices (Figure 1.2.2) existing at the NPP. At that, SFA are identified visually.

A standard crane equipment of the reactor hall and a tool set for a lifting device supplied within this Contract are used for SNF loading in the MPC at NPPs. The equipment described below will be used additionally for MPC drying, filling with helium, welding and confinement testing.

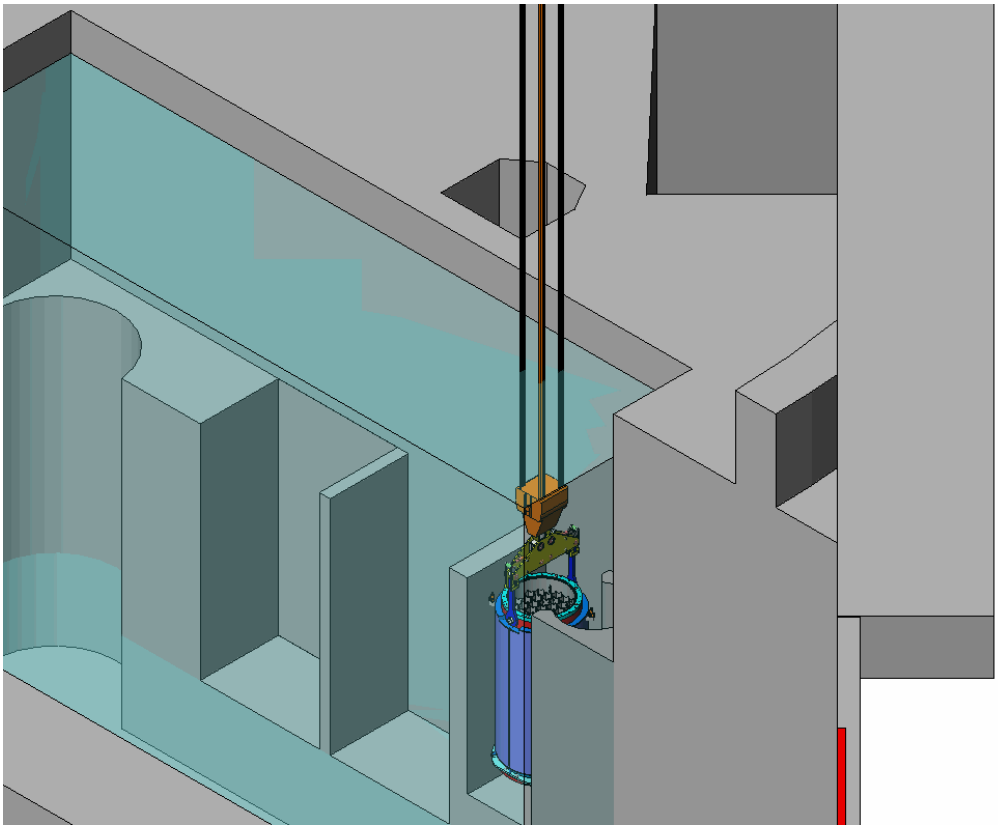


Figure 1.2.1 – **Installation of a transfer cask with the MPC in the cooling pool well**

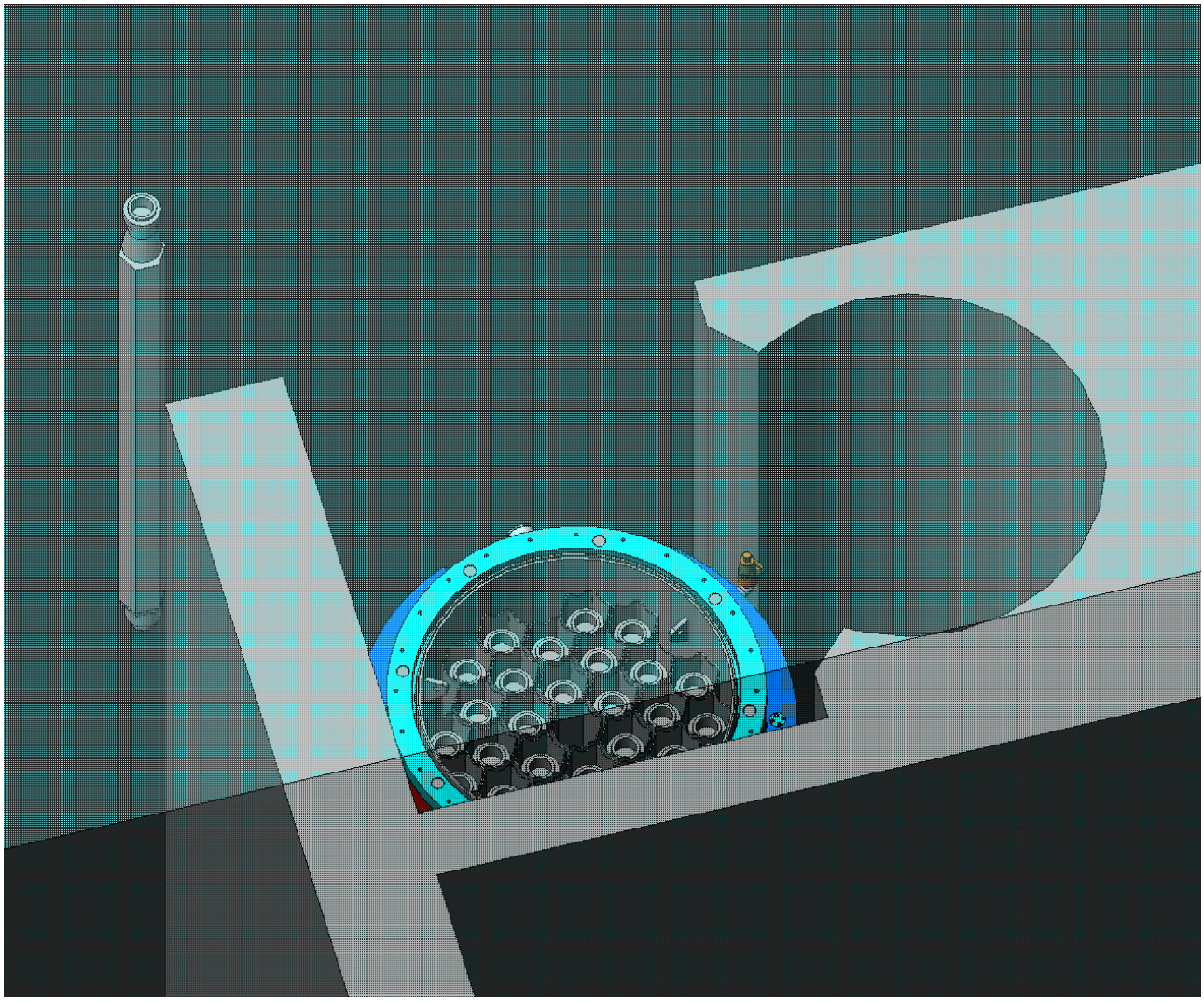


Figure 1.2.2 – **Loading of spent fuel assemblies in the MPC**

1.2.3 Removal of HI-TRAC with MPC from the Cooling Pond

After all the required SFA are loaded in the MPC, the following operations on removal of the HI-TRAC with MPC from the cooling pool are carried out.

The MPC lid is lifted up and installed over the area where the canister is loaded. A drain pipe is installed manually in an aperture in the lower part of the lid. Water level in the fuel cooling pool is reduced.

The MPC lid descends fluently and becomes level under the canister. The drainpipe becomes level as well under its receiver equipped with large guides. The MPC lid, equipped with guides, is loaded in the spent nuclear fuel cooling pool feeding well and is installed on the MPC (Figure 1.2.3).

After the lid is installed on the MPC, the remotely controlled cross-arm is caught on the HI-TRAC lifting trunnions. The HI-TRAC is lifted to the surface level of the spent nuclear fuel cooling pool feeding well (Figure 1.2.4~~Figure 1.2.4~~).

Radiation measurements are carried to make sure that hot particles have not been taken from the cooling pool. When radiation dose rate measurements confirm that the HI-TRAC removal is safe, the HI-TRAC is removed from the spent nuclear fuel cooling pool feeding well. The HI-TRAC transfer cask is washed with chemically demineralized water and is decontaminated.

Prior to removal from the SNF cooling pool feeding well, a certain quantity of water is pumped out from the MPC in order that less quantity of water from the cooling pool spills on the working site and to ensure preparation for lid welding. A quantity of water pumped out from the MPC is controlled accurately by using exhaust pumps. Additional measurements of water volumes are not required. Water is pumped out from the MPC back in the cooling pool well.

After removal of a certain quantity of water, the pump system is cut off and the HI-TRAC is taken out from the cooling pool. The HI-TRAC is completely removed from the cooling pool well and is moved at the cask decontamination area. The cross-arms are cut off and moved off. A working platform is installed around the HI-TRAC to ensure access to the HI-TRAC transfer cask and the MPC lid. Slings are detached from the MPC and the cross-arm.

The upper part of the MPC lid and the HI-TRAC upper skirting are decontaminated. The inflatable plug is removed and a biological shield is installed instead of it. The shielding along the circuit ensures additional protection of the personnel in the upper side of the canister and protects its inner side against ingress of small parts inside. The MED compliance with the calculated values is checked on the MPC lid.

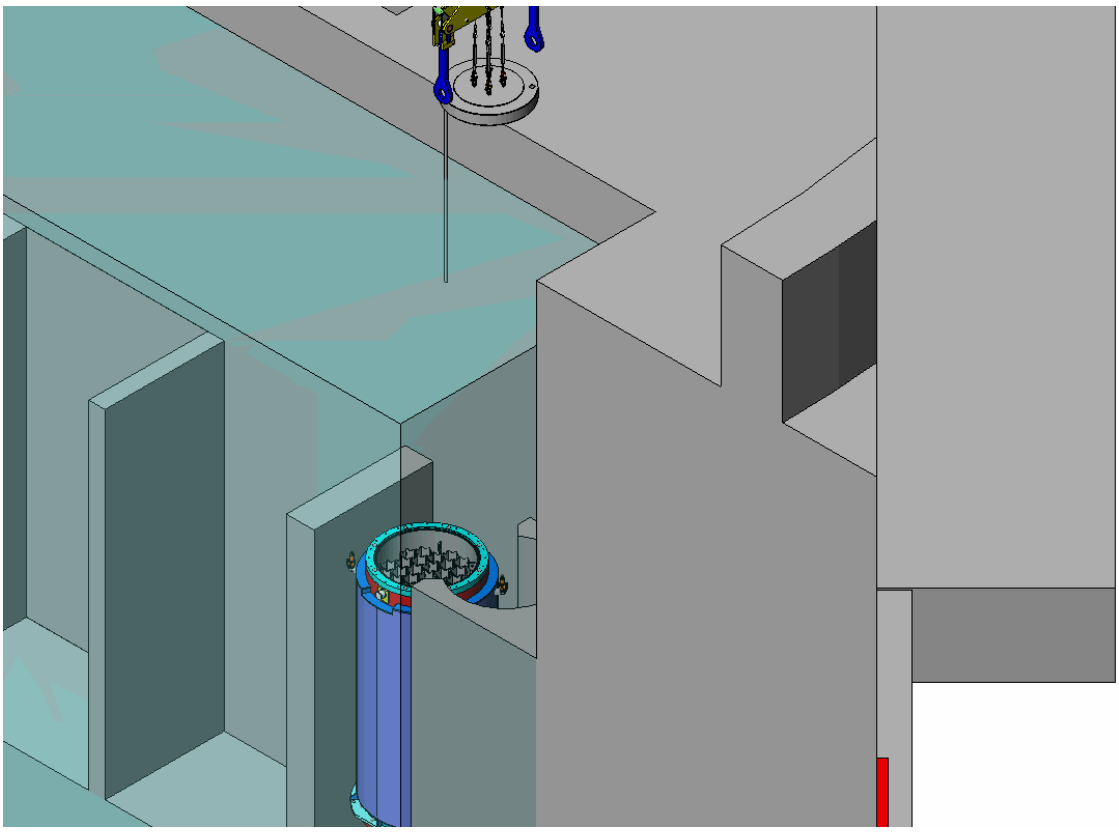


Figure 1.2.3 – **Installation of the MPC lid**

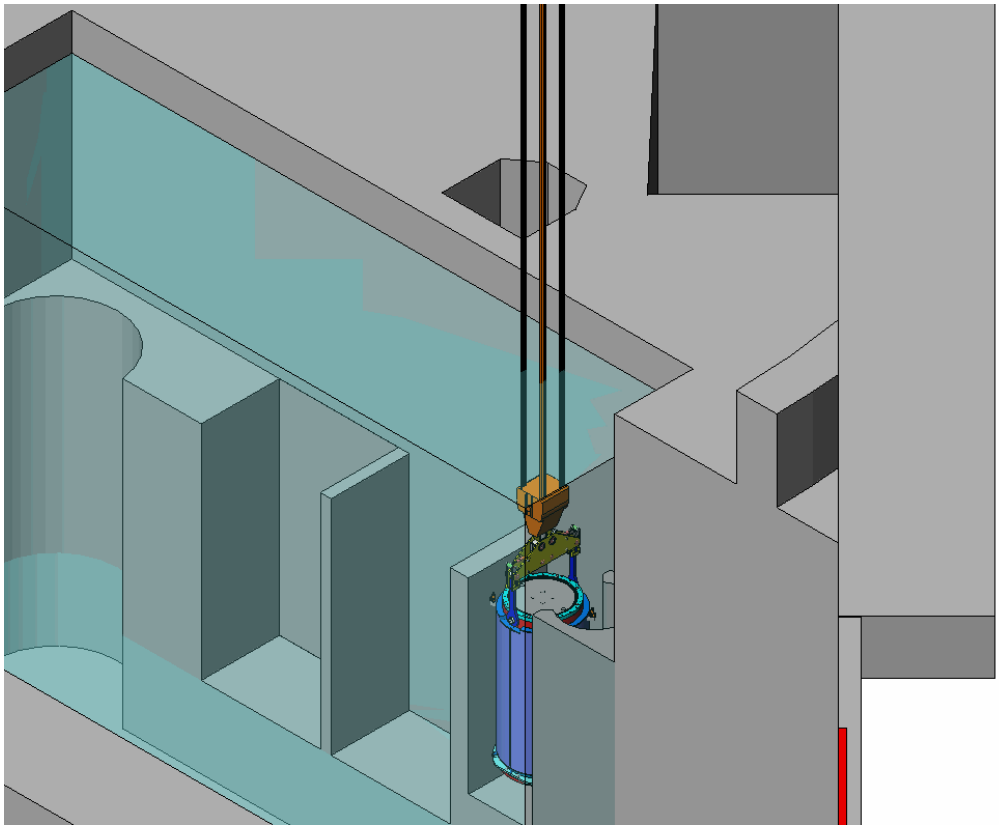


Figure 1.2.4 – Removal of the HI-TRAC transfer cask from the transfer well

1.2.4 MPC Confinement

The MPC lid is welded to the shell by using the automatic welded device (Figure 1.2.5). The automatic welded device is installed on the MPC lid and is leveled along bolt holes on the MPC lid.

Fixation welded joints are inspected visually and root, intermediate and final runs of the main joint are examined by a defect detection method.

Water level in the MPC is raised up to the upper again to check confinement of welded joints by hydrostatic pressure. Hydrostatic tests consist in pressure injection in the MPC by means of a hydrostatic test pump and keeping of such a pressure during 10 minutes. Absence of leakages from the MPC is the acceptance criterion.

Water inside the canister is removed though the drain system by pumping of helium under pressure through the vent port (Figure 1.2.6).

The drying/back-filling system is applied to remove residual liquid from the MPC. Due to this system, pressure in the canister is pumped-up to the appropriate level that leads to filling of the canister with helium. Filling with helium ensures the required heat transfer during storage, ensures the inert medium for long-term fuel integrity and provides with a possibility to check leakages in future through the MPC welded joints (if required). After this the drying/back filling system is detached from the MPC.

Protective plates are installed and welded on MPC apertures. After this, welded joints are checked by means of a defect detection method. Upper protective plates have the bodied bolts with ports for helium injection during leakage testing.

On completion of welding of the upper plate with a girth joint, helium is injected in the cavity through one of the rings in the bodied bolts. At that, air is forced out through other aperture. The sealed bolts are designed for keeping of helium medium inside. Then, apertures in the bodied bolts are sealed by a small welded joint and, next, a helium detector is installed on the plates to check a confinement criterion.

An enclosure ring is installed on the MPC, at that the welding device should not be taken away. The ring is leveled, gripped and, then – is welded completely assuring the next confinement barrier in addition to the canister itself. The tack welds are checked visually and the rood weld is checked by a defect detection device.

In the MPC enclosure ring there is a small aperture to test welded joints with which the canister lid is welded, as well as plates of vent and drain ports. The helium detector is installed over this aperture. After tests this aperture is welded and this weld and a final weld of the enclosure ring are checked.

In conclusion, smears are taken from the MPC lid and available sides of the upper shell in order to determine the removed contamination and the HI-TRAC dose rate is measured. The welding device is removed, as well as the biological protection from the gap between the MPC and the canister.

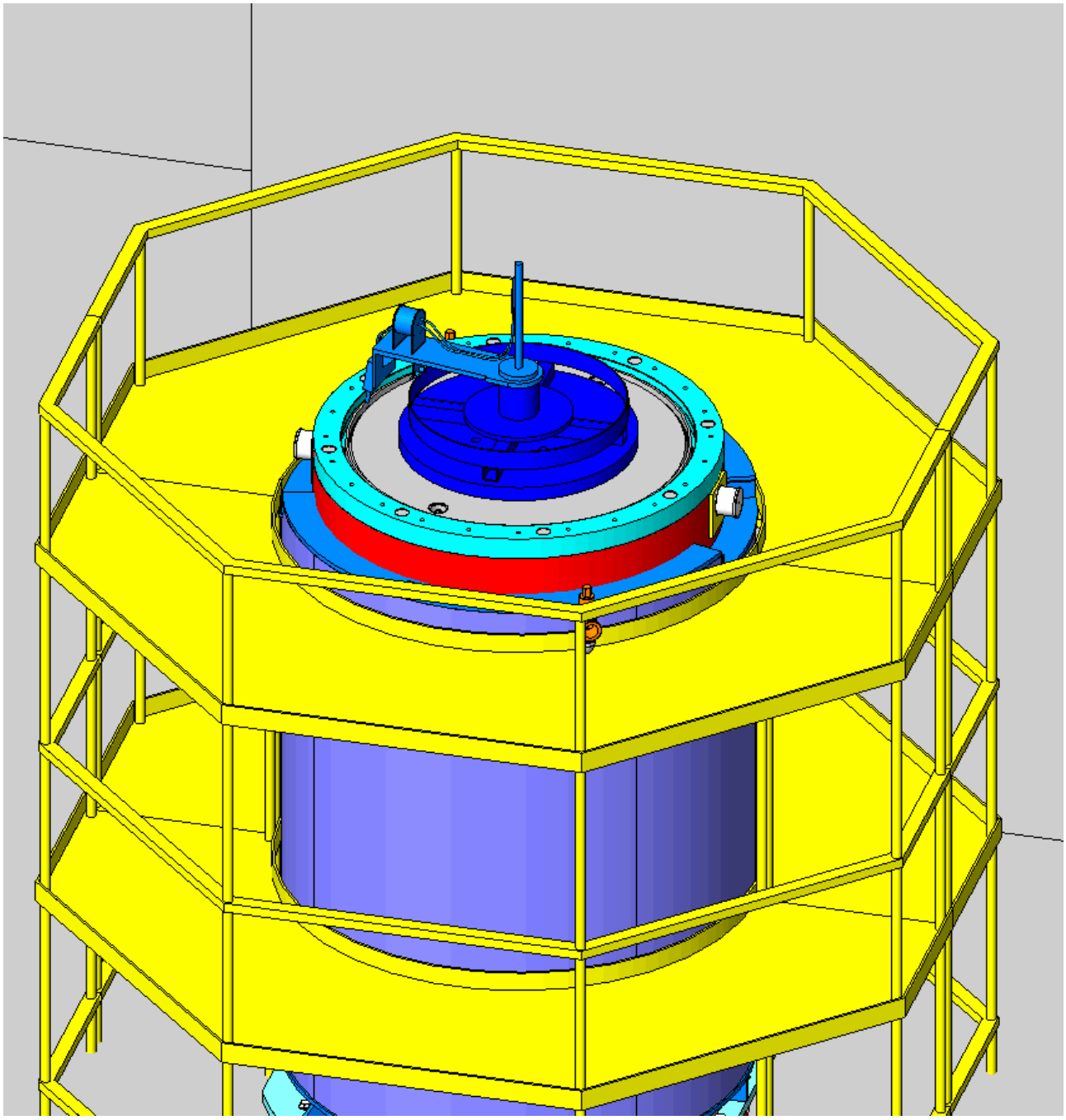


Figure 1.2.5 – **Welding of the MPC lid by means of the automated system**

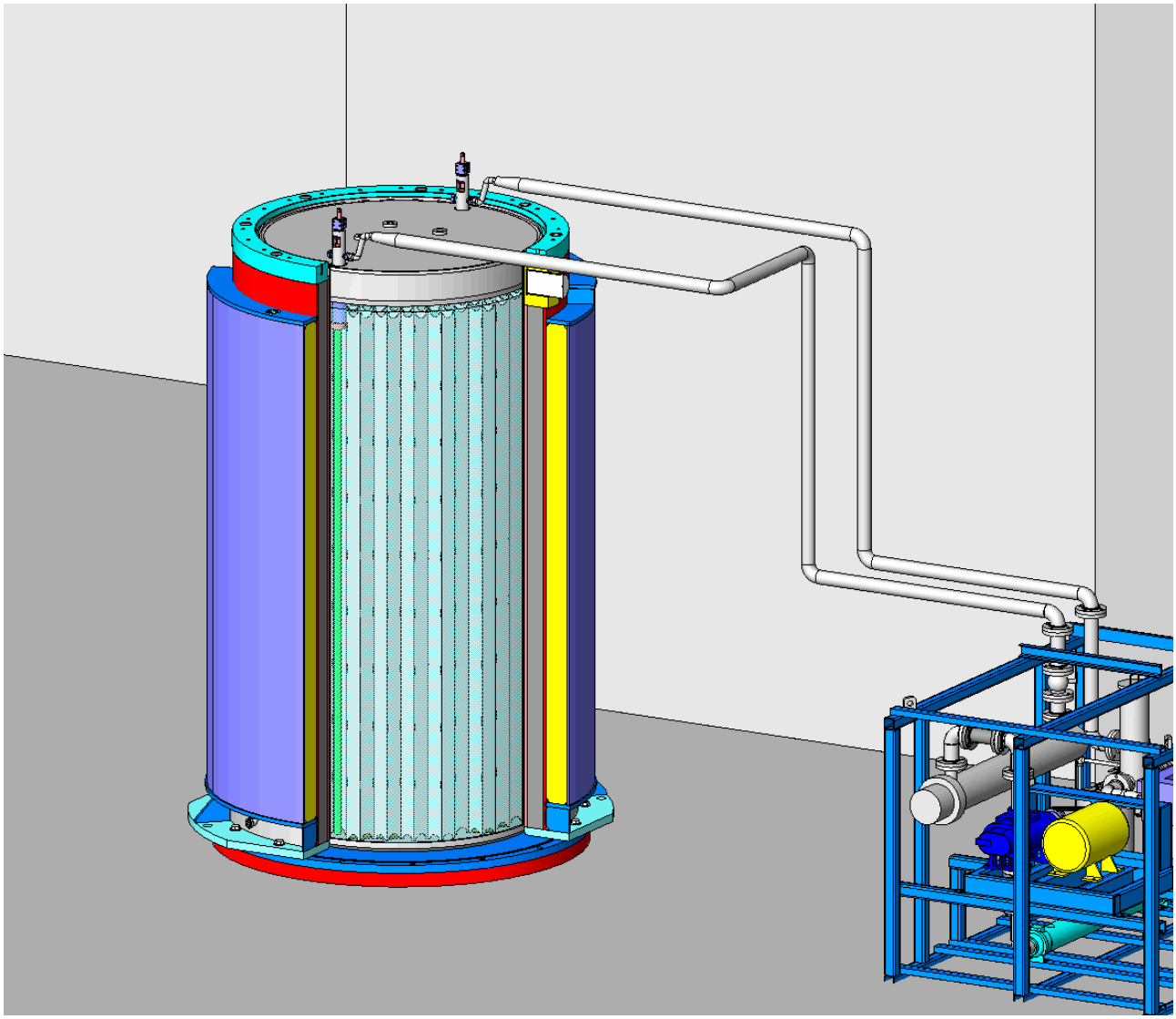


Figure 1.2.6 – **MPC confinement, drying and filling with helium**

The HI-TRAC upper lid is installed and bolts are drawn up. Gussets, which serve as the main lifting points, are installed in the MPC lid.

Gussets provide with excess support, because every one of them is able to bear the complete weight of the loaded MPC.

HI-TRAC, loaded MPC are lifted by means of the cross-arm from the cask washing area for the canisters.

1.2.5 MPC Transfer in the HI-STAR Transport Overpack

The MPC, loaded with the spent nuclear fuel and ready to be transported to the CSFSF, is lowered in the transfer tube to be housed in the transport overpack (Figure 1.2.7).

The HI-STAR transport overpack, being in the transfer tube of the power unit reactor department, prepares to receive the MPC loaded with SFA.

Preparation of the HI-STAR transport overpack to receive the MPC consists in:

- installation of the HI-STAR transport overpack in a position to receive the MPC;
- installation of a new HI-STAR overpack lid seal;
- installation of an adapter unit on the HI-STAR transport overpack;
- installation of a lifting device to lift the personnel near the HI-STAR;
- adapter unit operation test.

Then, the MPC is transferred in the HI-STAR transport overpack.

The HI-STAR transport overpack is located in a vertical position under the crane; its top lid is removed. The working platform is arranged around the HI-STAR, to ensure access of the personnel. A docking (mating) unit is jointed to the upper side of the transport overpack (Figure 1.2.8).

This unit is applied in order to create rigid connection between the HI-STAR and the HI-TRAC and to remove the HI-TRAC bottom lid.

HI-TRAC is located above the docking unit and is leveled by using a bridge crane. HI-TRAC descends; it is housed in the docking unit and fastened to it with bolts.

The arm-cross is removed from the HI-TRAC and is adjusted for the MPC slings that, in turn, are fastened to the gussets installed on the canister.

The docking unit has three inflatable (air) sacks that keep the lid weight during removal of bolts. Sacks are deaerated and the lid is descended approximately to 3 cm on the roller tray of the docking unit. The tray is opened by hydraulic cylinders and the lid is removed from the TI-TRAC transfer cask.

The arm-cross descends to the complete dipping of the MPC in the HI-STAR transport overpack. Having made sure that the MPC is completely dipped in the transport overpack, the slings are detached from the arm-cross and are laid on the MPC lid. The arm-cross is attached to the HI-TRAC transfer cask and it is removed from the docking unit. Slings and lifting gussets are removed from the MPC lid.

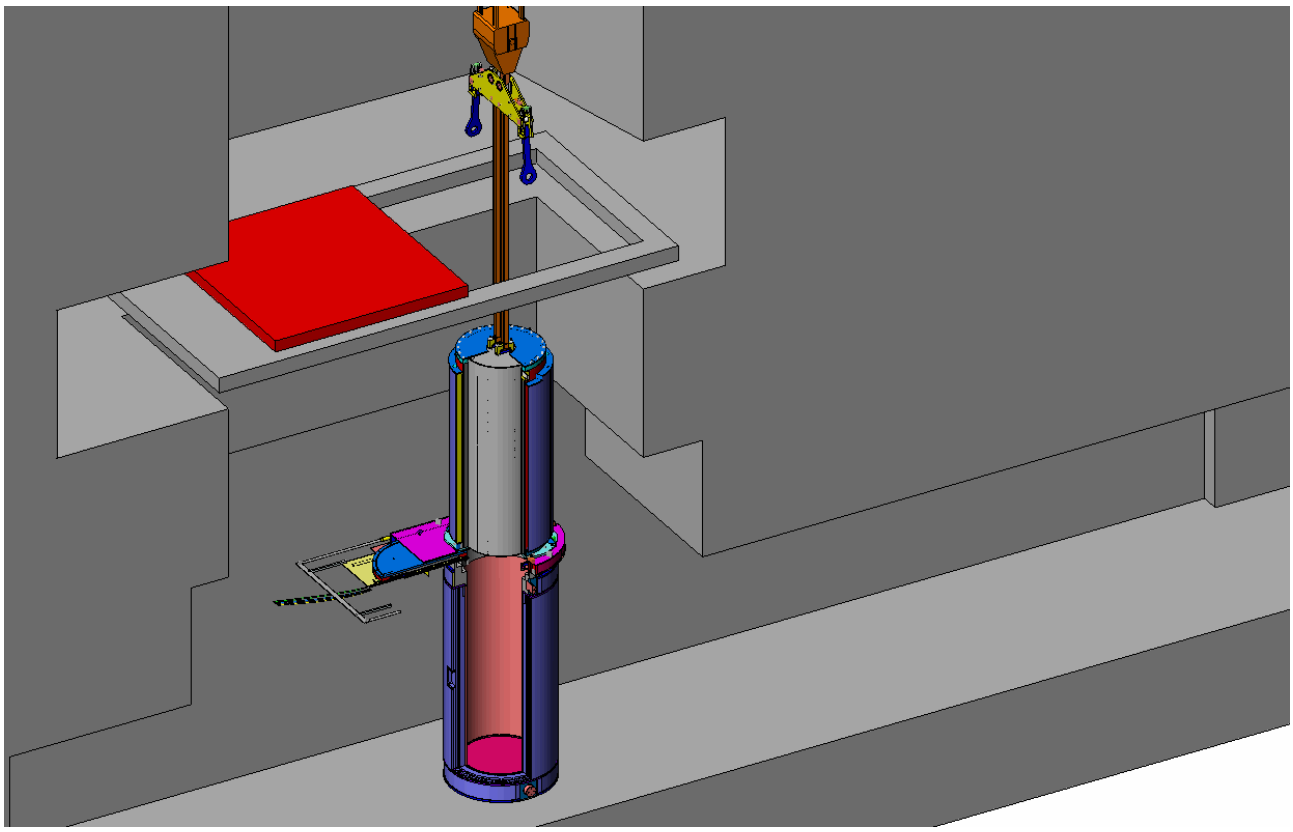


Figure 1.2.7 – **MPC is descended in the HI-STAR transporttion overpack**

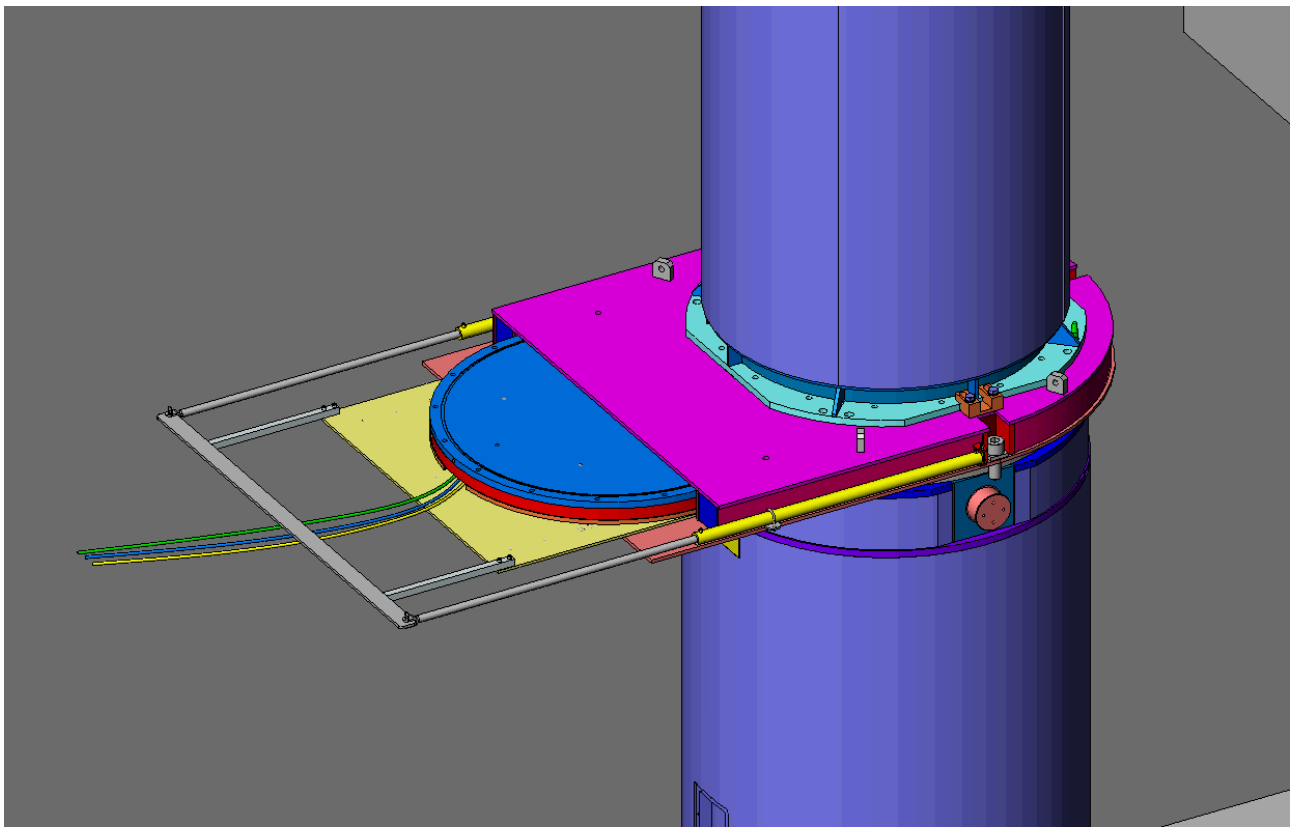


Figure 1.2.8 – **Matching unit between the HI-TRAC transfer cask and HI-STAR transport overpack**

Caps are screwed in the vacant fastening apertures of the lifting gussets. The docking unit is closed and taken away from the HI-STAR.

Then the following operations are carried out regarding sealing of the HI-STAR transport overpack.

A closure plate (top lid) of the transport overpack is installed. The bolts of the HI-STAR transport overpack are screwed to seal the inner space with the canister. The gaps are vaccumized between the canister and the transport overpack, and then it is filled with helium through the cutoff point on the HI-STAR lid. Cutoff points are sealed by a special cap.

Mechanical joints of the transport overpack and caps are tested for tightness in order to make sure that they are able to keep helium in the inner space. Shield plates are installed over the caps on vent and drain ports. The HI-STAR transport overpack is checked for radioactive contamination. The transport overpack is transferred on a transportation position. It is moved into a horizontal position by using a movable crane and a special pivoting frame. Then, the transport overpack is taken away from the pivoting frame and is laid on a wooden grate to install the end plate and shipping buffers protecting it in the event of transport accidents.

Next, the HI-STAR transport overpack is lifted and installed on the railway platform (Figure 1.2.9). Binding (binding rods) is installed, as well as shielding (protective) covering (Figure 1.2.10). Then, shielding properties of the transport overpack are tested: Radiation levels should be within the established limits for transportation.

The transportation module as the ready-assembled unit undergoes final inspections to check the compliance with all transport requirements. A protection enclosure is installed. Designations are stuck on, data plates are installed and then it is transferred for transportation.

Thereafter, the HI-STAR transport overpack shipping documentation is drawn up, the documentation required for this is sent to the carrier and a shipping permission to the CSFSF is issued.

1.2.6 Required Time for Loading Operations

A period of time required for loading constitutes about five – five and a half days.

The main operations require approximately, hours:

- Preparation of the HI-TRAC and MPC for loading 8;
- Fuel loading..... 10;
- Removal of the HI-TRAC and MPC from the cooling pool 8;
- MPC confinement (welding, sink, drying)..... 40;
- Installation of the MPC in the HI-STAR 6;
- Sealing of the HI-STAR 11;
- preparation of the HI-STAR for transportation ..... 6.
-

In total, the overall cycle of loading operations constitutes 89 hours.

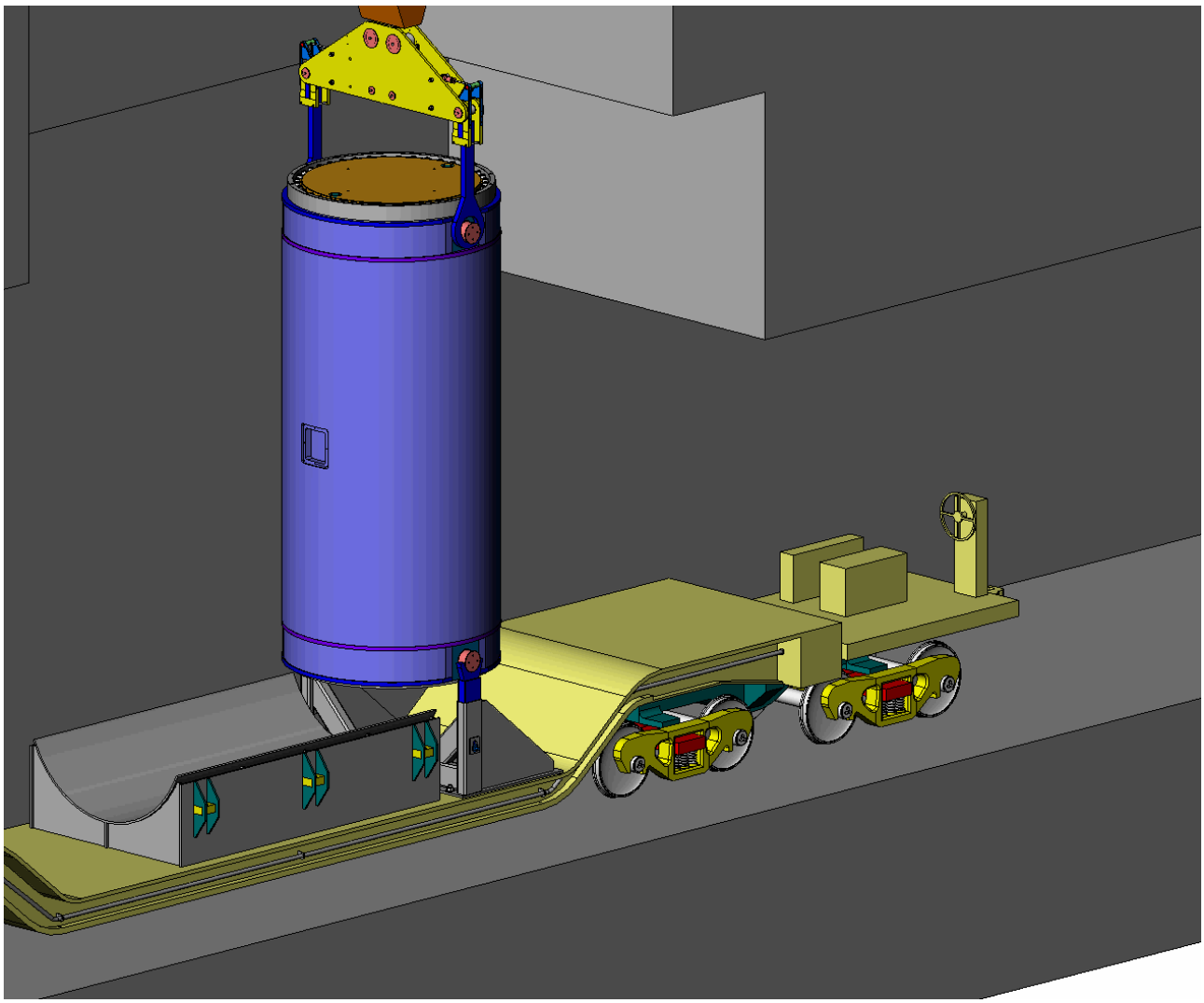


Figure 1.2.9 – **Arrangement and turning of the transport overpack on the railway platform**

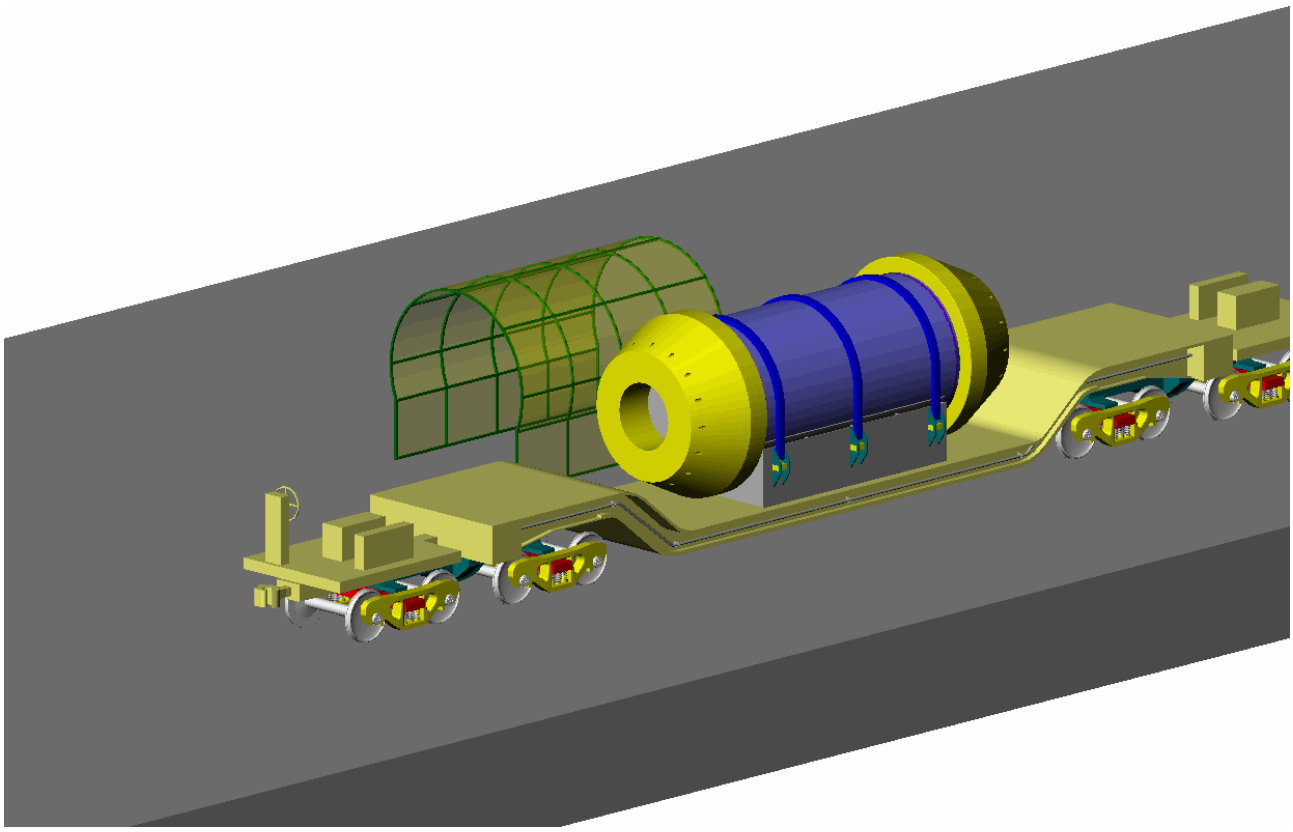


Figure 1.2.10– **Installation of dampers, binding and protective coating**

1.3 SNF Outside Transportation

1.3.1 General Principles

SNF transportation is one of the nuclear fuel cycle elements because it connects nuclear fuel handling stages. SNF transportation issues are the most important in decision making on SNF handling because transportation is carried out by national railways and, thus, touch upon all the population and not only those people who live near a nuclear facility.

The following tasks should be solved during the SNF transportation from NPP sites:

- ensure radiation safety of personnel and the public (including in emergency situations);
- exclude SNF overheating during transportation;
- take measures against attempted thefts of fuel;
- ensure integrity of fuel elements.

The main functions of outside transportation are:

- deliver the loaded canisters with SFA from NPP to the CSFSF site within the ChNPP exclusion area by railways of the Ministry of Transport of Ukraine;
- deliver empty canisters to load with SFA from the CSFSF to the Ukrainian NPPs by railways of the Ministry of Transport of Ukraine;
- maneuvering with the rail car train within the CSFSF site.

In fulfilling separate functions there are specific transportation properties related to transportation features and equipment applied.

The rail car train is transported by the general destination railways of the Ministry of transport of Ukraine in accordance with the transportation rules for special consignments in force within the system of the Ministry of Transport of Ukraine and in compliance with the requirements of the SNRCU regulatory documents as regards transportation of nuclear fission materials.

MPC are transported from NPPs to the CSFSF in the HI-STAR transport overpack. The technical decisions for the MPC ensure nuclear safety during transportation. The HI-STAR transport overpack ensures the required conditions for MPC protection in normal and emergency transportation conditions in accordance with the safety requirements in the USA and will be certified according to the requirements of PBTRM-2006[2] at the following stages.

During MPC transportation from NPPs to the CSFSF in the rail car, HI-STAR with MPC are housed in horizontal position, at that special damping devices are installed on the lid and the bottom plate of the HI-STAR to protect the canister in accidents.

Based on the annual volume of WWER-440 and WWER-1000 SFA transported from NPPs to the CSFSF, one rail car train is provided for, which is located within the CSFSF on a specially provided area – holding tracks and composition of one rail car train whose design decisions meet the similar decisions on NPPs sites.

A rail car train is composed at NPPs within the existing system at NPPs. Additional equipment and modernization of the existing equipment is not provided for within this contract.

In determining a composition of a rail car train the following provisions were taken:

- use of special railway platforms wit lodgments for HI-STAR canisters to transport SNF;
- use of single-type convoy cars and escort cars;
- determination of a number of transport means within the rail car in accordance with the current requirements for rail car trains for TK-6 transportation and taking into account actual capacity of canisters and fuel volume that corresponds to SFA number not less than one reactor reloading.

HI-STAR transportation modules for MPC-31 and for MPC-85 are identical. Five HI-STAR transport overpacks will be delivered. This number has been determined based on the fact

that the CSFSF should receive 504 WWER-1000 SFA and 192 WWER-440 SFA per year. In order to meet this requirement, Holtec International will provide for receipt of 20 MPC per year.

The HI-STAR transport overpack meets the US NRC requirements and IAEA shipping requirements.

- Spent fuel is transported from NPPs by a special train consisting of ten cars:
  - five rail cars with SNF;
  - one rail cars for the HI-TRAC transfer cask;
  - one platform for welding and auxiliary equipment;
  - one escort car;
  - two convoy cars.

1.3.2 Shipping of Canisters with SFA from NPPs to the CSFSF Site

The loaded HI-STAR is transported from NPPs to the CSFSF in the same way as TK-13. Only one rail car comes in the NPP reactor compartment transfer tube for loading.

In order to load HI-STAR canisters on the transfer platform, the existing handling scheme will be used to transfer TK-13 and TK-6 applying auxiliary arm-crosses. The NPP personnel will transfer canisters on platforms by means of reactor compartment central hall cranes and hoists located in the NPP reactor compartment transfer tubes.

The HI-STAR transport position on the platform will be horizontal.

The canister is installed on the platform in a vertical position, and then it is turned (turned over) in a horizontal position. The platform with the HI-STAR fastened on it is removed from the reactor compartment; shockproof damping devices and protective covering are installed on the platform. Further, a special railway train is formed in accordance with the existing scheme within the NPP territory.

Further shipment is carried out by the national railways of Ukraine in accordance with the safety ensuring requirements in shipment. The HI-STAR transport overpack meets the requirements of [2] and IAEA shipment requirements.

Railway platform for HI-STAR shipment

The HI-STAR overpack is a railway platform with a low-set center of gravity for the HI-STAR canister shipment (Figure 1.3.1).

The HI-STAR overpack in shipment outside the site is equipped with special limiters. The overpack includes a frame, fasteners, and a barrier for access restriction and personnel protection that will turn the canister in shipment. Holtec International developed a railway platform and a cradle for HI-STAR transportation.

The HI-STAR canister design meets completely the US NRC requirements (10CFR71) and IAEA recommendations in shipment.

Rail car components are sealed with a seal and wire.

TK-VS* convoy car is intended for placement of the personnel who accompanied a special train and guard, as well as equipment and life support means.

The train with fuel is accompanied by a military guard, and an expert team, who ensures permanent monitoring for a state of cars and canisters from the convoy car equipped with all necessary means for the work.

The safety of transportation is ensured by appropriate services of the Ministry of communications (MC), Ministry of Internal Affairs, SNRCU and other organizations.

On the way the personnel of the rail car train accompanying team monitors radiation from the external surfaces of transport means closely at surface, and at two meters distance from the car. The temperature is monitored and interaction is ensured by permanent communication with

* transliterated

the guard and a driving team of the train. At the same time, the CSFSF appropriate subdivisions monitor permanently the special train traffic along the whole route.

Design features of the transport HI-STAR not only provide with safety in SNF shipment but also ensure reliable protection in normal and emergency conditions, as well as in sabotage attempts.

1.3.3 Shipment of the Empty Rail Car Train

In accordance with the planned program for SFA removal from NPPs power units, a rail car train is being formed and rail cars are being loaded with canisters.

Rail cars are being loaded one by one with shipping casks that were previously monitored visually and contaminations of their surfaces were monitored as well, and rail cars are transferred by a diesel-locomotive shunter at the tracks for holding and loading of a rail car train.

Prior to loading of a rail car, the responsible for accounting and storage of nuclear materials checks registration numbers of a canister and availability of stamps on a canister lid.

After completion of a rail car train loading, it is driven by the diesel-locomotive shunter from the CSFSF territory to be transferred to the Ministry of Transport of Ukraine for further shipment at Ukrainian NPPs.

Radiation monitoring is carried out to drive the train from the CSFSF territory.

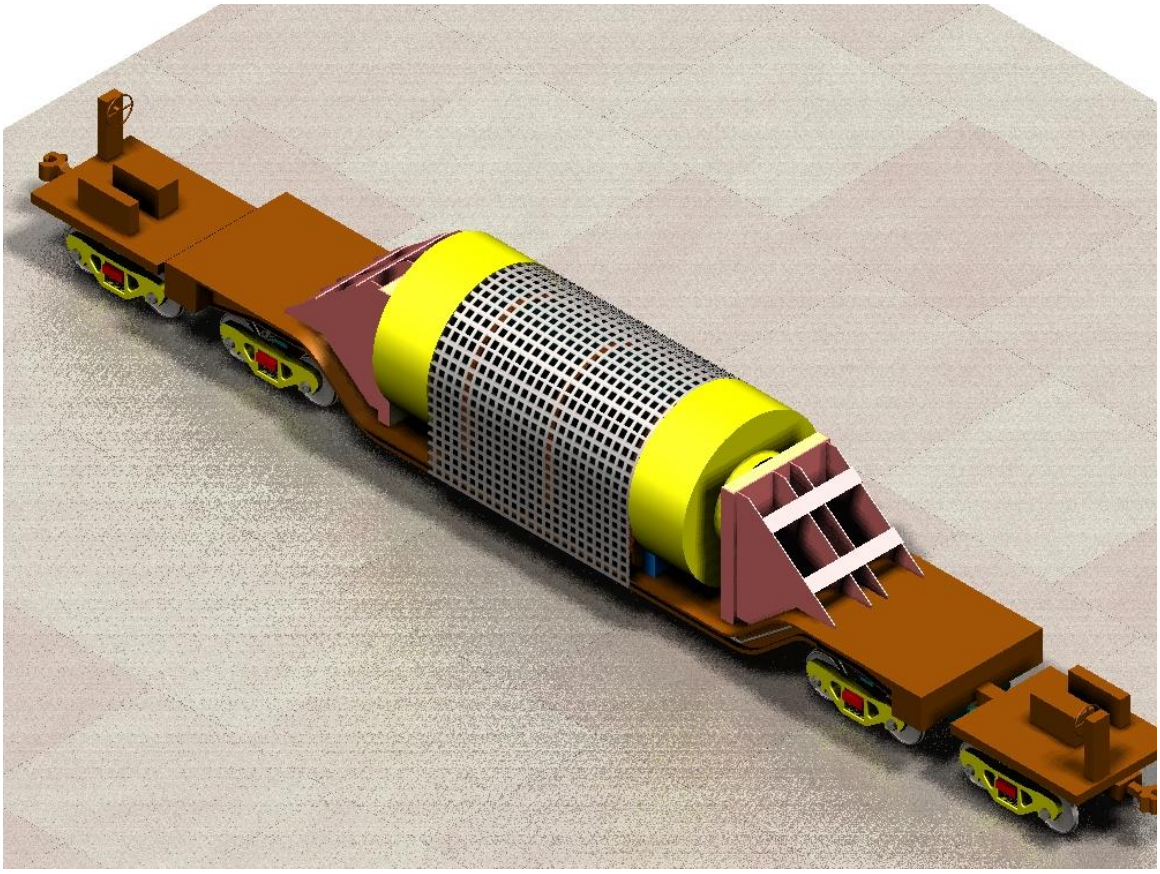


Figure 1.3.1 – **General view of a canister**

1.3.4 Maneuvering with the Rail car Train within the CSFSF Site

The rail car train is driven up at the CSFSF territory at the rail car train holding and maneuvering track.

Outer radioactive contaminations are monitored.

It is provided for to construct three branch lines for maneuvering of a shunting container with one of the components of the rail car train.

After the rail container train drives into the middle track of branch tracks, the diesel-locomotive shunter moves escort and convoy cars one by one at the parallel track.

After the rail cars remained at the middle line only, the diesel-locomotive shunter catches on one rail car and transports it ahead to the receiving building.

Then, handling operations on reloading of the canister are carried out.

Upon completing discharge of the last rail car and its loading with the delivered canister, a rail car train ready to be transported to NPPs is formed by using a diesel-locomotive shunter.

A building for cask maintenance is provided for within the CSFSF in order to carry out minor repair related to mechanical and electrical damages.

Maneuvering and holding tracks ensure:

- reception of the whole rail car line with 200 m length;
- maneuvers carried out by the diesel-locomotive shunter or with one rail car, or one escort car, or one convoy car.
-

1.4 Operations on SNF Reception to the CSFSF

1.4.1 General Principles

The main tasks at the CSFSF site in Holtec technology implementation are:

- acceptance of MPC with SFA (or WWER-440, or WWER-1000) in the HI-STAR transport overpack;
- MPC housing in the HI-STORM;
- HI-STORM transportation to their storage area;
- long-term storage of MPC with SFA in the HI-STORM;
- collection and delivery liquid and solid radioactive waste for processing/disposal;
- SFA protection against possible external extreme natural and man-made events;
- personnel and environment protection against ionizing radiation impact;
- ensuring of physical protection and accounting of nuclear materials. On arrival at the CSFSF, the HI-STAR transport overpacks are discharged from the rail car train and the MPC housed in them are reloaded directly without repackaging of fuel assemblies in the HI-STORM storage overpack in the receiving building.

The building for HI-STORM reception is the main CSFSF industrial building. The following operations are carried out in this building:

- acceptance of loaded HI-STAR;
- HI-STAR loading from the rail car;
- reloading of the loaded MPC from the HI-STAR to the HI-STORM;
- loading of empty HI-STAR canister with empty MPC to be transported to NPP;
- installation of the HI-STAR canister in the rail car to be returned to the reactor site.

In the receiving building there are systems and equipment required for the whole cycle of process operations on acceptance of the HI-STAR canisters and transfer of loaded MPC to the storage area.

Technical decisions related to nuclear safety ensuring in the receiving building are intended to reduce a probable mechanical damage of the MPC and exclude water ingress into

SFA in the event of MPC emergency depressurization. This is related to the fact that nuclear safety shall be ensured firstly in the MPC.

In order to reduce MPC probable mechanical damages, it is proposed to use seismic resistance equipment with higher reliability indexes in the receiving building to reduce MPC probable mechanical damages. In addition, the design decisions provide for MPC handling within the reloading box only, what excludes drop of MPC with damaged barriers.

In order to exclude possible contact of water with SFA in the case of a hypothetical event involving failure of confinement barriers, there is no water supply in the handling tube and the reception box. Moreover, the design decisions exclude water ingress in the reloading box from the adjacent premises.

Water is not used in designing of fire protection in these premises.

During the whole process chain, at the east two engineering barriers are provided for in the receiving building, that prevent water ingress in SFA: MPC enclosure shell, an enclosure vessel of the canister or of the HI-STAR, or HI-TRAC, or HI-STORM.

Remote observation is carried out for all the process operations, as well as neutron radiation in the transportation tube, where operations are performed on MPC reception and reloading.

All the main and auxiliary equipment and systems required for shipment, acceptance test, radiological monitoring, special sewage, RAW management, supply of process mediums, power supply etc. are included in the receiving building.

Electrical screw keys will be used to install and remove bolts in reception and removal of transportation canisters that will allow reducing time for these operations. This will allow minimizing residence time in the radiation field. Where it is considered effective, a temporary biological shielding will be installed to reduce total dose in task performance (relativity to doses for personnel involved in mounting and dismantling of equipment).

A cask handling area and reception area include systems required for reception and shipment of transportation canisters in rail cars and preparation of a transportation canister for movement by crawler at the CSFSF. In this area there are systems required for storage of mechanical impact limiters on the transportation canister, loaded and empty HI-STAR and empty MPC.

In this are there are equipment and systems required for the following operations:

- removal of the transportation canister from the rail lines;
- removal of mechanical impact limiters on the canister;
- overturn of transportation canisters;
- transference of transportation canisters to the canister crawler entry area;
- incoming and final check of transportation canisters;
- visual check of all the on-site shipping operations;
- decontamination, if necessary, of the HI-STAR transport overpacks;
- removal of the HI-STAR transport overpack in the cask storage area.

In the cask handling area there is a possibility for interim storage of both loaded and empty HI-STAR canisters, if any additional operations are required in order that canisters meet the requirements on radiation safety.

The complete successive description of all operations on handling with the HI-STAR transport overpacks are presented below, as well as scenarios for MPC loading in the HI-STORM 100 storage overpack at the CSFSF site.

Holtec International developed the technology described below for a SNF large centralized storage facility to which, as opposed to the SNF plant storage facility from one supplier, the loaded MPC will come, most likely, practically daily.

1.4.2 General Layout of the Receiving Building for HI-STAR Casks

A process building will be designed in accordance with the requirements for tasks of I category on nuclear and radiation safety and according to [8].

MPC with SNF is reloaded in the receiving building using a transfer box to which the transportation canister is coming from the above (Figure 1.4.1).

The transfer box creates auxiliary shielding in addition to the shielding that HI-STORM and HI-STAR canisters ensure themselves reducing essentially dose loads on the personnel who reload MPC.

The transfer box is a double-side opened structure with inner guides for the HI-STORM module with tightly doors and manholes for transportation of the loaded MPC from the HI-STAR transport overpack to the HI-STORM.

The upper face part of the transfer box for MPC includes guiding battens and HI-TRAC auxiliary mechanism. Since the HI-TRAC lift is not provided for in principle, its mass is not conditioned by any hoisting device limits. Moreover, the guides hold the HI-TRAC tightly and do not allow him to overturn even in a seismic event. The guides allow leveling the canister accurately in the transfer box, correspondingly, this excludes a possibility that the MPC “flies by” during reloading from the HI-STAR in the HI-STORM storage overpack.

In the transfer box the parallel leading lines are installed on which two roller dollies will be transferred. Roller dollies are intended to keep, transfer and position the HI-STAR transport overpack and the HI-STORM storage module in such a way that they be installed over and under transfer hatches for MPC transfer.

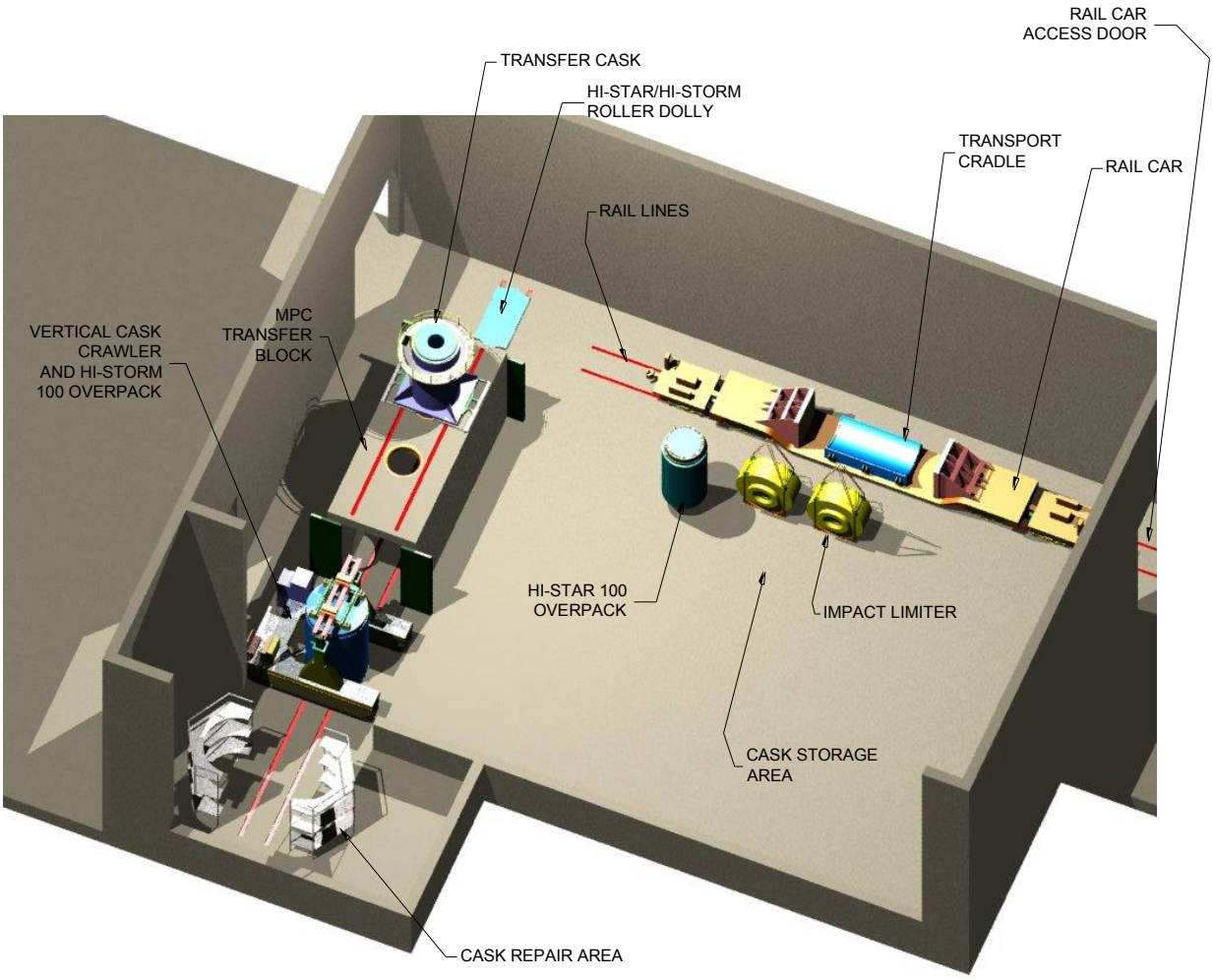


Figure 1.4.1 – **CSFSF receiving building layout**

An electrical 125-t carrying capacity bridge crane serves the receiving building. The bridge crane is used to receive HI-STAR canisters and to transfer other components in the receiving building.

The HI-STAR receiving building is equipped with a special entry for vertical cask crawler (crawler) that is used for HI-STORM shipment and a rail car access door. A cask repair area is provided for in the receiving building as well and a large storage area for containers and different auxiliary equipment.

1.4.3 Reception of the HI-STAR Transport Overpack in the Receiving Building

The HI-STAR is transferred to the CSFSF site in the overpack on the railway platform and comes to the HI-STAR receiving building (Figure 1.4.1). A railway brunch line is driven into the HI-STAR receiving building under the bridge crane.

The HI-STAR transport overpack comes into the receiving building in a horizontal position with damping devices installed in upper and bottom parts.

The HI-STAR is equipped with special fixing devices to be fastened in the rail car. Representatives of security service and dosimetric monitoring department check visually the rail car. The receiving building doors open, and the HI-STAR is transferred in the rail car into the receiving building. First, the HI-STAR is checked in order to determine damages during transfer and the accompanying documentation is checked and filled up. Wheels of the railway platform are blocked.

The bridge crane is brought in a position to remove a canister from the car. Further, bolts of the upper and bottom damping devices are unscrewed. And a mechanical protection is removed. The mechanical protection is a light honeycomb frame limiting access to the HI-STAR vessel during shipment. It is checked availability of the removable contamination on the HI-STAR outer sides and general measurements of the exposure level are carried out. Fixing devices are loosened and removed.

Fixing devices are intended to fix the HI-STAR canister on the railway platform. The HI-STAR canister along with the mechanical impact limiters is removed from the railway line cradle in a horizontal position by means of special sling equipment fastened on the bridge crane. The canister is laid in a horizontal position on the rack under it near the railway platform (Figure 1.4.2).

The removed mechanical impact limiters come to the storage facilities in special underframes that have lifting slings and prevent their drop or turnover. The HI-STAR supporting frame is removed and the HI-STAR canister is prepared for turn into a vertical position.

The HI-STAR canisters are installed in a vertical position upside-down by using a lift frame and a special turning frame consisting of two parts (Figure 1.4.3). The HI-STAR transport overpack is installed in a horizontal position and is arranged on a turning frame. The HI-STAR canister is fastened to the turning table by means of a quantity of belts.

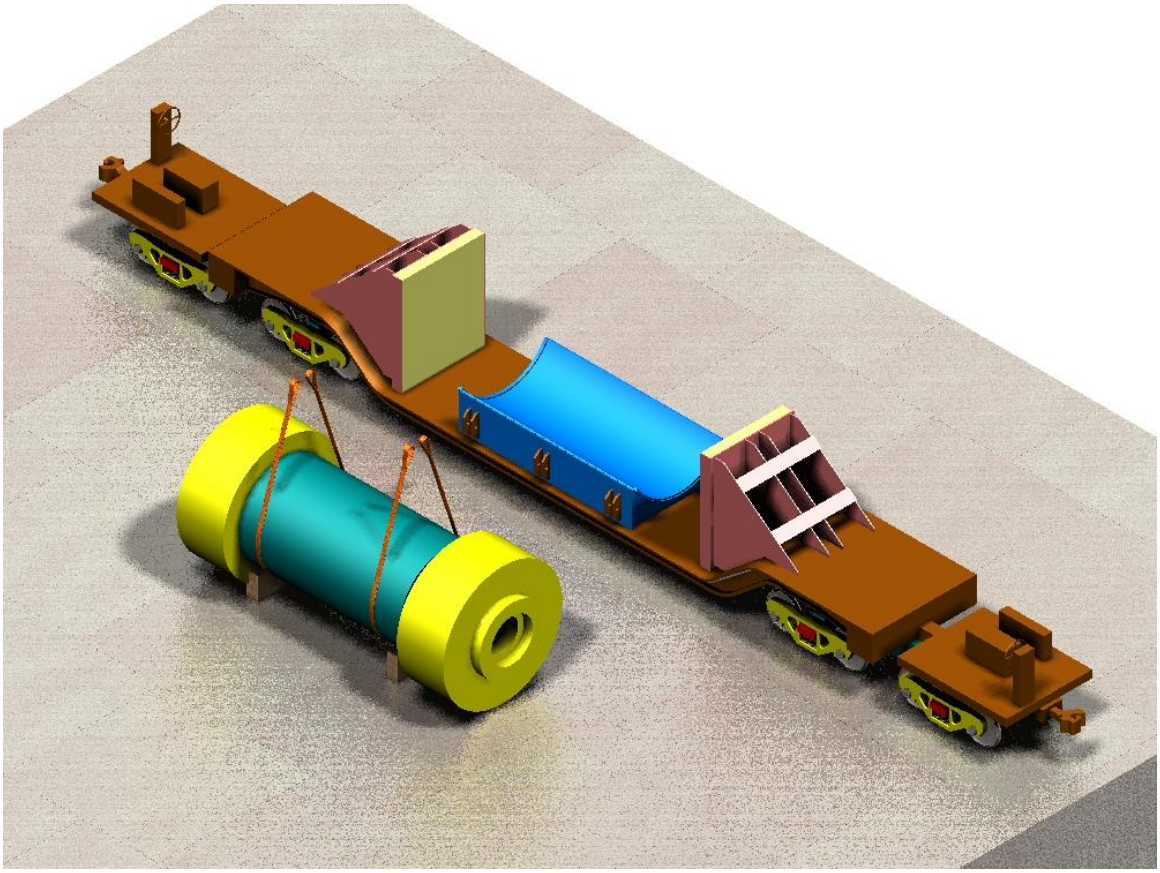


Figure 1.4.2 – **Removal of the HI-STAR transport overpack from the railway platform**

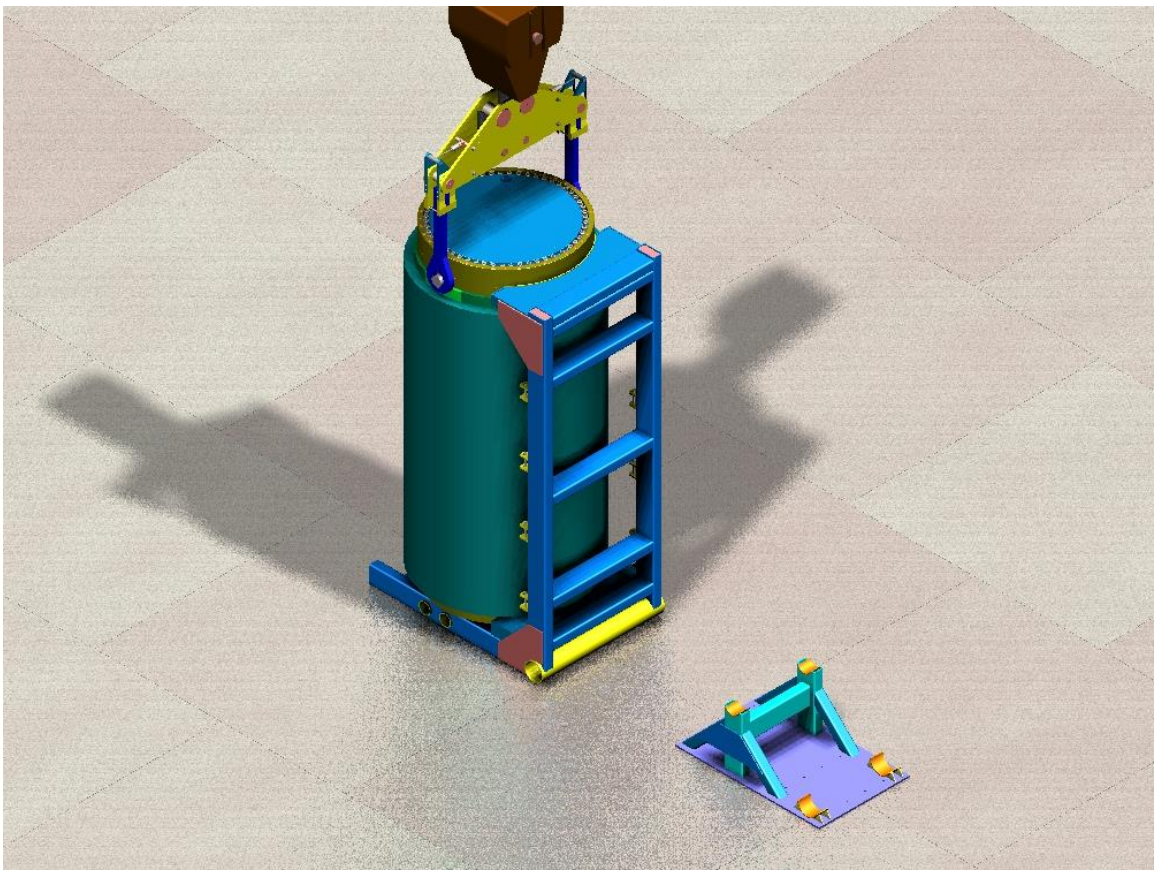


Figure 1.4.3 – **Turning of the HI-STAR by means of the turning frame**

The pivoting frame allows installing the HI-STAR in a horizontal position safely and efficiently after removal of safety belts from the HI-STAR, it is removed from the pivoting frame and is installed on the roller dolly outside the transfer box (Figure 1.4.4).

Preparation of the HI-STAR transport overpack for removal of the MPC from it consists of the following operations:

- arrangement on the low-profile crawler in the transfer box;
- removal of the HI-STAR secondary lid;
- removal of the HI-STAR primary lid;
- installation of auxiliaries on the MPC.

Figure 1.4.5presents equipment layout for the MPC transfer from the shipping canister in the storage container.

The main crane of the transfer building lifts the HI-TRAC in a vertical position and installs it on the HI-STAR transport overpack in the matching device. The bottom lid of the HI-TRAC transfer cask is removed by means of the matching device and the MPC is lifted into the

HI-TRAC transfer cask. Further, the HI-TRAC lid is installed into place and the HI-TRAC is removed from the matching device and arranged on the floor of the transfer building in the fixed position.

The matching device is transferred from the HI-STAR transportation module on the HI-STORM storage overpack. The HI-TRAC transfer cask is installed on the HI-STORM storage overpack and is positioned by means of the matching device.

Further the HI-TRAC bottom lid is removed by means of the matching device and the MPC is lowered from the HI-TRAC transfer cask into the HI-STORM. Then the HI-TRAC bottom lid is installed into position and the HI-TRAC is removed from the matching device and is installed on the floor of the transfer building in the fixed position. In conclusion, the lid is installed on the HI-STORM storage overpack.

The HI-STORM storage overpack consisting of the MPC with SNF is transferred by the crawler on the storage area where it is installed for storage.

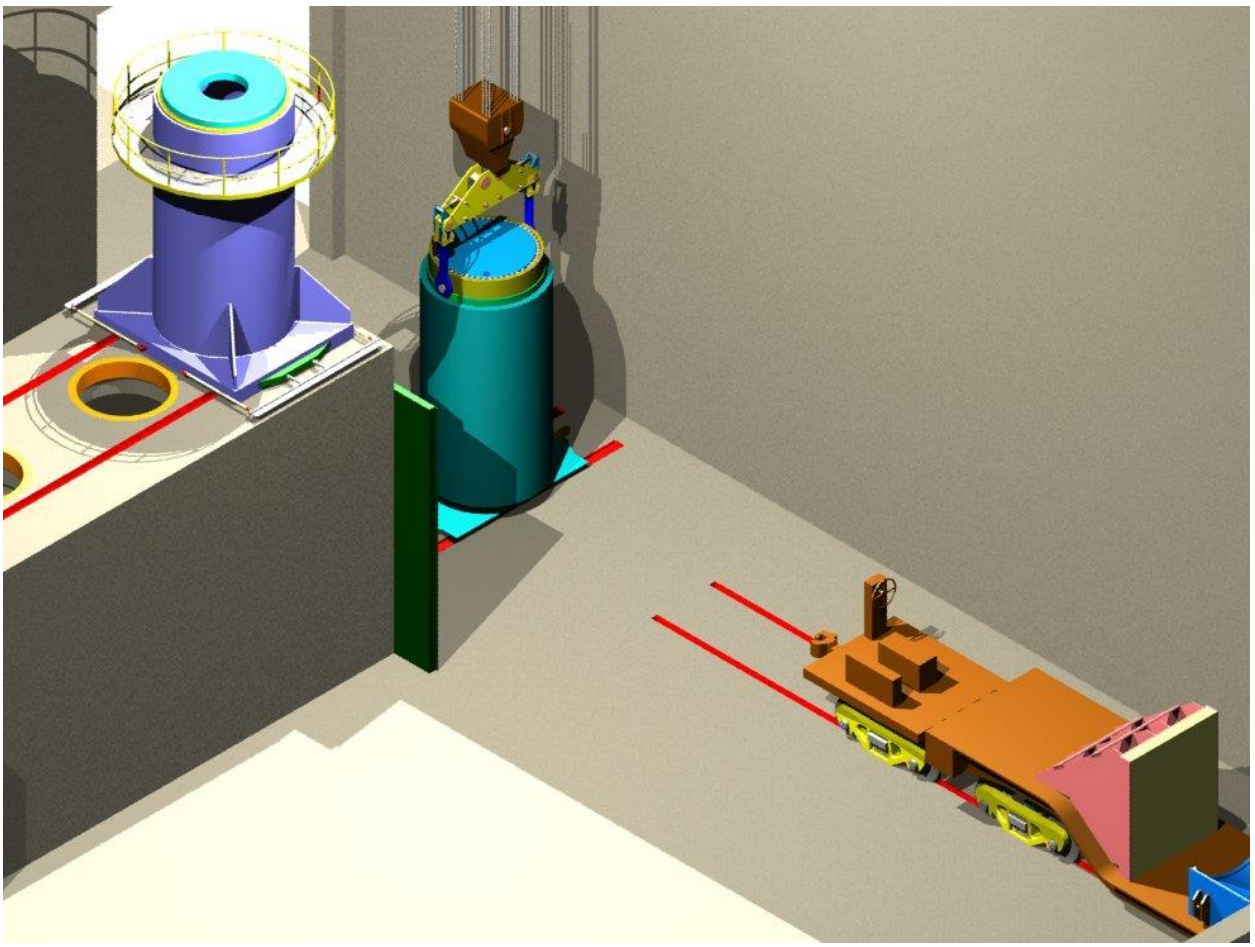


Figure 1.4.4- **Installation of the HI-STAR on the low-prfile crawler in front of the transfer box.**

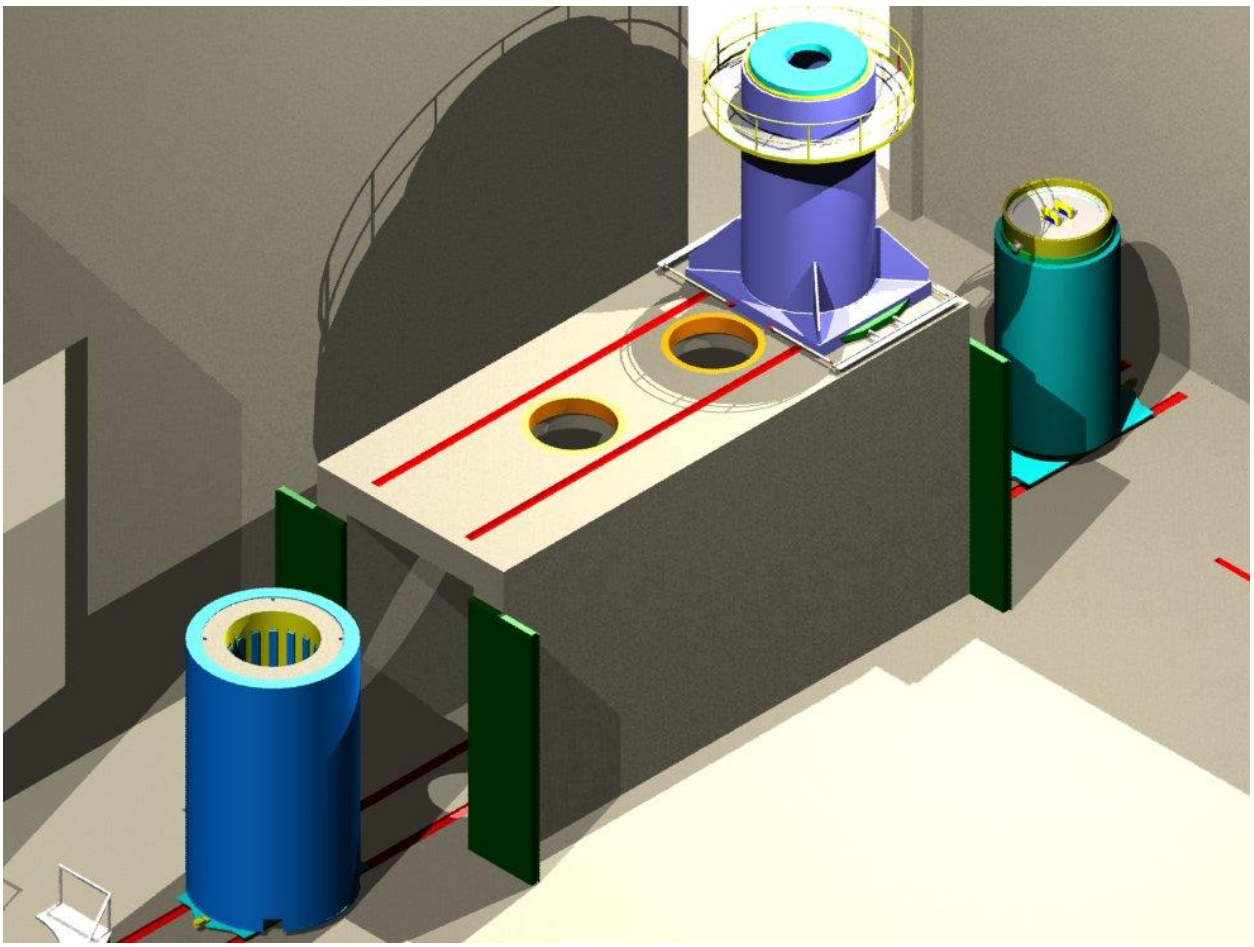


Figure 1.4.5- **Layout of equipment for MPC transfer from the transportation cask into the storage cask**

1.4.4 Preparation for MPC Transfer

The MPC is transferred from the HI-STAR transport overpack into the HI-STORM storage overpack in the transfer box (Figure 1.4.6).

The HI-STAR transport overpack is installed in the transfer box in a transfer position by means of a roller dolly.

The roller dolly is a low-profile platform of higher carrying capacity with captive guide rollers installed on it horizontally. The roller dolly is equipped with guiding and adjustable braking devices; this allows installing it accurately over the transfer box access panel under which the HI-STAR will be located.

The empty HI-STORM storage overpack is installed in a transfer position in the receiving building by means of a vertical crawler that comes to the building through the special gates and drives the HI-STORM. Them the empty HI-STORM is installed on the roller dolly by means of the same vertical loader outside the transfer box.

Preparation of the HI-STORM storage overpack for transfer in it the MPC consists of the following:

- installation of the HI-STORM on the crawler in the transfer box;
- removal of the HI-STORM lid;
- arrangement of the HI-STORM in a position under the opening in the transfer box;
- sealing of doors of the transfer box.

The HI-STAR installed on the roller dolly is liberated from the bridge crane pinches by weakening a lifting lug from the HI-STAR lifting trunnions. A closure plate is removed from the HI-STAR canister and lifting grippers are connected to the MPC lid into special holdsites arranged on the MPC lid.

MPC lid grippers are the main points for MPC lid lifting. Two grippers provide for additional support to the MPC in lifting. They are additional because each of them ensures itself sufficient support to the MPC being loaded.

A set of slings is fastened to the MPC lid and is winded round it. The HI-STAR transport overpack is installed in a transfer box under openings. The HI-STORM 100 storage overpack, correspondingly, is arranged under its loading openings. Doors are closed at both ends of the transfer box.

Transfer hatches are just a little bigger then the MPC outer sizes and are equipped with tapered guides to direct MPC in unloading and loading operations.

The HI-TRAC transfer cask is equipped with two shielding gate valves powered by a hydraulic system. Shielding gate valves support MPC in cask transfer from the HI-STAR into the HI-STORM. Shielding gate valves prevent also exposure during MPC reloading while it is inside the HI-TRAC and when the MPC is installed or removed from the HI-TRAC.

The built-in stairs and the working platform ensure access to the upper part of the HI-TRAC transfer cask, if necessary.

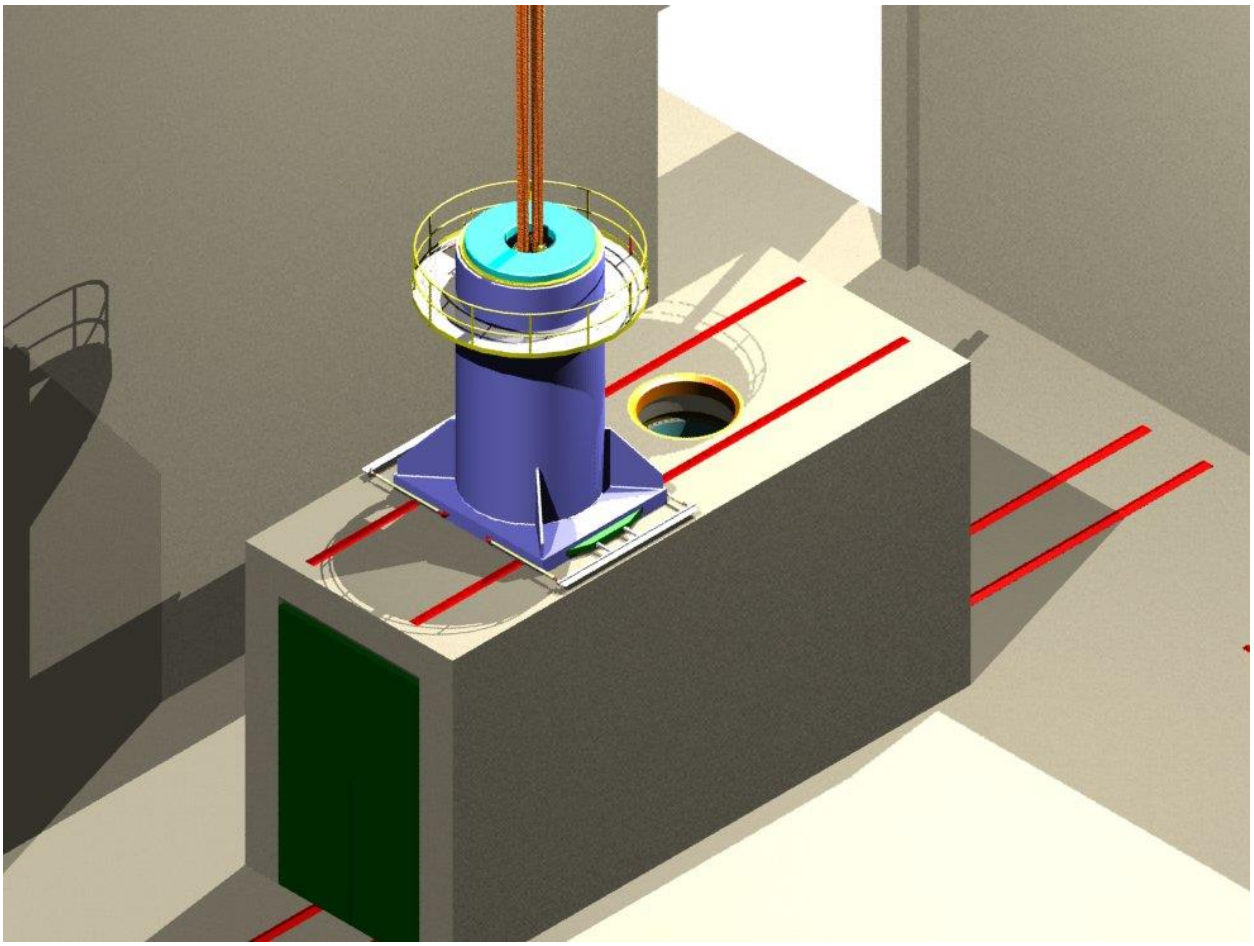


Figure 1.4.6 – **Installation of the MPC on the transfer box under the HI-STORM 100 storage**

1.4.5 MPC Transfer

The HI-TRAC transfer cask is installed above hatches for the HI-STAR and shielding gate valves are opened (Figure 1.4.7). The MPC slings are pulled through the HI-TRAC transfer cask and are fastened on the bridge crane.

The bridge crane removes the MPC and pulls it through the HI-TRAC transfer cask and lower shielding gate valves are closed. Then the MPC is lowered on the closed bottom shielding gate valve allowing weakening tension of slings.

The transfer dolly for HI-TRAC allows installing it above hatches (for the HI-STORM storage overpack). The bridge crane lifts a little the MPC in order to weaken load on the lower gate valve. Then, the HI-TRAC bottom gate valve is opened and the MPC is lowered into the HI-STORM (Figure 1.4.8).

The MPC slings and grippers are detached from the bridge crane and are lowered on the MPC lid. The HI-TRAC transfer cask lower gate valve is closed and the HI-TRAC canister is transferred above the HI-STAR hatch in order to liberate the working territory.

The transfer box doors are opened and the HI-STORM storage overpack is removed from the transfer box by means of roller dollies.

1.4.6 Transfer of the HI-STORM at the Storage Area

The HI-STORM overpack loaded with MPC is prepared for shipment to the storage area. Slings and grippers for MPC lifting are detached and caps are inserted in their holdsites and attachment points.

A vertical loader is used to lift and position the HI-STORM storage overpack. The lid on the HI-STORM (Figure 1.4.9) module is installed by means of the vertical loader as well. Then, the vertical loader lifts the HI-STORM storage overpack from the roller dolly and removes it from the receiving building (Figure 1.4.10).

The HI-STORM storage overpack is transferred to the storage area and it is ready to be installed for storage (Figure 1.4.11).

There is a list of operations on the HI-STORM storage overpack transfer and installation in the storage area:

- installation of the HI-STORM storage overpack on a vertical loader;
- transfer of the HI-STORM storage overpack to the storage area;
- HI-STORM arrangement on the storage plate;
- removal of the vertical loader;
- bolt tightening on the HI-STORM storage overpack lid;
- connection to the temperature sensors.

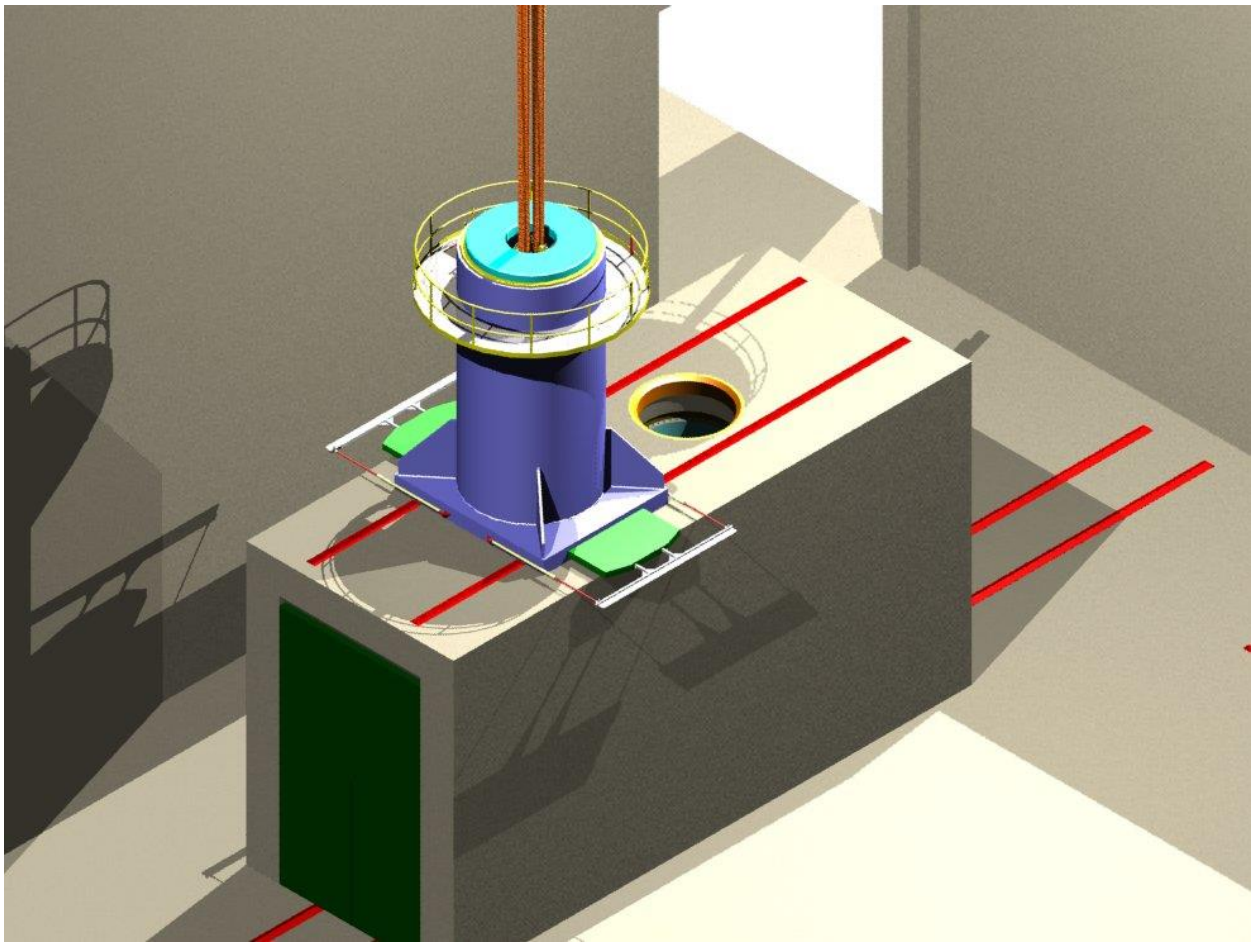


Figure 1.4.7 – **Removal of the HI-TRAC bottom shielding gate valve and MPC lowering into the HI-STORM**

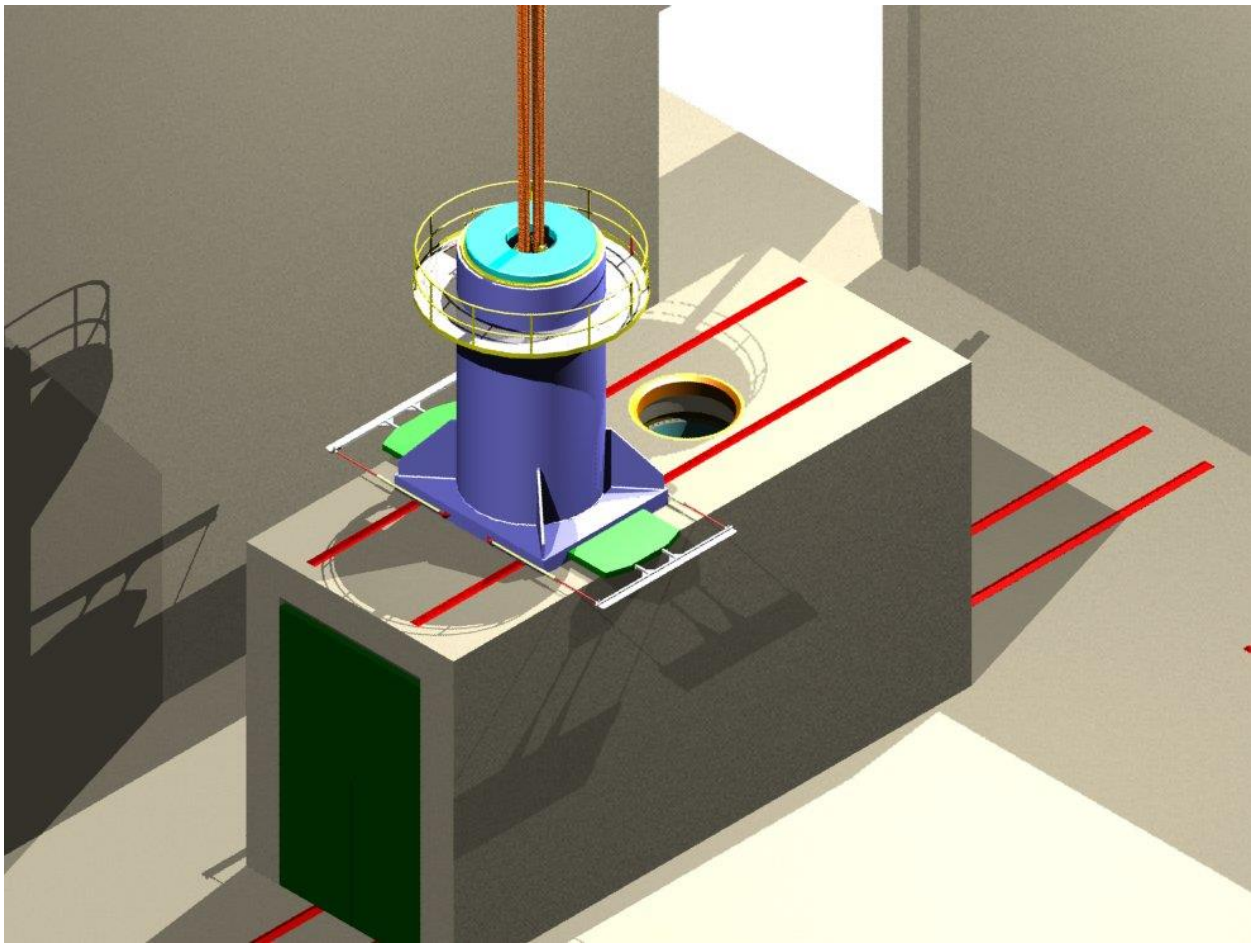


Figure 1.4.8 **– MPC transfer (lowering) in the HI-STORM**

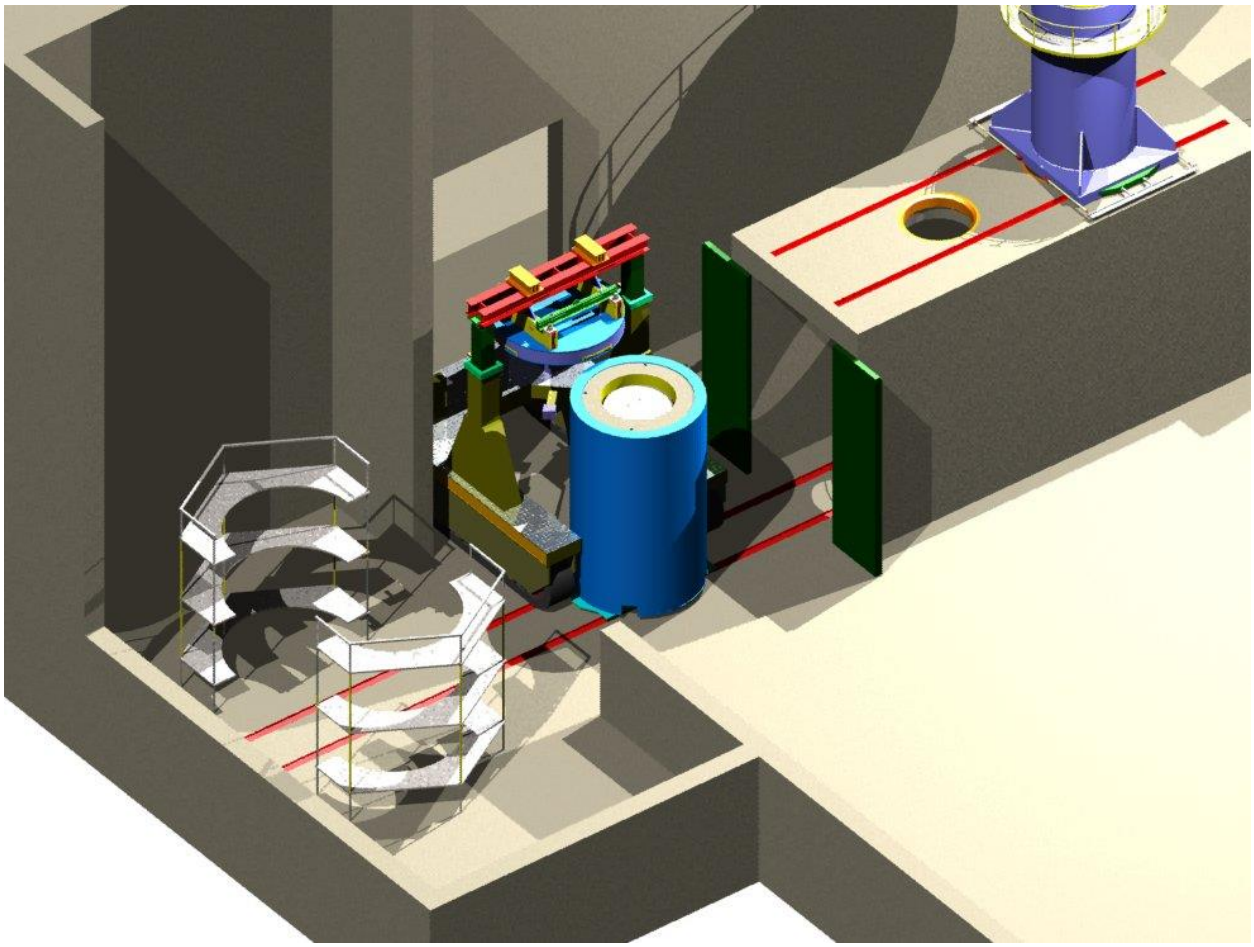


Figure 1.4.9 – **Removal of the loaded HI-STORM storage module from the transfer box and a lid mounting by means of a crawler**

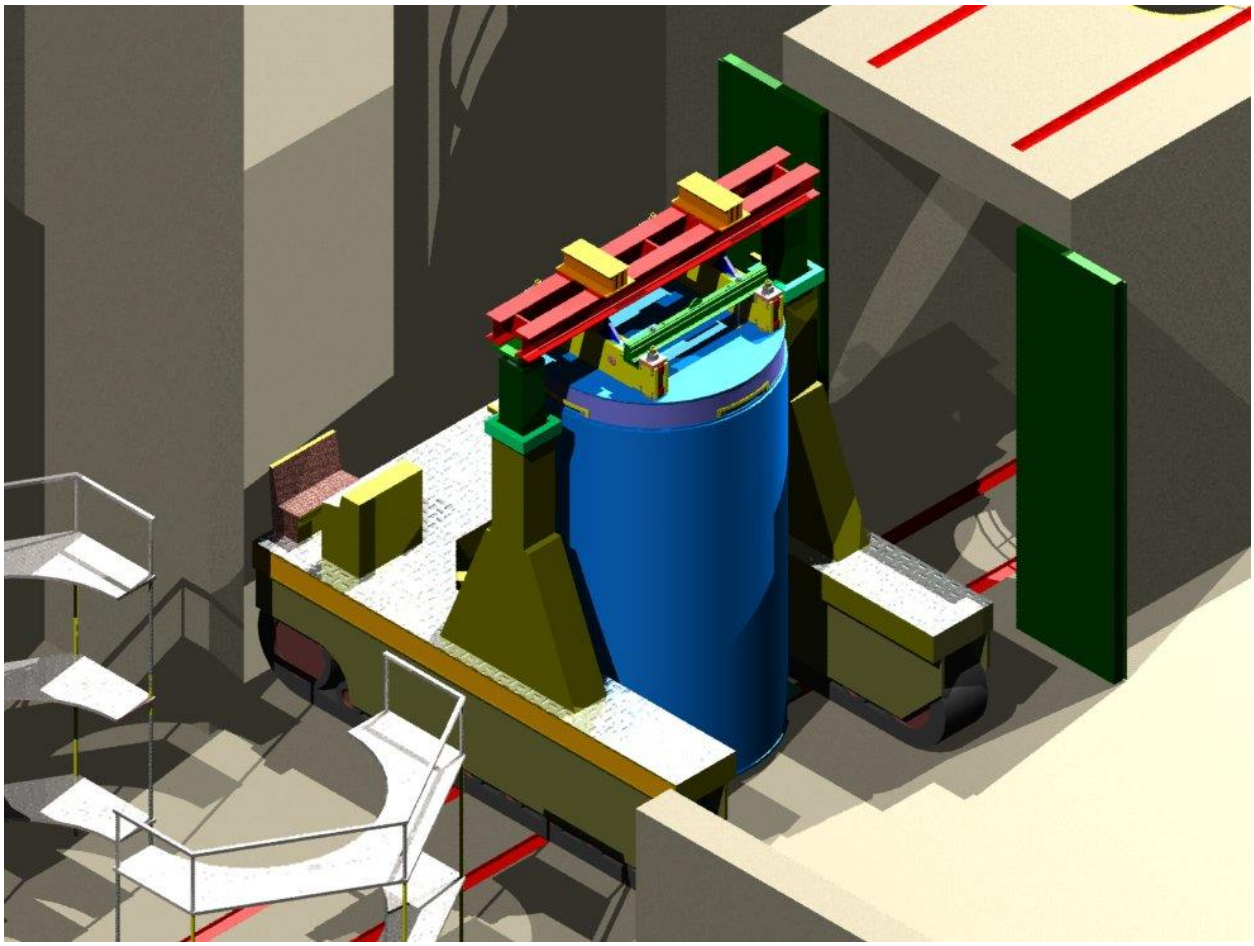


Figure 1.4.10 – **Gripper of the HI-STORM module by the vertical loader (crawler)**

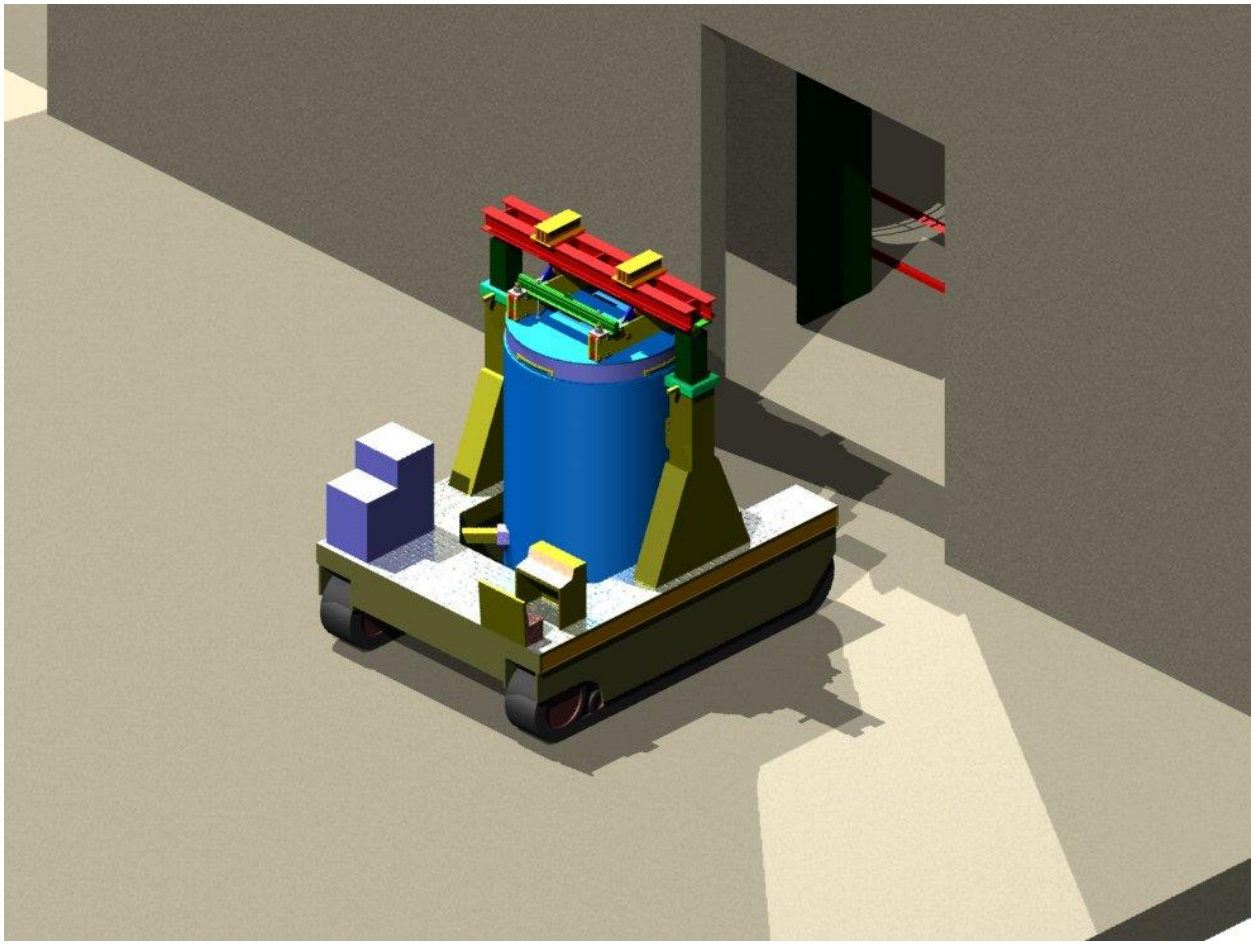


Figure 1.4.11 – **Transfer of the HI-STORM module from the receiving building to the storage area**

1.4.7 Preparation of the HI-STAR Overpack for Reuse

The HI-STAR transport overpack is removed from the transfer box and the closure plate of the transfer box is installed back. Any special inspections or tests are not required at this stage.

The HI-STAR transport overpack is prepared for shipment lowering it bottom firs. Then it is installed at the support plate, equipped with limiters of mechanical impact and is installed back on the railway platform. It means that all these operations are performed in a similar way as in acceptance of the HI-STAR transport overpack, but in the reverse order. The HI-STAR transport overpack is ready for shipment.

There is a list of operations, performed after SNF unloading into the storage overpack, on the HI-STAR transport overpack preparation for reuse:

- opening of doors of the transfer box;
- removal of the HI-STAR transport overpack from the transfer box;
- installation of a primary lid on the HI-STAR overpack;
- installation of a secondary lid on the HI-STAR overpack;
- installation of an empty HI-STAR transport overpack back on the railway platform together with fixing roads, limiters for mechanical impact (damping devices) and a barrier for personnel access restriction;
- issue of a shipment permit for the HI-STAR transport overpack.

1.5 Cask Storage Area

1.5.1 Assignment and Main Design Principles

The MPC is a basic element assuring nuclear safety during SNF storage at the storage area. The main technical decisions on nuclear safety ensuring at the storage area are intended for:

- ensuring of MPC protection from the environment external factors;
- ensuring of MPC protection from the environment external man-made factors, including diversion;
- isolation by the MPC neutron interaction with each other;
- ensuring of sufficient heat removal from the MPC.

The following technical decisions are proposed to ensure nuclear safety during SNF storage:

- the HI-STORM protective overpack, whose structure is designed for extreme impacts right up to aircraft crash, is used for the MPC storage. At the same time, the canister design and, correspondingly, the MPC remain undamaged;
- the HI-STORM overpacks are located at storage area with a step not less than 700 mm that excludes mutual neutron impact of two adjacent MPC;
- to exclude the storage area flooding, it is provided for a rainwater sewage system designed for water flow removal from the maximum daily precipitations within the CSFSF site;
- stationary continuous monitoring of temperature at the inlet and outlet of the HI-STORM vent ports reflecting the state of the MPC heat removal and, correspondingly, SNF;
- the CSFSF construction site (volume 1, Section 5) has been selected with low level and amplitude of subsoil water level oscillations that excludes accident initiators involving the site underflooding and, correspondingly, water ingress into the MPC through the HI-STORM vent ports;
- the site has been selected for CSFSF construction (volume 1, Section 5), located far from ponds and rivers, that excludes accident initiator involving the site underflooding and, correspondingly, water ingress into the MPC through the HI-STORM vent ports;

– in accordance with the design decisions, the storage site within the CSFSF protected perimeter is included into a specially important area, where personnel access without a permit is prohibited;

– CSFSF personnel makes rounds at regular intervals at the storage site to detect possible plugging of the HI-STORM vent ports and clean them timely;

– incombustible materials are used in storage site designing to exclude such an initial event as fire.

Stationary temperature monitoring at the inlet and outlet of vent ports allows monitoring possible helium leakage from the MPC. Considering availability of the stationary temperature monitoring system, there is sufficient time to take measures on removal of emergency MPC up to the moment when the temperature of FE cladding reaches the maximum accident threshold (570°C).

The air temperature at the inlet and outlet of the HI-STORM vent ports is monitored from the CCR in the receiving building with continuous attendance of the presence.

1.5.2 Description of the HI-STORM Overpack Storage Area

A cask storage area with spent nuclear fuel (storage area) is a complex designed and built for 100 years of spent nuclear fuel storage. The system of SNF storage in canisters will by applied in the CSFSF because such a system does not require transfer operations with separate SFA after loading and welding of canisters at the NPP site.

The site storage overpacks should be designed in accordance with the requirements for buildings of I category on nuclear and radiation safety in compliance with [18], and as a SNF dry storage facility - in compliance with the requirements of [51].

The design storage area will contain 12500 WWER-1000 SFA and 4000 WWER-440 SFA that will constitutes 458 HI-STORM storage overpacks.

The cask storage area includes:

- foundations for the HI-STORM;
- HI-STORM storage overpacks;
- roads for the crawler and service vehicles;
- mesh fence with retention means;
- lighting;
- radiation monitoring along the perimeter;
- raining sewage system.

The cask storage area is located within the CSFSF protected area. Its overall dimensions are 280×105m and represents 15 metal-concrete (monolithic) plates of 80×9m, 32 HI-STORM storage overpacks may be installed on each of it. Roads of 9,0m width are provided for between the plates for the crawler. Plates and roads are constructed with a slope for rainwater drain. Structures of the cask storage area are described in Section 6 of this volume.

Full capacity of the storage site will constitute 480 HI-STORM by storage overpacks.

The cask storage area will be commissioned in four stages: startup complex, I extension order, II extension order, III extension order.

The storage site within the startup complex will be three metal-concrete stripes, on which 32 HI-STORM storage overpacks may be installed for dry storage. The CSFSF startup complex provides for compact storage of 94 storage overpacks containing 2500 WWER-1000 SFA and 1080 WWER-440 SFA on site.

It is provided for to perform the subsequent extensions as follows: first order– 130, second - 128 and third - 106 storage overpacks.

The cask storage area includes the HI-STORM dry storage overpack, protection means (restricted by the mesh fence with barbed wire above, because the cask storage area is located within the protected area), lighting and monitoring system of storage overpacks.

The MPC metal tight canisters in the SFA storage system are applied to store a quantity of SFA in the monitored area. The welded metal canister is housed in the HI-STORM overpack that ensures shielding and meeting of the requirements on SNF physical protection during storage.

The storage system will meet the requirements on physical protection, heat removal, radiation shielding, monitoring of confinement during SNF long-term safe storage.

Design of the cask storage area provides with a possibility of free movement of the crawler to transfer canisters in the vertical position.

The following requirements should be met at the cask storage area:

- maximum permissible dose rate during monitoring operations, maintenance, repair and other operations during storage should be determined on the basis of calculating a sequence and durability of these operations under condition that dose limits given in [5] will not be exceeded;
- the cask storage area should maintain its functions in initial events of design-basis accidents [51];
- biological protection should be calculated with a double safety margin in accordance with item 3.4 [7];
- the conditions of temperature mode should be meet during transportation and storage, monitoring of this mode and exceeding of the maximum permissible temperature of FE cladding should be excluded under normal operation and in the event of design-basis accidents;
- conditions should be provided for to monitor integrity of protective barriers, process parameters, maintenance and repair of process equipment etc.;
- means for monitoring transfer of nuclear materials should be provided for;
- reparability of the cask storage area should be provided for during the whole life-time, considering climate conditions and radiological impacts.

The HI-STORM with MPC are completely passive systems, they do not require power supply, application of special equipment or direct monitoring.

The only one thing required to monitor the HI-STORM spent nuclear fuel dry storage overpacks is an everyday visual inspection of canisters in order to verify that vent meshes are not plugged.

A quantity of the activated material resulted in irradiation of the HI-STORM overpacks, while fuel is inside it, is brought to the minimum to reduce decommissioning costs maximally. The cask storage area design should facilitate decontamination of structures and equipment, maximally reduce amount of radioactive waste and contaminated equipment and facilitate removal of radioactive waste and contaminated materials. These objectives are the main during designing of the CSFSF and the site storage for canisters as its component.

Design of storage overpacks, whose external surfaces are completely faced with steel, facilitates decontamination work, if it is necessary.

ALARA principle requirements will be taken into account in designing the cask storage area. Some design decisions are indicated below:

foundations should have sizes allowing to have a sufficient distance between storage modules to allow workers to fulfill their functions efficiently during instillation/removal of storage overpacks on the foundations and during maintenance (for example, cleaning of inlet vent ports) and oversight. Availability of sufficient area will give a possibility to minimize time spent by the workers near the storage overpacks limiting, at the same time, dose loads on workers;

the cask storage area design is based on application of the MPC metal canister that is sealed automatically by welding for SNF confinement preventing radionuclide leakage from the canister. Thus, the design excludes possibility of radiation leakage. Under normal operation conditions there are no radiation leakages at the cask storage area . Such a passive system design requires also the minimum personnel maintenance and supervision;

- data collection on the temperature mode from the monitoring system of storage overpacks (if any) allows receiving remotely the information on the module mode without

everyday personnel rounds of facilities, measuring or reading of data from the instrumentation and control devices near the storage overpacks.

Figure 1.5.1 – **General view of the HI-STORM storage overpacks on the CSFSF site**

1.5.3 Handling of Damaged MPC

Helium leakages from the MPC are detected by means of temperature monitoring of air inlets (cooling channels) of the HI-STORM storage overpack. Significant changes in indications of temperature sensors will mean helium leakage and pressure drop inside the MPC. A decision is being made on the necessity to remove the MPC from the HI-STORM storage overpack. This HI-STORM containing the MPC loaded with SNF is transported by the crawler from the site to the transfer building. Then, the MPC is transferred to the HI-STAR transport overpack by means of the HI-TRAC transfer cask.

If a leakage from the MPC is detected, it is proposed to use one of five available HI-STAR transport overpacks for its isolation.

Damaged MPC is stored in the receiving building up to the nearest preventive maintenance at the NPP. Then, it is shipped to the NPP in the HI-STAR transport overpack; it is transferred there into the HI-TRAC transfer cask and is transported to the central hallmarking. A discharge procedure is reverse to the procedure mentioned above in describing of the shipping process.

The transfer cask with leaky MPC is installed in cooling pool transfer well. The MPC lid is removed by means of special equipment. Then, SFA are removed from the MPC one by one and are installed in the canisters of the detection system of damaged assemblies (DSDA), after that assemblies are installed either in the tight canisters in the cooling pool or in the cooling pool shelves.

The empty MPC has to be inspected. It is necessary to note that the MPC whose upper lid was unsealed using special equipment can be reused. After the MPC lid removal, it can be reused. The lid may be installed and welded repeatedly after removal.

1.5.4 Handling of Damaged SFA

In accordance with the Technical Specification data, according to the current technical requirements for discharged SFA (U0401.04.00.000.DKO, U0440.00.00.000.DKO, U0401.21.00.000.DKO*), failed SFA* are those that reached the rejection criteria, i.e. the iodine-131 specific activity level of water in KGO* stand has reached $4{,}0\times10^{-5}$ Cu/kg (in calculation to the moment of reactor facility shutdown) or according to FA mechanical integrity violations preventing its further normal operation. *Defective* FA includes all leaky FA detected during KGO and FA with design violations detected during examination.

A quantity of defective SFA (according to operation experience) constitutes 4-5% of the total number of WWER-440 SFA. Thus, a quantity of defective SFA to be stored in the WWER SFSF for design capacity is approximately 625 WWER-1000 SFA and 120 WWER-440 SFA;

Currently, defective SFA are stored in NPP spent fuel pools in tight canisters. Tight canisters are designed to house one cartridge without cover with leaky FE and to store for a long-term such a FA. Damaged SFA are identified prior to transfer and may be divided into two types: debris (that require special handling) and assemblies that mainly preserved their integrity (that can be handled using standard means).

SFA that preserved integrity can be handled according to the standard scheme but will be housed in one of the MPC cells equipped with a tube for damaged fuel.

The tube for damaged fuel is designed to house any components of fuel assemblies. It has thin stainless steel walls and a removable upper lid. Small sieves are installed at the tube ends that may retain any FA fragments without preventing water pump-down and helium circulation. The removable lid allows closing and raising the tube for damaged fuel. These tubes will be installed inside the MPC before the MPC installation in the cooling pool. The tube lid for damaged fuel is installed at the tube after its filling by means of remote manipulators. It is possible to install

* transliterated

up to 12 tubes for damaged fuel along the outer perimeter in MPC-31. Cells of the MPC fuel basket for tubes with damaged fuel have bigger sizes than cells for tight SFA, as a result, a total number of SFA installed in MPC-31 considering damaged SFA will reduce up to 24 pcs. Similarly, for MPC-85, a total number of SFA will reduce up to 78 pcs.

Figure 1.5.2 demonstrates the tube for damaged fuel housed in one of the peripheral MPC-31 cells designed especially for damage fuel. Technical characteristics of containers for damaged fuel are given in Table 1.5.1.

Table 1.5.1 – MPC technical characteristics for damaged fuel

Characteristic	Value
MPC-31 (WWER-1000)	
Internal dimension between hexagon sides	241 mm
External dimension between hexagon sides	244 mm
Cell height	4695 mm
Cells for tubes with damaged fuel (MPC-31)	
Number per MPC	up to 12
Internal dimension between hexagon sides	248 mm
Cell height	4699 mm
MPC-85 (WWER-440)	
Internal dimension between hexagon sides	150 mm
External dimension between hexagon sides	154 mm
Cell height	3356 mm
Cells for tubes with damaged fuel (MPC -85)	
Number per MPC	to 24
Internal dimension between hexagon sides	158.75 mm
Cell height	3385 mm

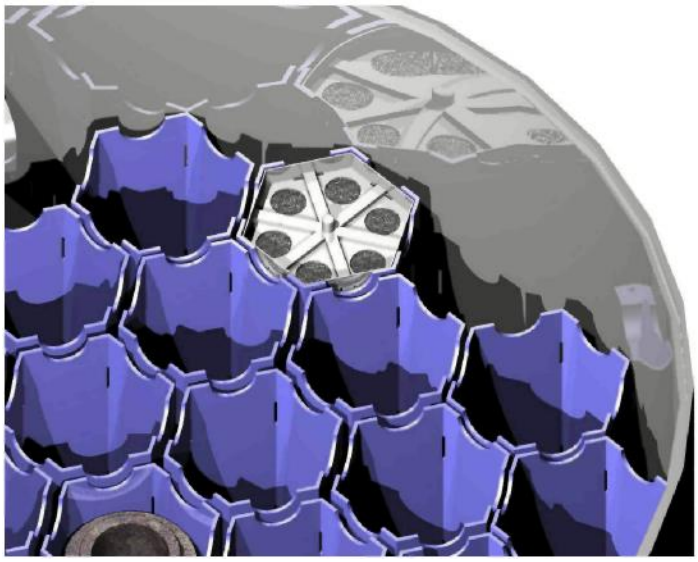


Figure 1.5.2 – Damaged fuel tube in MPC

1.6 Description of the Main Equipment

1.6.1 MPC Multi-Purpose Canister

In order to ensure nuclear safety in SNF loading and storage, design technical decisions have been proposed considering the specificity SNF storage in the CSFSF. The Holtec storage technology basic element is a multi-purpose canister (MPC) whose design ensures nuclear safety during SNF storage.

The MPC consists of an enclosure vessel and a fuel basket. General view of the MPC is given in Figure 1.6.1. The vessel is a two-layer cylindrical canister of corrosion-resistant steel with a baseplate, a lid and a closure ring designed in accordance with ASME requirements, Section III, Subsection NB (class 1). The MPC cylindrical canister is made of two rolled sheets, at the same time longitudinal welds of shells do not coincide (Figure 1.6.2). The inner layer of a cylindrical vessel and a lid form the first confinement barrier. The outer layer of a cylindrical vessel and a closure ring form the secondary confinement barrier. FE cladding was not considered to be confinement barrier in the MPC design. The MPC is a welded pressurized vessel that meets the requirements for transfer limits of ASME standards on caldrons and vessels under pressure, Section III, Subsection NB (class 1). Geometrical characteristics of confinement barriers are presented in Figure 1.6.3.

The MPC design includes special devices (bracing) that ensure SFA immobility in the MPC during transportation in the horizontal position.

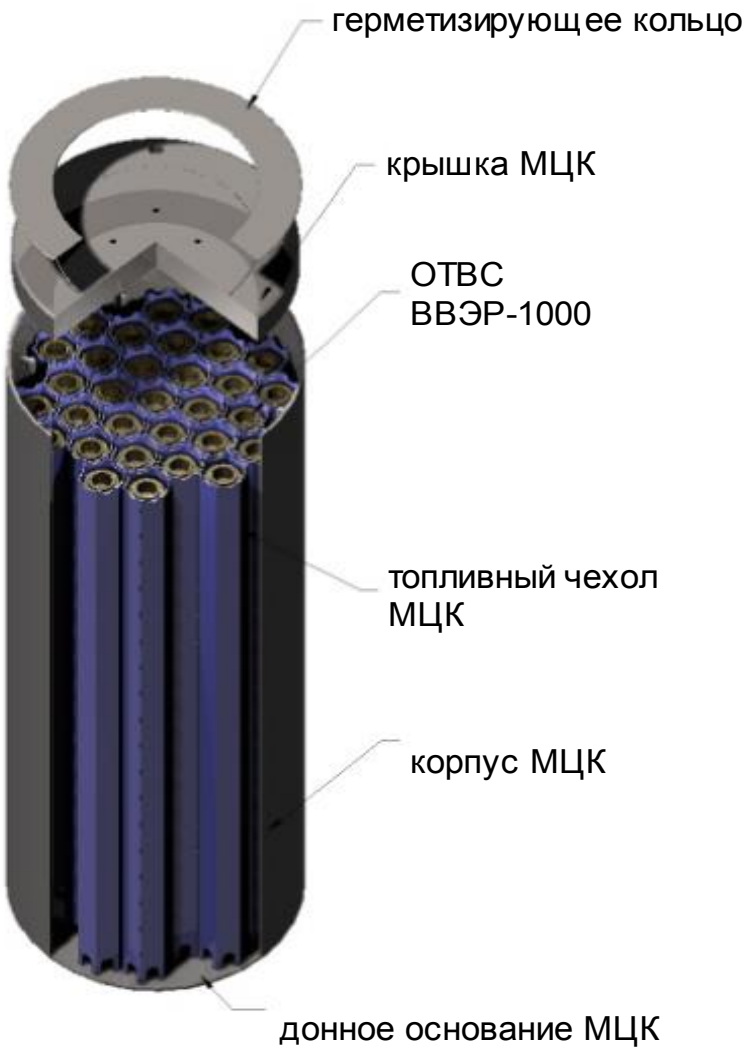


Figure 1.6.1 - **Multi-Purpose Canister. General view**

Top-down: closure ring, MPC lid, WWER-1000 SFA, MPC fuel basket, MPC body, MPC bottom plate.

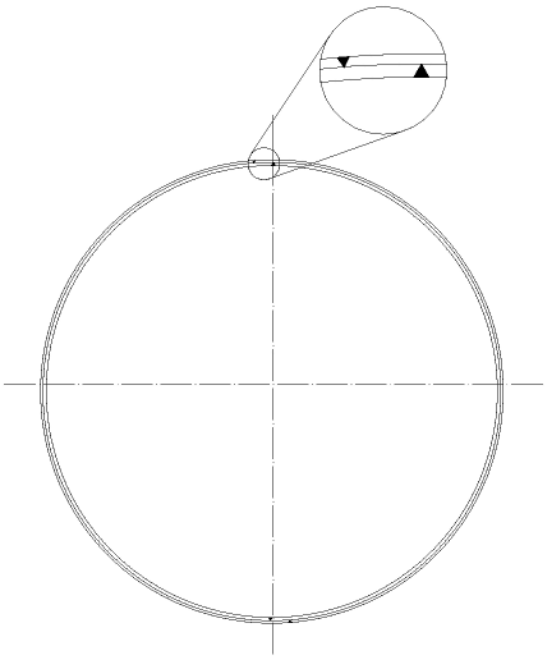


Figure 1.6.2 – **Arrangement of the MPC longitudinal welds**

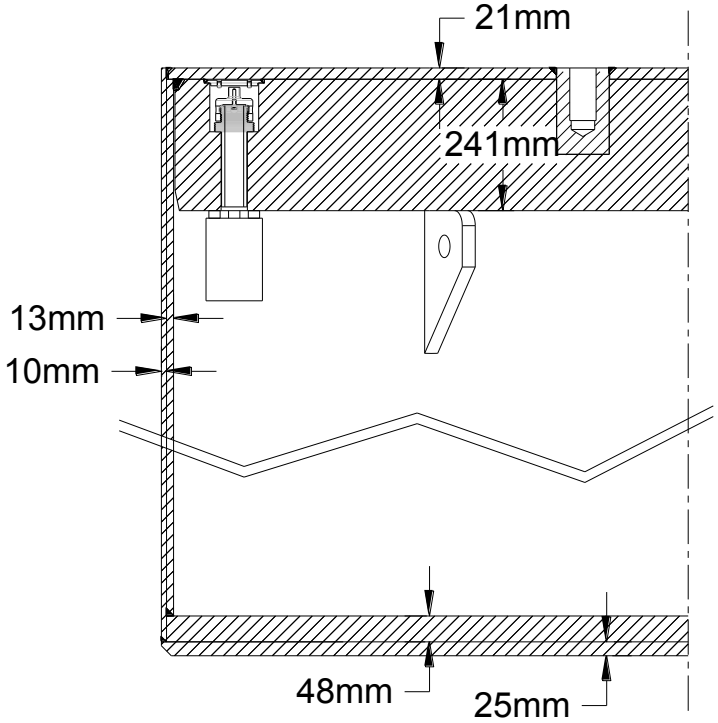


Figure 1.6.3 – **Geometrical dimensions of the MPC confinement barriers**

Design of a fuel basket allows housing WWER-1000 and WWER-440 fuel, including damaged fuel assemblies and fuel debris. Constructively, a fuel basket supports the spent fuel assemblies and removes heat generated by spent fuel to the canister vessel. A fuel basket provides also for meeting of the subcriticality criterion. The stainless steel MPC vessel ensures support to the fuel basket design and spent fuel assemblies. During storage, a two-wall cylindrical shell, a

baseplate, a MPC top lid, vent and drain port cover played, and closure ring made a double confinement barrier to prevent release of radioactive material from spent fuel.

A multi-purpose canister MPC-31 with capacity of 31 assemblies is used to store WWER-1000 spent nuclear fuel assemblies; MPC-85 canister with capacity of 85 assemblies is used to store WWER-440 fuel.

MPCs for WWER-1000 and WWER-440 SFA have the same external diameter (1782 mm) but different length. MPC-31 has total length of 5124 mm and MPC-85 is of 3765 mm length (Figure 1.6.4, Figure 1.6.5). Special spacers are used due to smaller length in MPC-85 transportation with WWER-440 SFA in the HI-STAR transport overpack that is multi-purpose for both MPC.

The main technical characteristics of MPC-31:

- capacity, SFA…...……..31;
- height, mm..……..5124;
- external diameter, mm…..……1831;
- internal diameter, mm…….……..1786;
- mass of empty MPC without lids, kg……8940;
- mass of empty MPC with lids, kg ……13390.

Main technical characteristics of MPC-85:

- capacity, SFA…..……..85;
- height, mm..……3765;
- external diameter, mm…..……..1831;
- internal diameter, mm……..……...1786;
- mass of empty MPC-85 without lids, kg …….8200;
- mass of empty MPC-85 with lids, kg …….12950.

The fuel basket in the MPC has a honeycomb structure generating hexagon cells for fuel storage. Walls of all cells in the fuel basket are structurally connected with walls of the adjacent cells. MPC fuel baskets are designed and tested on compliance with requirements on reloading limit in accordance with Section III, Subsection NG of ASME standards.

Hexagon adjacent cells of the fuel basket are connected in a way that the following is located between two SFA in the fuel basket: two sheets of heterogeneous absorber Metamic and two corrosion-resistant steel sheets. The MPC fuel basket is designed in a way to use completely heat conductivity of the Metamic material (six times higher than steel has). This decision allows reaching values of heat removal from the MPC in the vertical position to 40 kW.

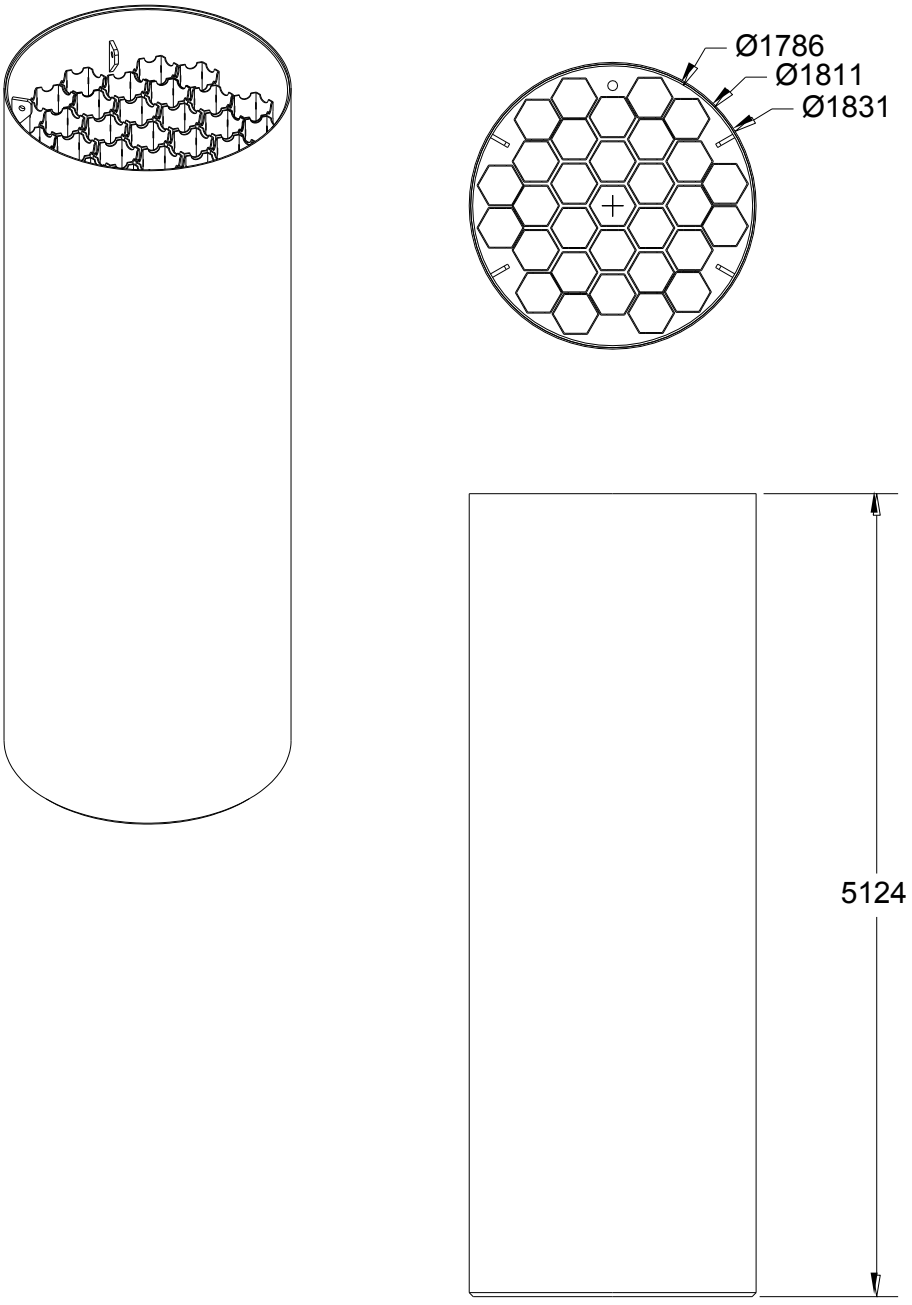


Figure 1.6.4 **– Multi-Purpose Canister MPC-31. General dimensions**

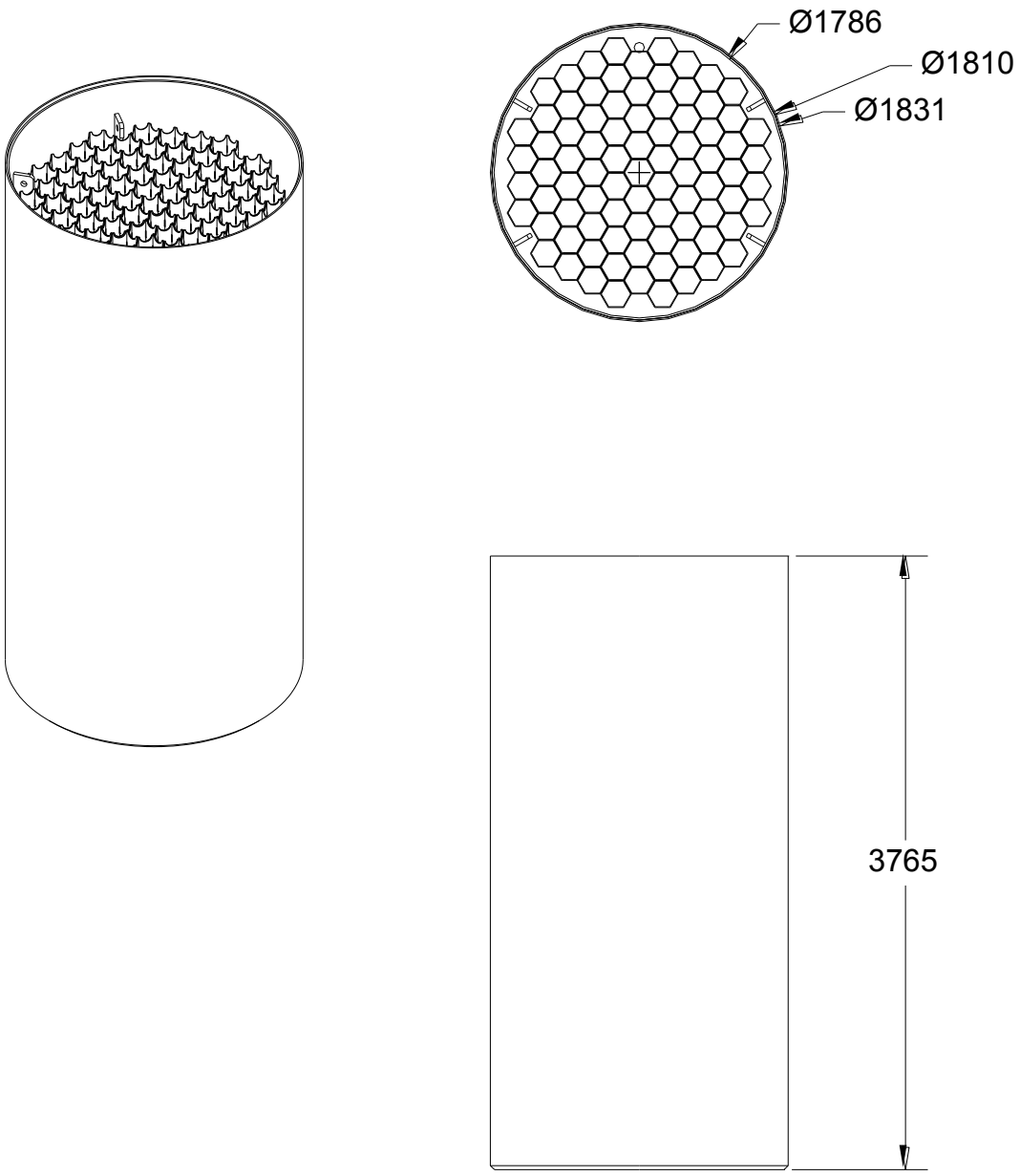


Figure 1.6.5 – **Multi-Purpose Canister MPC-85. General dimensions**

In addition to the MPC design features, in order to ensure nuclear safety in storage, the MPC after loading is dried and filled with inert gas (helium) under pressure of 4,2 kgf/cm^2. Under normal operation conditions, in thermal load in the MPC of 38 kW, the maximum pressure of 7 kgf/cm^2 is created in the MPC. After sealing of the lid and the closure ring during the MPC preparation for storage, the welded joints are tested for confinement by the helium detector. In accordance with the USA standards, the regulatory helium leakage 5×10^{-6} cm^3/s ensures that the possibility of the MPC confinement loss during storage will not exceed $3{,}71\times10^{-12}$ of leakages per welded joint.

In the MPC manufacture, all welded joints pass 100 % radiography. Each barrier is tested for leakages by means of the helium detector. The baseplate and longitudinal joints are welded in the MPC manufacture, welded joints of the MPC top lids are tested after SFA are installed in the MPC. Confinement barriers in the baseplate welding spots are submitted at Figure 1.6.6. Confinement barriers in the MPC lid welding spots are submitted at Figure 1.6.7.

Radioactive decay heat of SNF loaded in the MPC is removed from the HI-STORM storage and the HI-STAR transport systems by using passive means. None of the active cooling systems is used.

In order to ensure possible passive heat removal from the HI-STORM storage and the HI-STAR transportation systems, the following design decisions for normal operation conditions and design basis accidents are realized for the MPC design:

the MPC fuel basket has a Metamic honeycombed structure, where all cells are connected with each other to ensure free heat transfer;

the MPC welded confinement barrier provides with helium inside the MPC in regular, non-regular and emergency storage and transportation conditions;

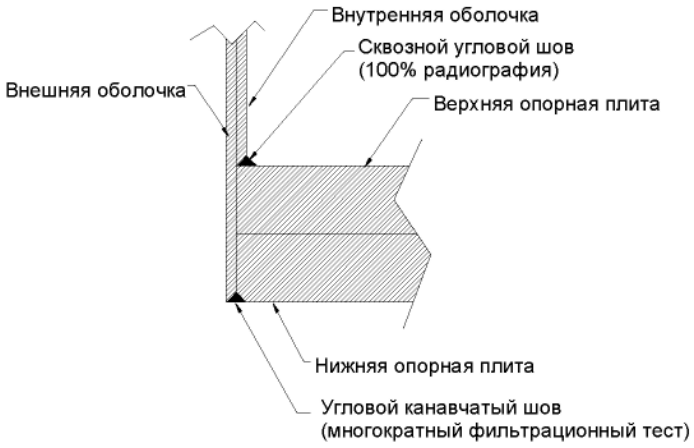
the MPC temperature mode keeps the temperature of FE claddings lower then the permissible temperature limits, that excludes damages of fuel claddings during fuel long-term storage;

the HI-STORM storage system has an optimal design of vent ports and the ring space between the MPC and the storage overpack, which reinforce airflow assuring radiation protection.

Air compaction in a ring gap between the HI-TRAC and the MPC prevents from contact of water from fuel cooling pools with the MPC outer enclosure and the HI-TRAC transfer cask inner wall in SNF reloading. Any residual radioactivity from water of fuel cooling pools stays inside the MPC confinement barrier along with spent nuclear fuel.

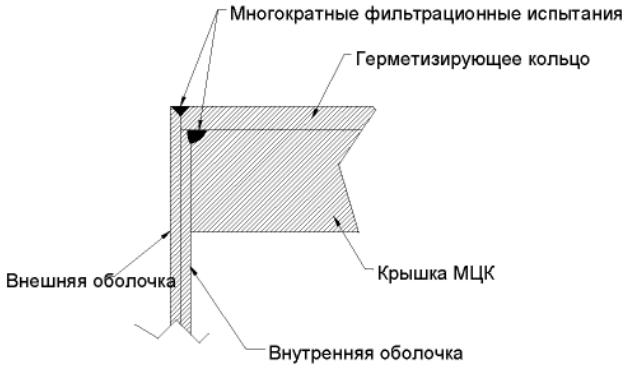
Defective (damaged) fuel assemblies or fuel debris are located in the MPC equipped with special tubes to store damaged fuel. Handling with damaged fuel assemblies is submitted in Section 1.5.3.

In case of the MPC seal failure, it should be removed (in the HI-STORM storage overpack from the storage area in the transfer building. Section 1.5.2 describes further handling with damaged MPC.



On the left: External shell. On the right, top-down: inner shell, through fillet weld (100 % radiography), upper base plate, lower base-plate, fillet grooving weld (repeated filter test).

Figure 1.6.6 – Confinement barriers of the MPC baseplate



Top-down: external shell (on the left), repeated filtering test, closure ring, MPC lid, inner shell

Figure 1.6.7 – Confinement barriers of the MPC upper lid

1.6.2 HI-TRAC Transfer Cask

The HI-TRAC transfer cask (abbreviation of the Holtec International Transfer Cask) is an interim (shuttle) container designed to contain the MPC during loading and sealing and for vertical reloading of the MPC from the transport overpack in the HI-STORM storage overpack. The transfer cask is equipped with a gate valve and a special biological protection means.

The HI-TRAC interim transfer cask – is a metal multi-walled cylindrical vessel with a removable lid and a rolling bottom plate/transfer lid (Figure 1.6.8).

The main mass of the transfer cask is a concentric three-layer structure (steel/lead/steel) to ensure structural strength and radiation protection.

The transfer cask structural material is carbon steel. The transfer cask outer shell is neutron shield. Neutron shield is a steel water jacket. Water and lead ensure the main shield from, correspondingly, gamma- and neutron radiation (Figure 1.6.9).

Colored carbon steel showed itself better then the stainless steel in view of possible decontamination.

Dimensions of the HI-TRAC transfer cask inner cylindrical cavity allow housing there the MPC (Figures 1.6.10).

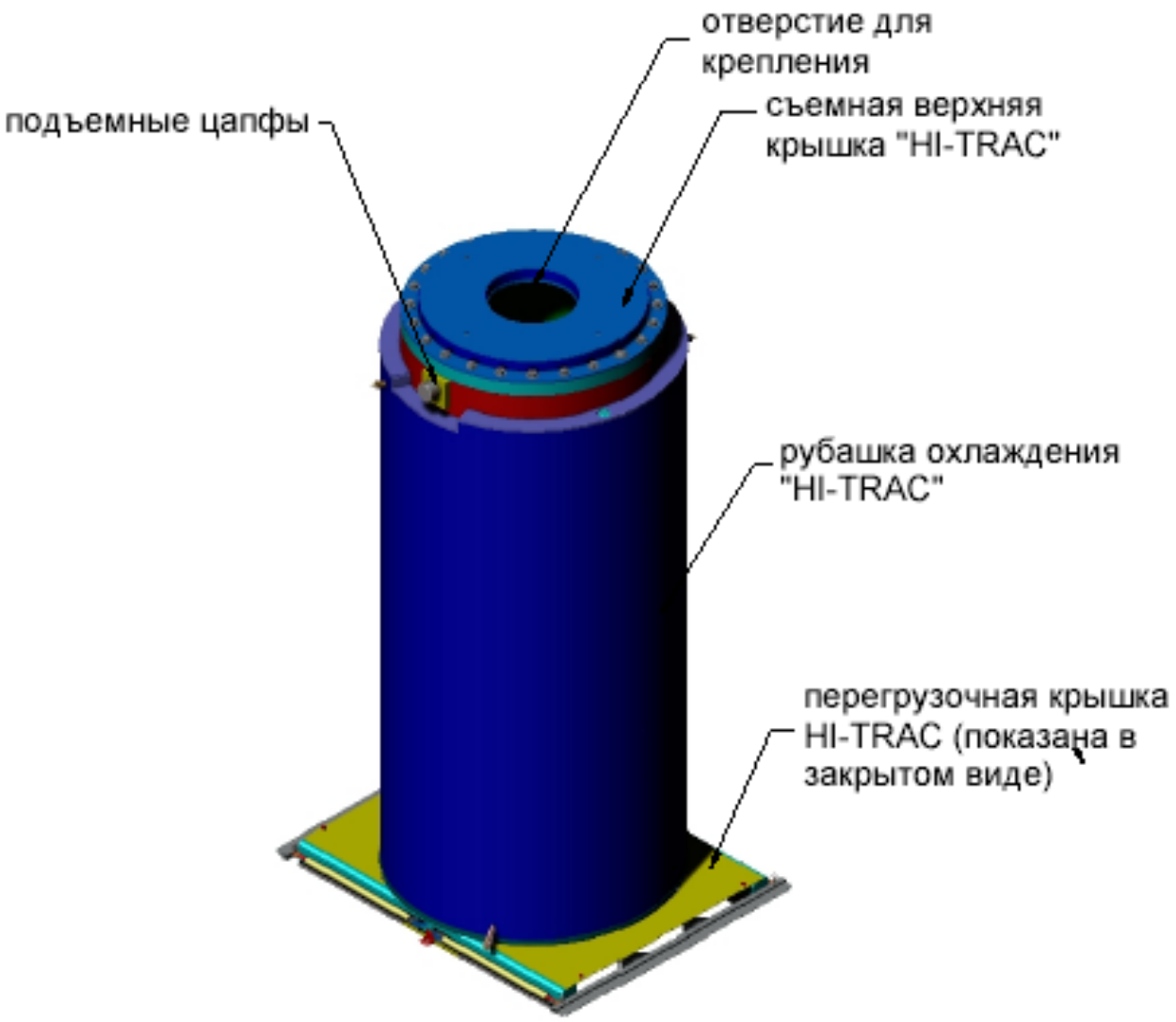
There are the main HI-TRAC transfer cask technical characteristics:

- height, mm..... 5302;
- outer diameter, mm 2429;
- bottom plate diameter, max., mm..... 2642;
- mass of en empty transfer cask, kg 65000;
- mass of the loaded transfer cask (with loaded MPC), kg…...95000.

The HI-TRAC transfer cask has a double-leaf bottom removable lid. The bottom lid is heavy steel sliding doors installed on the parallel guiding rails. The transfer door leafs overlap each other to stop radiation spread. Opening and closing of transfer shielding doors is carried out by using hydraulic cylinders arranged on each side of the bottom lid. Mechanical doorstops are used to fix doors in opening.

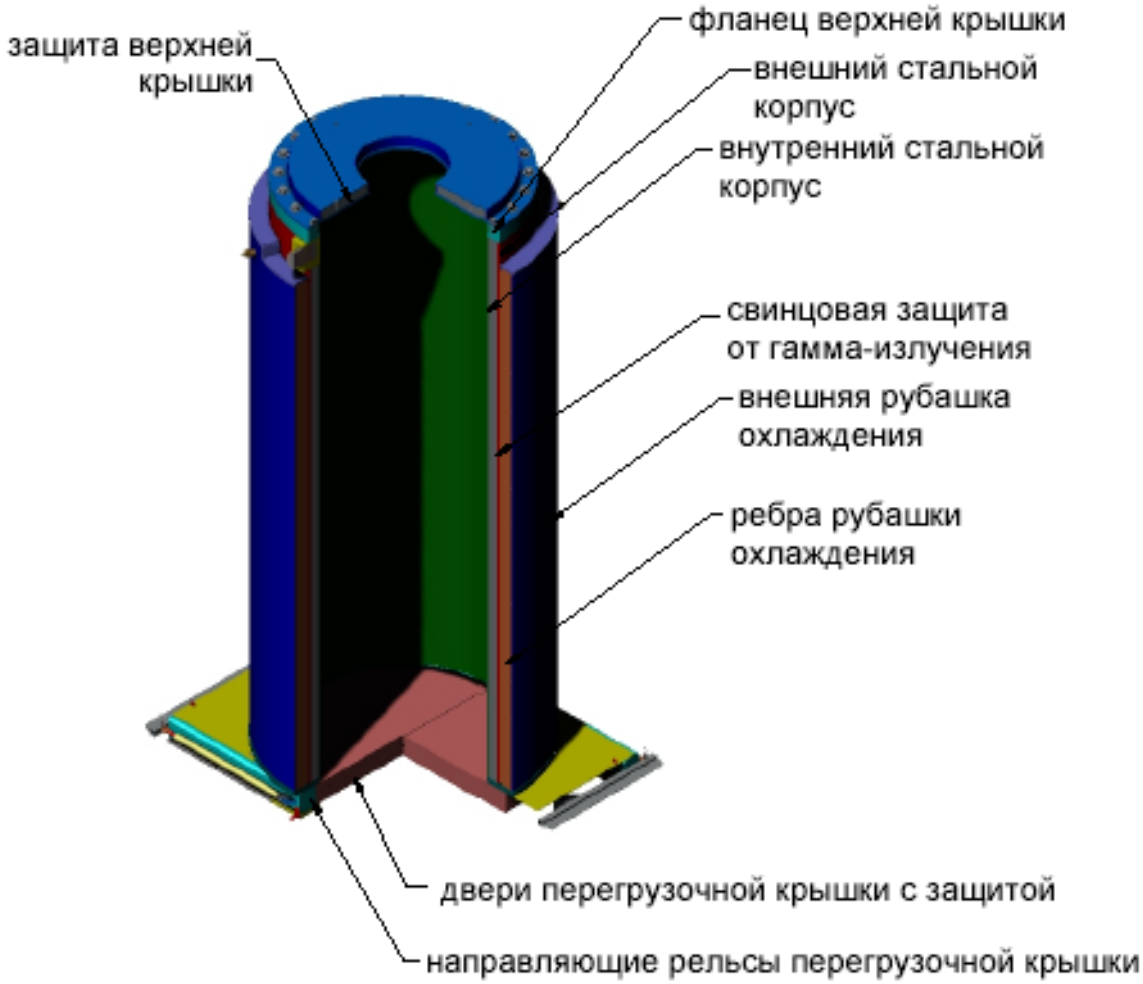
In order to diminish fatigue of guiding rails, they are installed in replaceable troughs assuring reduced friction. If it is required, all working components of the transfer lid may be removed for survey or replacement.

The HI-TRAC upper lid has an aperture for MPC lowering/lifting between the HI-TRAC and the HI-STORM.



Top-down: Lifting trunnions (on the left), fastening aperture, HI-TRACK removable upper lid, HI-TRACK water jacket, HI-TRACK transfer lid (closed position)

Figure 1.6.8 – **General view of the HI-TRAC transfer cask**



Top-down: Upper lid shielding (on the left), top flange, steel outer shell, steel inner shell, gamma radiation lead shield, water outer jacket, water jacket ribs, transfer lid doors with shielding, transfer lid guiding rails.

Figure 1.6.9 – **HI-TRAC transfer cask cross sectional view**

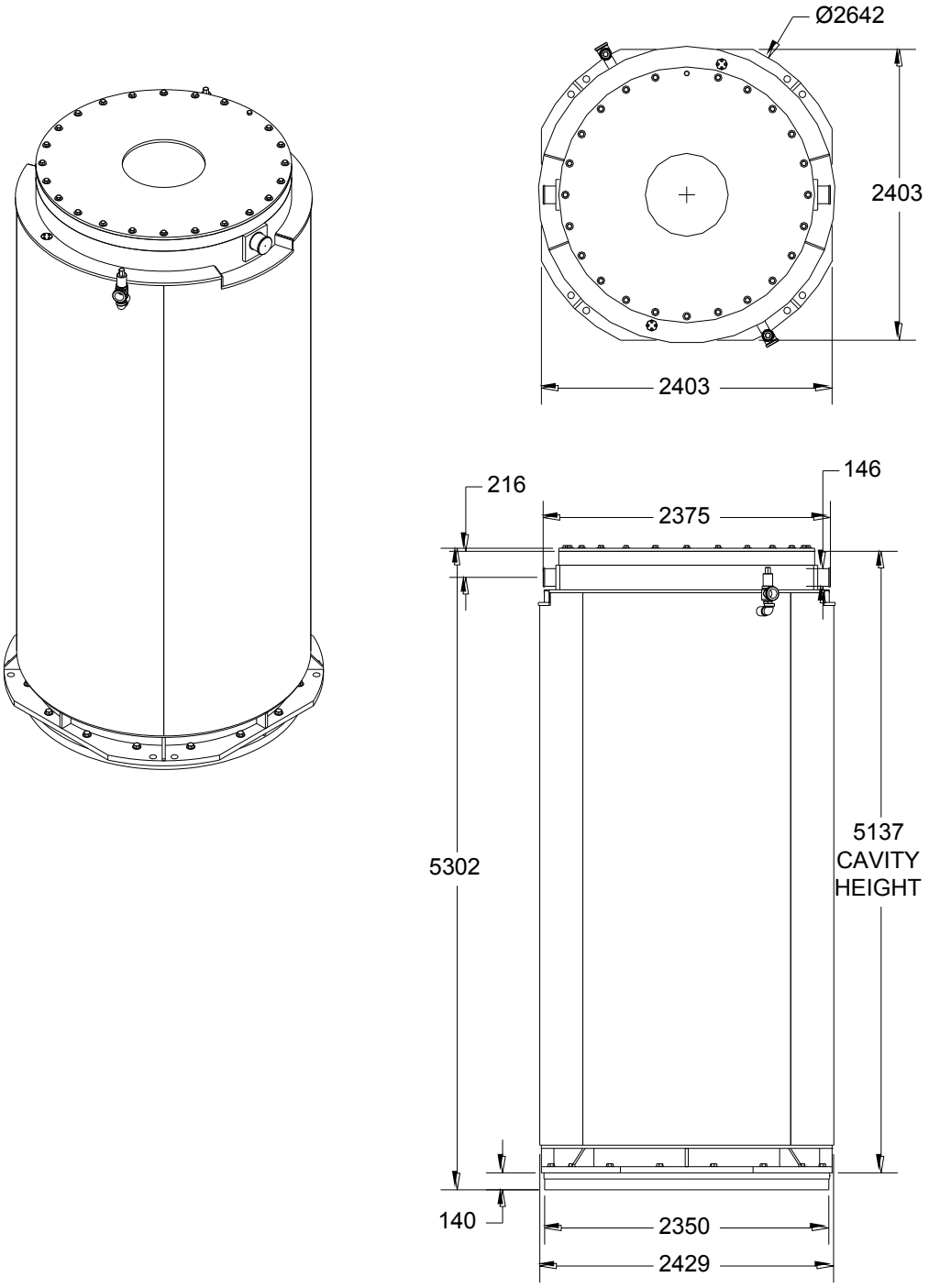


Figure 1.6.10– **HI-TRAC transfer cask. Geometrical dimensions**

1.6.3 HI-STAR Transport Overpack

A dual-purpose HI-STAR overpack of the Holtec International will be used for transfer of spent fuel loaded in the MPC from nuclear power plants at the CSFSF.

Nuclear safety in shipment is ensured by the technical decisions for the MPC. The HI-STAR overpack provides for the required conditions for the MPC protection in normal and emergency shipment conditions in accordance with safety requirements in the USA and it will be certified in accordance with the requirements of PBTRM-2006[2] at the subsequent stages.

During MPC transfer from NPPs to the CSFSF in a rail car, the HI-STAR with MPC is installed in the horizontal position, at that, special damping devices are installed on a lid and a bottom plate of the HI-STAR to protect in accidents.

The HI-STAR is a cylindrical canister consisted of a heavy-walled cylindrical vessel, a bottom plate and a lid (Figure 1.6. The main cutoff point between the overpack and a lid is pressurized with a bolt joint and is sealed with two pads. The HI-STAR is equipped with lifting trunnions to perform handling operations.

There are the main technical characteristics of the HI-STAR transport overpack:

- height, mm..... 6133;
- outer diameter, mm 2700;
- inner diameter, mm 1850;
- mass of an empty overpack, kg 107000;
- mass of the loaded overpack (with the loaded MPC), kg.....…37000.

Spent nuclear fuel is loaded in the MPC in the transfer well of the cooling pool and spent fuel pool of the NPP reactor compartment. At the same time, a welded sealed package (MPC) with SNF is being formed at each NPP within the inert gas atmosphere. The required dosimetric monitoring is performed at NPP for absence of contaminations on the MPC outer surface prior to their transfer to the CSFSF.

The welded MPC is housed in the HI-TRAC transfer cask and then is transferred in the HI-STAR transport overpack.

Since the transport overpack is not installed in the spent fuel pool, there is no contamination risk for its outer surfaces. That is why decontamination is not required.

On arrival at the CSFSF, the HI-STAR transport overpack is discharged from the rail cars and the MPC is reloaded directly without repacking fuel assemblies into the HI-STORM storage overpack. That is why there is no practically possibility for contamination spread in the CSFSF. The HI-STAR overpack decontamination at NPP or CSFSF is not required because this overpack does not coming into contact with water from the spent fuel pool or with spent fuel assemblies.

The HI-STAR overpack fulfills radiation protection functions: vessel walls have sufficient thickness to shield from gamma-radiation (Figure 1.6.8). Moreover, it is intended for the MPC physical protection from external impacts in normal operation conditions and design basis accidents during a storage period and shipment.

The HI-STAR transport overpack includes a neutron shield. The Holtite-A neutron absorber passed radiation and thermal tests under the temperature much exceeding the maximum temperature under which it is operated.

Holtec International analyzed the heat removal efficiency in order to assess efficiency of the heat removal form SNF in the HI-STAR transport overpack to confirm a possibility for its transportation in the horizontal position and to ensure the FE wall temperature in accordance with the regulatory requirements. The HI-STAR system heat removal was assessed in the radial direction for a medium section. The temperature of the fuel element wall is obtained as a result of calculations. The classical heat transfer calculation approach has been taken into account that considers the following heat removal mechanisms:

- heat removal from the overpack outer surface due to natural turbulent convection;
- heat transfer due to heat conduction of solid and gaseous materials that the MPC, transport overpack consist of or that include the MPC or the overpack;
- heat transfer due to thermal radiation between steams of surface-surface and surface-the environment.

The following boundary conditions have been accepted in calculations:

- the HI-STAR section with heat generation section are reviewed in the input model;
- thermosiphon effect is not reviewed in the input model;
- the minimum values of heat conductivity coefficients for structural materials are used in calculations;
- axial heat removal (trough) the MPC and HI-STAR upper and lower surface) are not taken into account in calculations;
- uniform heating of the HI-STAR overpack surface due to solar insolation is proposed in calculations;
- the input model supposes a circular gap to the diameter between cylindrical shells of the HI-STAR and the MPC (HI-STAR and MPC walls consist really of layers closely fitting each other);
- the calculation supposes maximum heat generation from SNF In the MPC - 30 kW, and the heat generation axial irregularity will constitute 1,1.

As a result of the analysis performed, the calculated temperature of the fuel element wall is 340°C, that is lower then the regulated temperature of the fuel element wall under normal operation conditions (350°C). This calculated value is obtained for SFA fuel elements located through the MPC center and have the worst temperature conditions relatively to periphery SFA. Thus, it is supposed that temperatures of SFA FE walls by periphery will lower then 340 ^{o}C.

In HI-STAR transport overpack certification in Ukraine, in accordance with the requirements of PBTRM-2006 [2], calculations will be made for WWER-440 SFA and WWER-1000 SFA. The HI-STAR meets all the requirements of the international standards as a shipping cask.

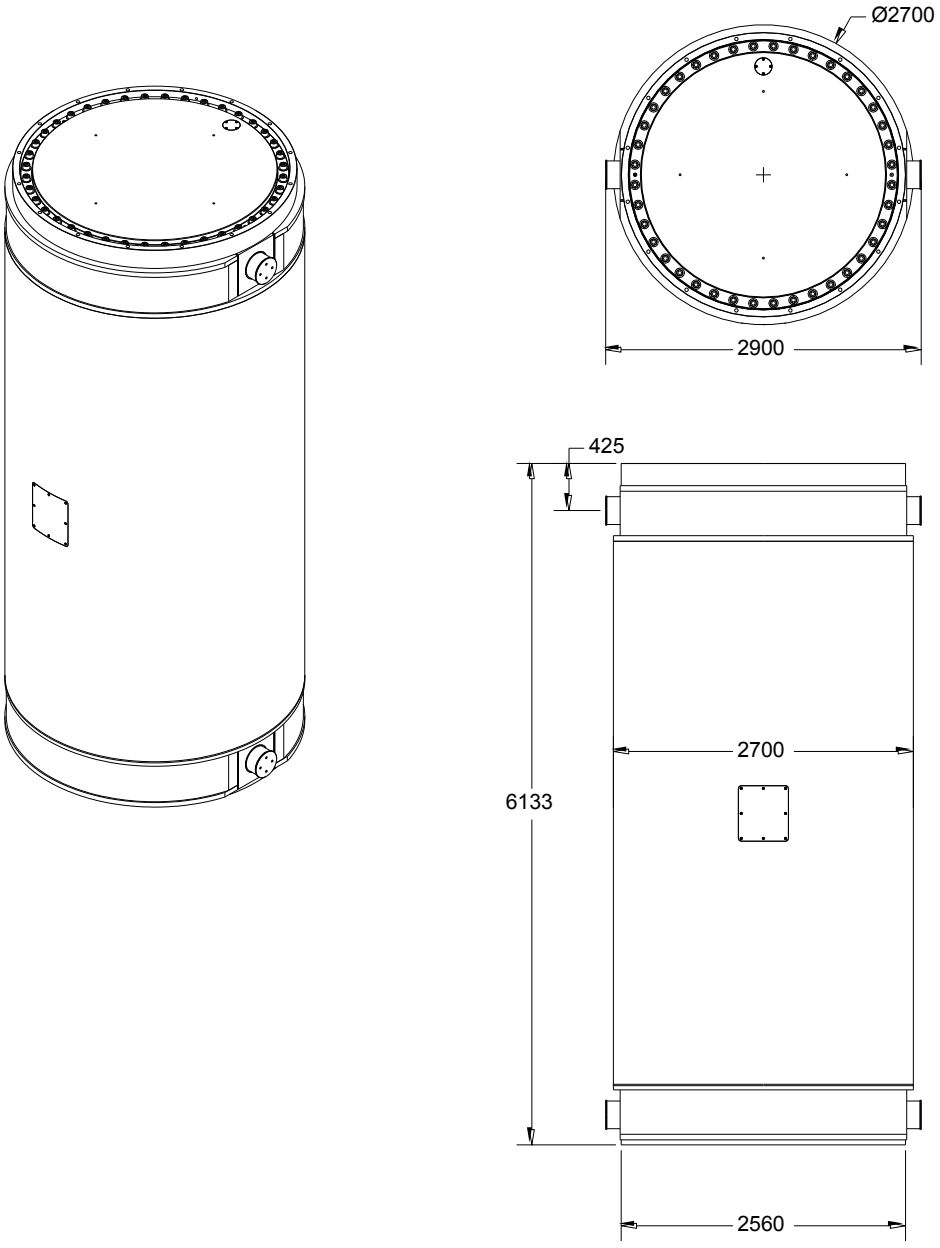


Figure 1.6.11 **– HI-STAR transport overpack. General dimensions**

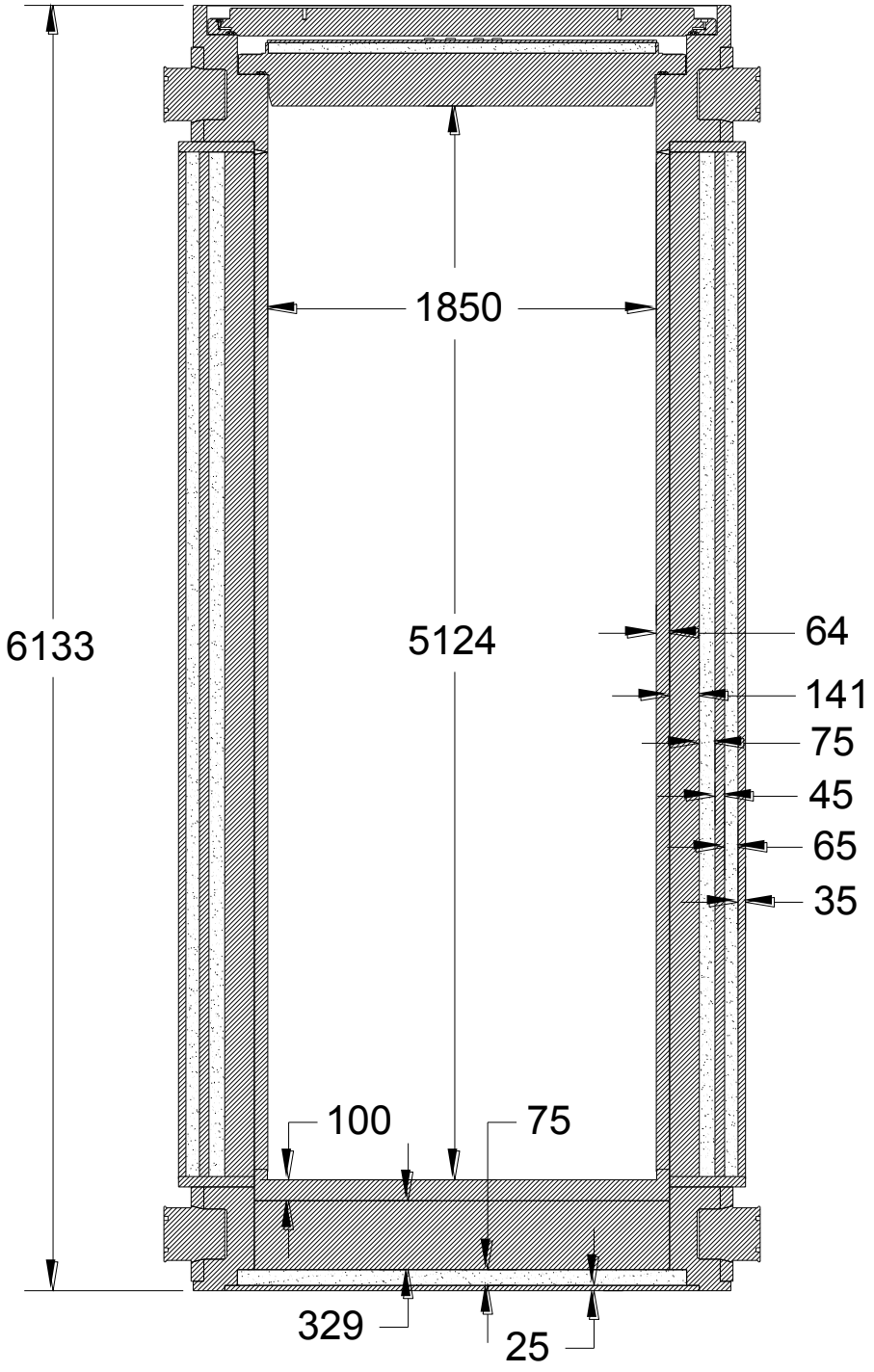


Figure 1.6.12 – **HI-STAR transport overpack. Dimensions of protection components**

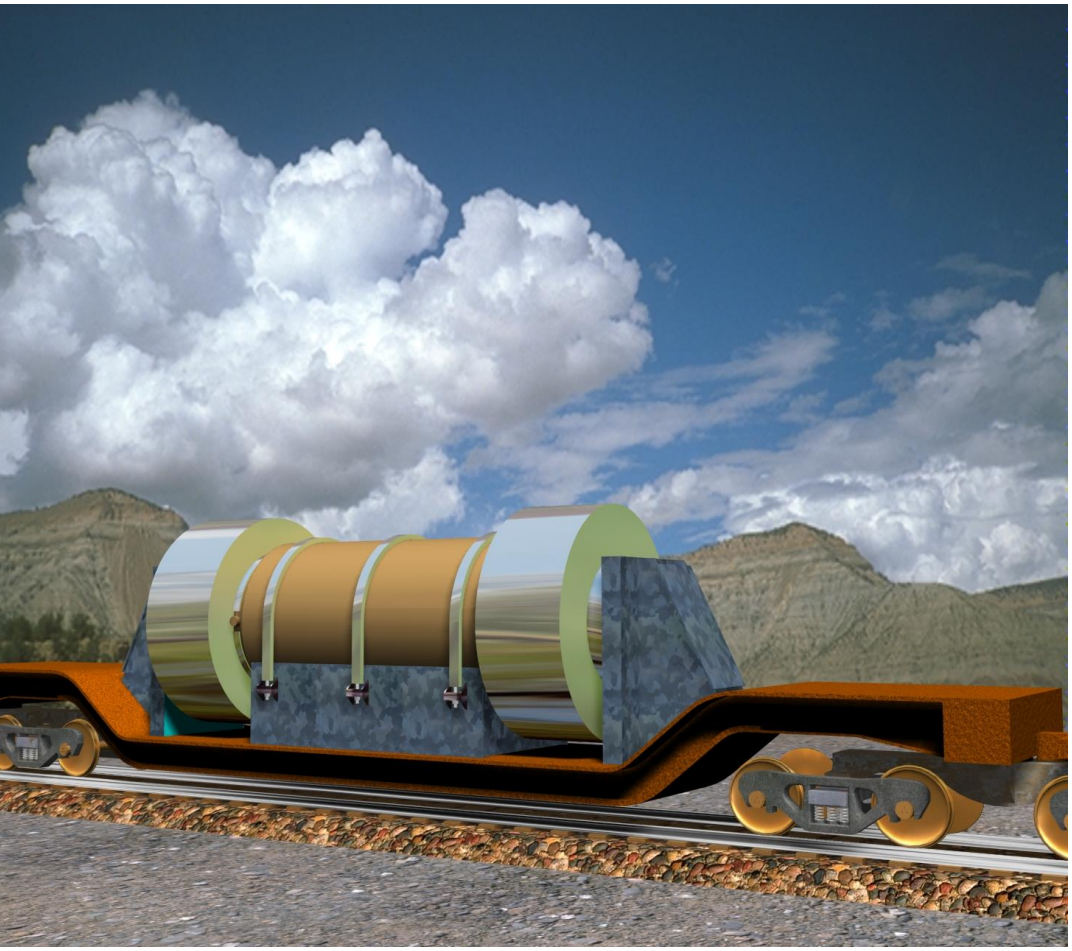


Figure 1.6.13 – **HI-STAR overpack (biological shielding for personnel is not presented). General view on the railway platform**

1.6.4 HI-STORM Storage Overpack

The HI-STORM system is the main decision of Holtec International to store SNF and other high-level waste.

The system developed by Holtec International consists of the following main components:

- multi-purpose canister (MPC);
- metal-concrete storage overpack (HI-STORM);
- transport overpack (HI-STAR);
- steel transfer cask (HI-TRAC).

Figure 1.6.14 describes the interrelation between components of HI-TRAC, MPC, HI-STAR and HI-STORM systems.

HI-STORM (abbreviation from Holtec International Storage Module) is designed for storage only and serves as biological shielding and a passive heat removal from SNF stored in it.

The HI-STORM is an independent system because it ensures isolation of SNF and nuclear materials, radiation shielding, keeping of fuel and passive heat removal subcriticality regardless of any other systems, structures or components. The HI-STORM required scope for monitoring and maintenance is minimum because the system is completely passive and is manufactured from materials designed for long-term use.

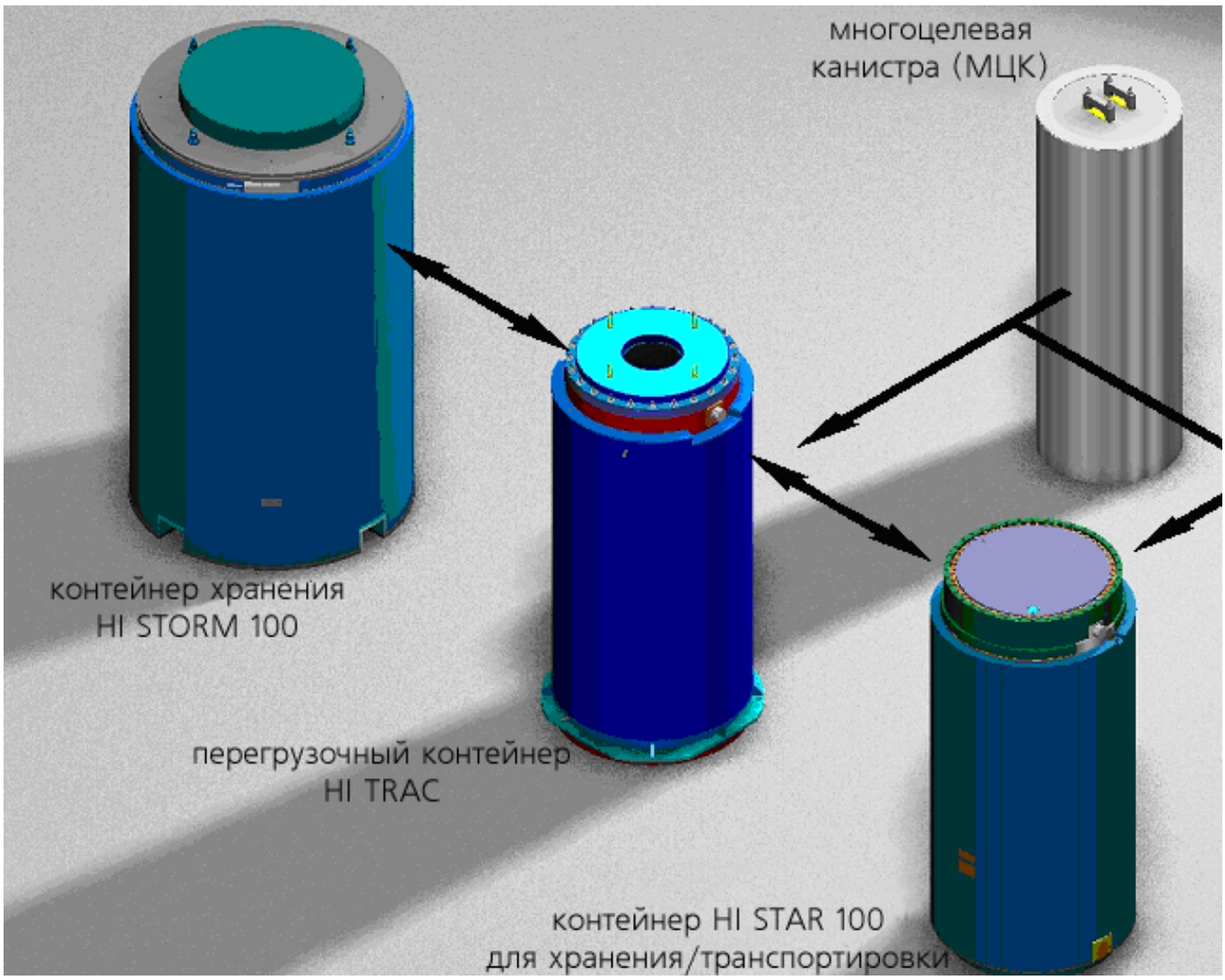
The HI-STORM storage overpack main task is to provide for the highest protection level from the MPC and the highest physical protection level of the MPC itself and its content from missiles etc. Figure 1.6.15 presents the scheme of protection levels.

The HI-STORM consists of a heavy-walled welded vessel whose cavities are filled with concrete (after its delivery to the CSFSF site) to ensure shielding properties. The HI-STORM general dimensions are given at Figure 1.6.16.

The HI-STORM cross-sectional view represents two concentric circles with total 50°-mm thickness of walls connected by radial gussets that stiffen the structure exclusively. From the bottom the structure is sealed with a steel plate with about 50 mm thickness and then it is filled with concrete with about 680 mm thickness.

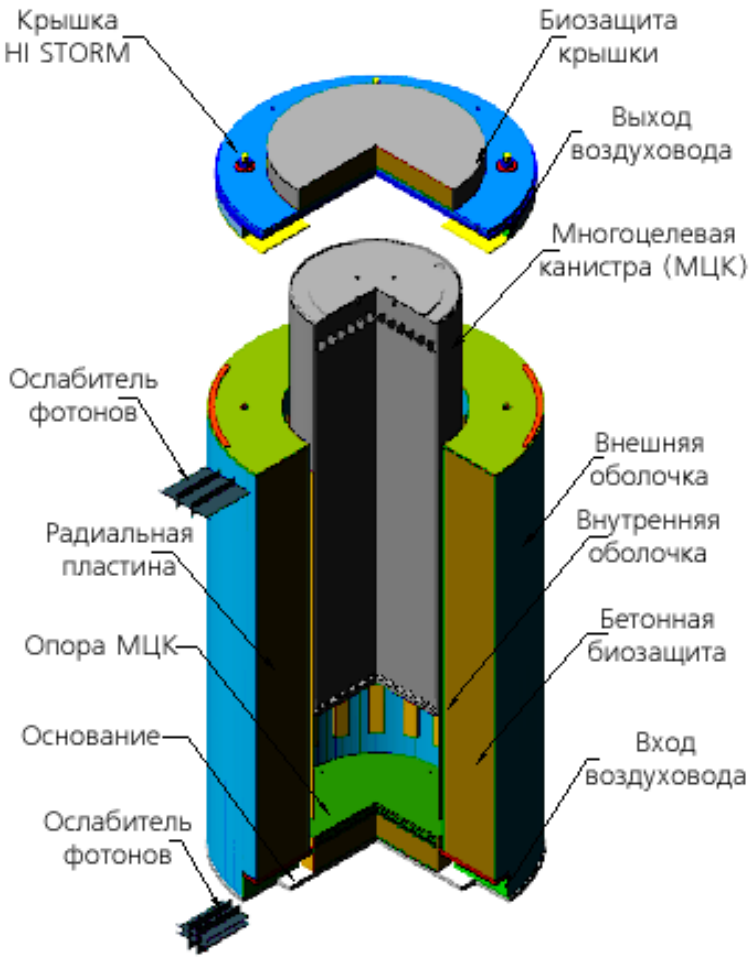
There are the main technical characteristics of the HI-STORM storage overpack:

- height, mm……..6227;
- outer diameter, mm…….3492;
- inner diameter, mm…….1959;
- thickness of the vessel inner wall, mm……..25;
- thickness of the vessel outer wall, mm……...25;
- thickness of the concrete filling, mm……680;
- mass of an empty storage overpack, kg……..136000;
- mass of the loaded storage overpack, kg…….166000



Top-down: Multi-purpose canister (MPC), HI STORM 100 storage overpack, HI TRAC transfer cask, HI STAR 100 storage/transportation overpack

Figure 1.6.14 – **Interaction system between components of the HI-TRAC, MPC and HI-STORM systems**



Top-down: On the left: HI STORM lid, photon reducer, radial shield, MPC bottom plate, baseplate, photon reducer/ On the right: lid shield block, exit vent, multi-purpose canister (MPC), outer shell, inner shell, concrete shielding, inlet vent.

Figure 1.6.15 – **System of shielding levels in the HI-STORM storage overpack**

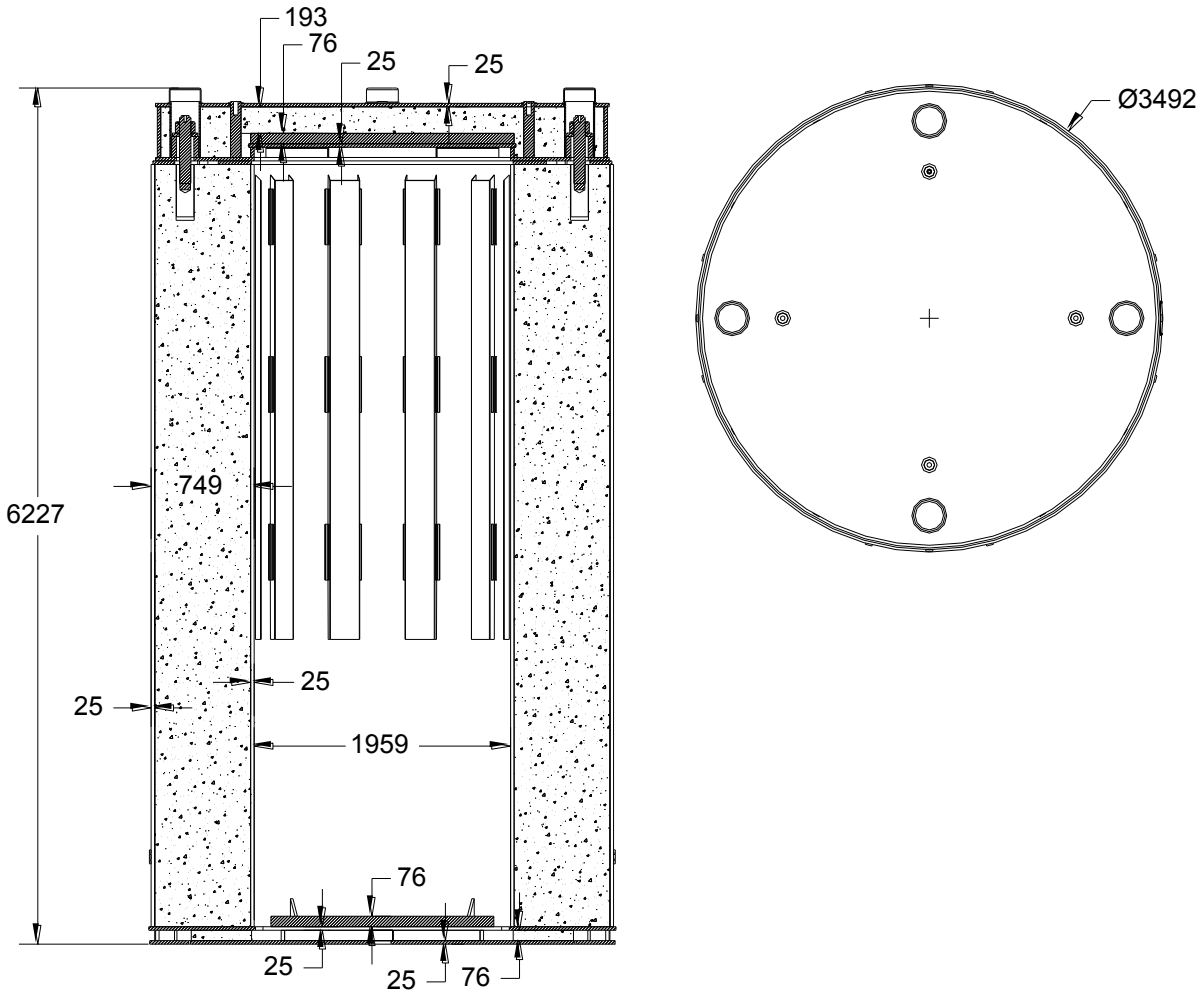


Figure 1.6.16 – **HI-STORM storage overpack general dimensions**

The HI-STORM reinforced carbon steel outer vessel was developed in accordance with the ASME requirements (Section III, Subsection NF). This vessel meets also the requirements established for nuclear power plant equipment. There are two concentric shells that serve as protective mass keeping vessel properties under exposure. This reduces a possibility of the vessel radioactive contamination to minimum and allows reuse it. It is a solid steel welded outer vessel that protects the concrete structure from external impacts and prevents worsening of a state and properties of concrete, which may be caused by weather conditions. A special geometric structure of inlet and outlet vent ports prevents radiation flow. A protective inner shell reduces the operating temperature of the concrete shield and reserves functional efficiency of the overpack. Antiseismic characteristics provide for stability of the overpack on sites and are specified by high seismic activity.

In order to facilitate the task regarding shipment of HI-STORM 100S, the concrete biological protection is concreted after shells are delivered at the site.

The HI-STORM 100 finished lid is delivered at the site simultaneously with the shell.

The HI-STORM structure has no reinforcement. A heavy steel lid with concrete filling is bolted up. The overpack has the required level of biological protection and the required design durability to protect its content from natural events, in particular, from wind load or flying objects raised by tornados. Guides, which facilitate the MPC insertion and removal, are attached to the HI-STORM inner shell. The guides absorb impact loads in a postulating event "turnover" and ensure free circulation by the air-cooling module.

Concrete has protection properties and mitigates both gamma- and neutron radiation. However, it is susceptible to cracking event in insignificant tension loads, this is totally impermissible for biological protection materials. On the other hand, steel is a solid flexible material whose percent elongation before break exceeds 15% (i.e. it is very cracking resistant) but at the same time, steel is inefficient in neutron absorption.

A steel welded structure takes upon itself all mechanical loads while concrete is the main barrier against radiation. Complete encircling of concrete with steel will create an additional advantage – concrete protection from rainwater, frost, and saline mediums.

Application of the inner carbon shell will allow reducing concrete temperature preserving its properties during the whole lifetime of overpacks.

The welded structure, encircling concrete, performs bearing functions. Therefore, it is excluded a possibility of durability loss following concrete fatigue under weather factors. The necessity is eliminated in performing very complex activities on armature installation in field conditions. All inner and outer surfaces of the low-carbon steel HI-STORM are covered with a protective coating resistant to the high temperature, radiation and flaking-off.

The overpack inner surface is outfitted with shock–absorbers to minimize loads on the MPC in the postulated event "turnover".

The HI-STORM system is a vertical ventilated structure that creates conditions for passive air cooling of MPC housed in it.

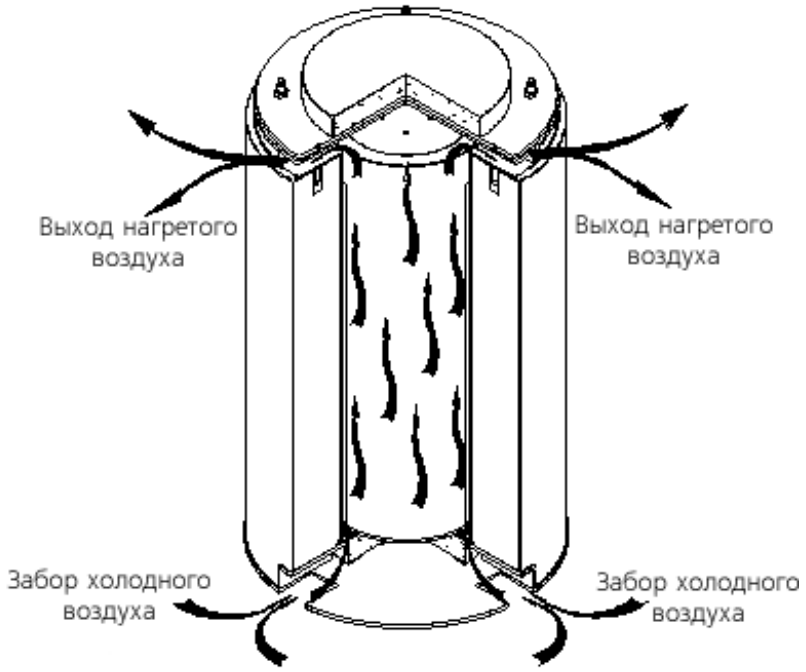
The overpack has four air inlets that create conditions for the MPC passive air cooling (Figure 1.6.17). Photon reducers are installed (a device registered by the Holtec International) in air inlets that decrease radiation release outside. Outlets are closed with small mesh that prevents penetration of insects and rodents.

The HI-STORM is outfitted with lifting slings that allow lifting it by the upper lid (by means of the crawler or crane). The overpack may be lifted by the lower lid as well – by means of jacks, air bags and rollers.

The HI-STORM overpack is assembled directly on the CSFSF site as follows:

1. The HI-STORM vessel (shell) is discharged from the railway platform using an autocrane. After reloading, the HI-STORM shell is located in a vertical orientation in a workshop for manufacture of overpacks and is installed on an assembly plate.
2. In order to facilitate access to the upper part of the HI-STORM overpack, portable or standard scaffoldings are installed.
3. The shell is installed, which does not admit ingress of foreign materials to protect the HI-STORM overpack inner side from ingress of concrete.
4. Concrete batch is realized at the concrete factory on-site by the receipt and in accordance with the design criteria established by Holtec International. A concrete layer on the HI-STORM overpack serves mainly to protect against exposure, that is hwy it is reasonably to use such high-density admixture as hematite to improve density and radiation protection properties.
5. Concrete is delivered on the site in a concrete hauler and is underpoured in cavities between the HI-STORM overpack inner and outer shell by means of the concrete hauler pump. In order to avoid creation of cavities in concreting, vibrators are used. Each of the shell chambers is concreted up to the top.

6. Then, efficiency of the HI-STORM overpack biological protection is tested using the nondestructive inspection method.
7. After cleaning of the HI-STORM overpack surfaces, lids and different auxiliary components such as input vent devices are installed. Therefore, the complete assemblage of the HI-STORM overpack is performed on-site including painting, if necessary.
8. When the required time for concrete cure expires (i.e., 28 days), the overpack is ready to be tested.
9. After completion of installation and tests, a “Component availability act” is drawn up for use (overpack certificate).
10. Empty HI-STORM overpack is delivered to the interim storage area by means of the crawler.



Top-down: heated air outlet, cold air inlet.

Figure 1.6.17 - **Cooling system by means of natural convection**

1.6.5 Special Auxiliary Equipment

After completing the MPC filling in the spent fuel cooling pools at the reactor site, the MPC is welded, dried, and filled up with gas.

For this purpose the following special non-production equipment is used:

- an automatic welding system;
- an installation for draying and filling with gas;
- a system for detecting leakages to check the MPC tightness.

The automatic welder is used for welding. A system for detecting leakages is used to check the MPC tightness. All the stated equipment is briefly described in the following Sections.

Automatic welder

The automatic welder is standard welding equipment manufactured by Holtec International and used for MPC welding and confinement. This is a high-speed welder that may weld the MPC lid in about 10 hours, including monitoring of welded joints etc.

There are the main components of the automatic welder: a welding robot, a control panel and a power supply source. The robot is installed on/over the MPC by means of the bridge crane and operators control this robot remotely from the control panel of welding operations.

The automatic welder in the half-automated mode welds the MPC lid to the vessel, as well as the closure ring. Operators control robots from the control panel and observe the robot's work by means video cameras, installed in a welding position. Cameras represent a few images of welding operations, as well as display a general view of a welding area. All pictures are displayed at the control panel. The automatic welder has also an embedded speaking device with headphones allowing the control panel operators to communicate with the operator at the working platform. The automatic welder uses argon for welding. As a result of welding, any smoke is generated, however, this device has the high-performance air filter HEPA system to remove excess welding gas and gases from the MPC released before the MPC confinement.

System of drying/filling with gas

After the lid is welded to the vessel, there is the MPC drying (vacuumizing or forced drying with helium) and filling up with helium. The installation for drying and filling with helium tested by the Holtec International is used for these processes.

This installation includes a vacuum pump designed specially to remove moisture, connectors to attach the MPC to the system for drying and filling with gas, control equipment to monitor operations of drying and filling with gas, reference valves, a gas consumption measurement system to monitor the MPC filling with gas as well as necessary hoses and pipelines.

During drying and filling with gas, the installation is placed at a traveling service platform and is rolled to the MPC. This installation is attached to the MPC by flexible conduits. The MPC is vacuumized to remove gases and residual moisture that may be in fuel assemblies or in the canister. After verified completeness of moisture removal, this supposes that the MPC was in vacuum during 30 minutes, a usual quantity of helium, which is used for SFA long-term storage, is injected into the MPC.

Helium and nitrogen are used in this installation. Helium is used to fill the MPC after complete removal of moisture from it and nitrogen is used to bleed a vacuum pump after completion of the drying cycle and its operation.

Equipment for detecting helium leakages

Helium leakage tests from the welded joints should be carried out after welding of joint strips and after nondestructive tests.

A mass-spectrometric detector of leakages (MSDL) is used to check integrity of tight and confinement systems.

The MPC confinement is checked at the manufacturer to assess welded joints on the vessel and the support plate.

The HI-STORM 100 system does not require the MPC leak-tightness tests except the above stated.

However, such tests may be carried out simultaneously with leak-tightness tests of welded joints connecting the canister lid to the vessel and welded joints fastening lids of forcing and drain ports.

Leak-tightness tests are conducted in the following way. After the MPC are filled with helium, appropriate equipment is disconnected from the canister. Lids are installed and welded on the forcing and drain ports.

Lids of ports are equipped with two in-bodied screws. Helium is forced inside through one of ports of the in-bodied screw. At that, air is forced out through the other port. The abovementioned in-bodied screws are installed to keep the helium atmosphere inside the cavity. Further, a welded joint covers all port of the in-bodied screw and a helium sensor is installed.

A closure ring is installed on the MPC, is than aligned, fastened, and completely welded, creating by this excess canister tightness. Tack welds are monitored visually and a root weld undergoes tests.

The MPC closure ring has small opening to test welded joints of the MPC lid and lids of forcing and drain ports. A helium leakage sensor is installed over this opening and all sealing joints of the MPC are checked. The total leakage speed through joints of the shielding plates and the lid should not exceed 5×10^{-6} cm^3 per second.

On completion of helium leakage tests, a test port is welded and a joint generated as well as a joint of the closure ring are tested. After that, smears are taken from the MPC lid and accessible parts the upper shell to detect the removable contamination; dose rate from the HI-TRAC is measured. The welder and the ring-type biological shielding are removed.

The MPC tightness criterion, that is, the maximal total leakage of the whole MPC (but not confinement of welded joints of the upper lid and the closure ring), is decrease of pressure and increase of temperature, what is identified by the temperature monitoring system.

The MPC is filled with helium under pressure of 4,2 atmospheres. In heat loading of the canister in 38 kW, gas pressure will reach about 7 atmospheres. The maximal temperature of fuel element cladding, which corresponds to this pressure, will make up about 358°C. In helium leakage from the canister, decrease of pressure at each 6,9 kPa will result in increase of fuel maximal temperature in about 2 C^o. The rated free volume of the MPC will be about 10,5 m^3. Thus, helium leakage in volume of 0,1 m^3 will correspond to an increase of the maximal temperature of the fuel element cladding in 2 C^0. Consequently, considering availability of the stationary temperature monitoring system, there is enough time to undertake measures on elimination of emergency MPC before the moment when the temperature of the fuel element cladding will reach the maximum accident limit (570^oC).

1.6.6 Maintenance of HI-STAR, HI-STORM and HI-TRAC Overpacks

The HI-TRAC transfer cask, HI-STAR transport overpack and HI-STORM storage overpack are absolutely passive equipment. Any active components and monitoring systems are not required to ensure fulfillment of their safety functions. During the whole lifetime, these systems require only minimal maintenance and such maintenance will be caused mainly by environmental conditions at the storage facility site.

A typical operation in maintenance will be repeated anti-corrosion covering on accessible external surfaces. It is required also to check visually air intakes to approve absence of air inlets blocking that prevent air entering to inlet and outlet vent ports (or, instead of this, it is possible to use temperature mode monitoring sensors as well).

The HI-TRAC, MPC, HI-STAR overpacks are checked visually, their lifting trunnions and tested, as well as recesses for grippers in lifting to tensile strength before each regular fuel loading in accordance with the operating instructions. The objective of tests is to detect cracks, deformations, or fatigue markings. In detection of unacceptable defects, it is required to conduct repair or replacement in accordance with requirements of the instructions. Load testing of lifting trunnions of the transfer cask is carried out annually or before use of the HI-TRAC transfer cask, if the interval between using the HI-TRAC transfer cask is over one year.

The HI-STORM storage overpack does not require maintenance. In the CSFSF operation, storage overpacks should be inspected and any contamination or activation products have to be removed and handled as LRW.

Thermocouples and appropriate equipment to monitor a temperature mode of the HI-STORM should be maintained and calibrated according to the quality assurance program.

Additional biological protection is used in on-site handling operations.

The materials assuring neutron- and gamma-radiation shielding from the HI-STAR, HI-STORM and HI-TRAC overpacks are prone insignificantly to damages with time or during operation.

Effectiveness of biological protection is tested every 5 years after commissioning to ensure long-term compliance of the system with the dose rate design values.

The integrity pressure tests of the MPC or the HI-STAR transport overpacks within the maintenance programs are not required, except for initial tests in commissioning.

The schedule maintenance (SM) and calibration tests will be required for a vacuum dehydration system, helium filling system and leakage monitoring system. The equipment, remote controlled welders, cranage and lifting beams should be tested to ensure appropriate maintenance and their normal uninterruptible operation.

In the event of an improbable leakage from the MPC, such a canister is simply transferred from the HI-STORM storage overpack to the HI-STAR transport overpack and is sent to the NPP for repacking. The MPC is transferred by means of the HI-TRAC transfer cask. The HI-STAR has additional confinement means and may be used to store the MPC during the required period of time (up to the next preventive maintenance). Then, it is transferred with the MPC to the NPP site in the reactor compartment for SNF repacking.

Barriers, power transmission towers and other equipment of the storage facility site do not require special decontamination because spread of contamination in these structures is not supposed.

1.7 On-Site Transfer

On-site transfer of SNF is conducted by the crawler, at that, the HI-STORM containing the MPC with SFA is transferred. The main element ensuring nuclear safety in SNF transfer by the crawler is the HI-STORM. The main technical decisions on nuclear safety ensuring in on-site transfer are intended to ensure the HI-STORM protection from mechanical damages in transfer.

The following technical decisions are proposed to ensure nuclear safety in on-site SNF transfer:

- the crawler transfers only one HI-STORM canister with MPC in one run, that is, the quantity of the transferred nuclear material is limited by a structure of the applied equipment;
- use of water is not provided for in the crawler structure and at its pathway, that excludes hypothetical possibility of water contact with SFA;
- the crawler design ensures canister lifting on a height not more then 28 cm, this excludes the HI-STORM damage in drop during transportation (HI-STORM is designed for drop from the height of 28 cm with no damages of canister and its content);

- the site general layout is designed to reduce the pathway of crawler with the HI-STORM from the receiving building to the storage site and to exclude pathway crossover by loaded crawler and other cargos at the CSFSF site, that reduces probable emergency situations in transportation;
- the crawler structure excludes high-speed movement, that excludes possible personnel errors in the crawler movement regulation and, correspondingly, the probability of cask drop during transportation is decreased.

The crawler to transfer the HI-STORM overpacks in vertical position (Figure 1.7.1) is a large-size caterpillar used to lift, install, and transport loaded MPC of the HI-STORM storage overpack to the storage area. The crawler for transfer of canisters in a vertical position consists of lifting mechanisms, the upper lifting beam, chassis, a drive, and a control system.

There are the following main technical characteristics of the crawler:

- carrying capacity, t ……..……....230;
- mass in the empty state, t…….…...…..…..75;
- length, mm……...7620;
- width, mm……..…….…….5640;
- height, mm…….…….variable;
- turning radius……..automated turning on-site;
- movement at slope, %.....…….10;
- capacity, horse power……..……...310;
- kind of engine……turbo-diesel;
- fuel tank capacity, l……..…….89;
- surface suitable for movement……gravel, concrete;
- width of caterpillar track, mm……700;
- length of caterpillar track, mm……..….6700.

A special garage is provided for holding and minor repair of the crawler. Taking into account that operations on the HI-STORM loading and installation are round-the-clock, it is provided for that a garage for the crawler be heated.

Figure 1.7.1 – **Crawler for transfer of canisters in the vertical position**

1.8 Maintenance Building with the MPC Storage

The maintenance building with the MPC storage is intended to:

- provide with annual reserve of new shells and lids of the HI-STORM overpacks;
- provide with annual reserve of new MPC;
- ensure concreting of HI-STORM shells;

- ensure quality monitoring and the required time to cure HI-STORM concreted shells;
- provide with a possibility for repairs of electrical and process equipment, CSFSF I&C equipment;
- provide with sanitary conditions for maintenance staff attendance in the building.

The storage for new HI-STORM and MPC – is an unheated part of the building equipped with a bridge crane that is rated at 125 t.

The HI-STORM shells are concreted under the covering to the building. Concrete comes in concrete haulers from the concrete plant located on the construction site outside the CSFSF perimeter.

Workshops for the CSFSF free access area equipment, office and sanitary buildings for personnel are located in the heated part of the building.

2 MAIN DECISIONS ON MONITORING AND CONTROL SYSTEM

2.1 General Structure of Control and Monitoring

CSFSF monitoring and control system (MCS) should ensure a comprehensive monitoring and control of engineering processes on acceptance and storage of containers with spent nuclear fuel.

MCS will integrate separate primary systems into a uniform system that will allow carrying out a comprehensive process, submission, and archiving of information in one place - a central monitoring and control room. MCS should support radiation and general technical safety in SFA acceptance and their storage. MCS should provide with functions of personnel information support in a way suitable for perception and the analysis in order to determine negative tendencies in changing a state of the CSFSF hazardous sources and implementation of measures on preventing development of these tendencies.

The following design criteria constitute the MCS basis:

- system reliability (is achieved due to use of components with high reliability indicators and an optimal structure, a possibility to detect defects in system operation by diagnosis of technical means);
- system openness (is achieved due to a possibility to involve additional components and systems into its structure and its proper integration into other information systems).

MCS – is a distributed information and control system with two hierarchy levels.

Lower MCS level constitutes the following local systems:

- acceptance monitoring of shipping canisters;
- monitoring of storage process;
- radiation monitoring;
- accounting and monitoring of fission materials;
- control and monitoring of heating and ventilations;
- control and monitoring of special sewage;
- control and monitoring of compressed air;
- control and monitoring of water supply;
- control and monitoring of shower water;
- control and monitoring of rain drains;
- control and monitoring of power supply;
- control and monitoring of fire safety ensuring system;
- communication.

Monitoring system of package design parameters, including nondestructive monitoring of state of metal and welds, is not included into the MCS and is implemented at the MPC and HI-STORM manufacturer.

Nondestructive monitoring of the MPC lid welds is performed at a power unit before transfer to the CSFSF and is not included into the MCS.

Monitoring of the concrete state during HI- STORM manufacturing at the CSFSF site is not included into the MCS and is realized in a concrete laboratory at the concrete factory.

Monitoring and control of local systems will be implemented by using the distributed control system based on microprocessor-based devices or guided logic controllers (for processors requiring complex control algorithms).

The following will be implemented at the technical means of the lower level:

- conversion of electrical signals (analogous or discrete) into a digital form;
- forming of control signals by the given algorithm;
- data reflection at local displaying means (if necessary).

Highly productive control servers connected by an Ethernet system bus with technical means of the upper level will be installed at the MCS higher level.

The MCP high level will be ensured with the following functions:

- collection and processing of the information from the lower level technical means;
- reflection of the parameters monitored in a way suitable for perception, diagnostics and control;
- information archiving;
- exchange of information with the adjacent systems.

The CSFSF engineering processes will be controlled and monitored from the control rooms – central (CCR) and local (LCR). A working place will be located at the CCR for an operator-technologist who monitors and controls in on-line mode a subject as a unified process complex.

Local monitoring and control rooms of the following systems will be reviewed once more:

- ventilation;
- handling part including acceptance of canisters with SFA;
- compressed air;
- sewage pump station (SPS);
- shower water.

A working place will be provided for an engineer on accounting of fission materials.

MCS maintenance will include the following:

- on-line service;
- repair service;
- regulatory service;
- software and dataware support.

On-line service is a twenty-four-hour service and it should include MCS operation monitoring and its restoration in case of defects and failures of technical means.

The technical means will be repaired by replacement of the failed units, and circuit cards by the ones from spare part sets. MCS reparability will be ensured by:

- accessibility, interchangeability, easy removability, unification and standardization of devices, units and circuit cards;
- built-in self-diagnostics allowing detecting failures or damages in the system;
- possibility of free access to separate components of the system;
- ZIP completeness and sufficiency.

MCS power supply will be implemented by means of a 220V one-phase voltage from uninterrupted power supply sources of the first category.

The radiation monitoring system, ventilation control and monitoring system of the receiving building restricted access area and the MCS high level should refer to safety-related systems of 3H class in accordance with [4]. Other primary monitoring and control systems refer to the normal operation system of 4H class.

MCS belongs to the second category of seismic resistance according to [8] criteria.

MCS structural diagram is presented in Figure 2.1.1

The main functions of the local monitoring systems and the arrangement are described below.

2.1.1 Acceptance Monitoring System of Shipping Casks and SFA

The following will be performed during process operations related to acceptance of the HI-STAR transport overpacks and SFA:

- surface contamination monitoring of transport canister;
- monitoring of gamma- and neutron-radiation dose rate from surface of canisters along the whole process chain;

Gamma-radiation and surface contamination MED will be monitored by means of portable dosimeter-radiometers.

The information on coming transport canisters and SFA is entered into the database of the accounting and monitoring system of fission materials.

2.1.2 Storage Process Monitoring System

The following will be performed in SNF storage in the HI-STORM overpacks:

- periodical temperature monitoring on the HI-STORM surface;
- continuous monitoring of the cooling air temperature at the inlet and outlet of each HI-STORM vent ports;
- periodical integrity monitoring of protective and confining barriers;
- continuous monitoring of radiation situation at the storage site.

The temperature on the surface of concrete canisters will be monitored with by means of portable (movable) equipment. The cooling air temperature will be monitored remotely using radio modems installed at each module. The radiation situation at the storage site will be monitored by technical means of the radiation monitoring system (Section 2.2).

2.1.3 System of Monitoring and Accounting of Fission Materials

Nuclear materials coming to the storage facility will be considered by means of the computerized database on nuclear fuel management.

The system includes a set of technical and organizational measures assuring continuous monitoring of available amount of nuclear materials (including: record-keeping, identification and inventory of incoming SFA and the HI-STORM, data archiving).

Accounting and monitoring of nuclear materials is performed in accordance with the requirements of “Rules for Accounting and Monitoring of Nuclear Materials at the Facility” [50].

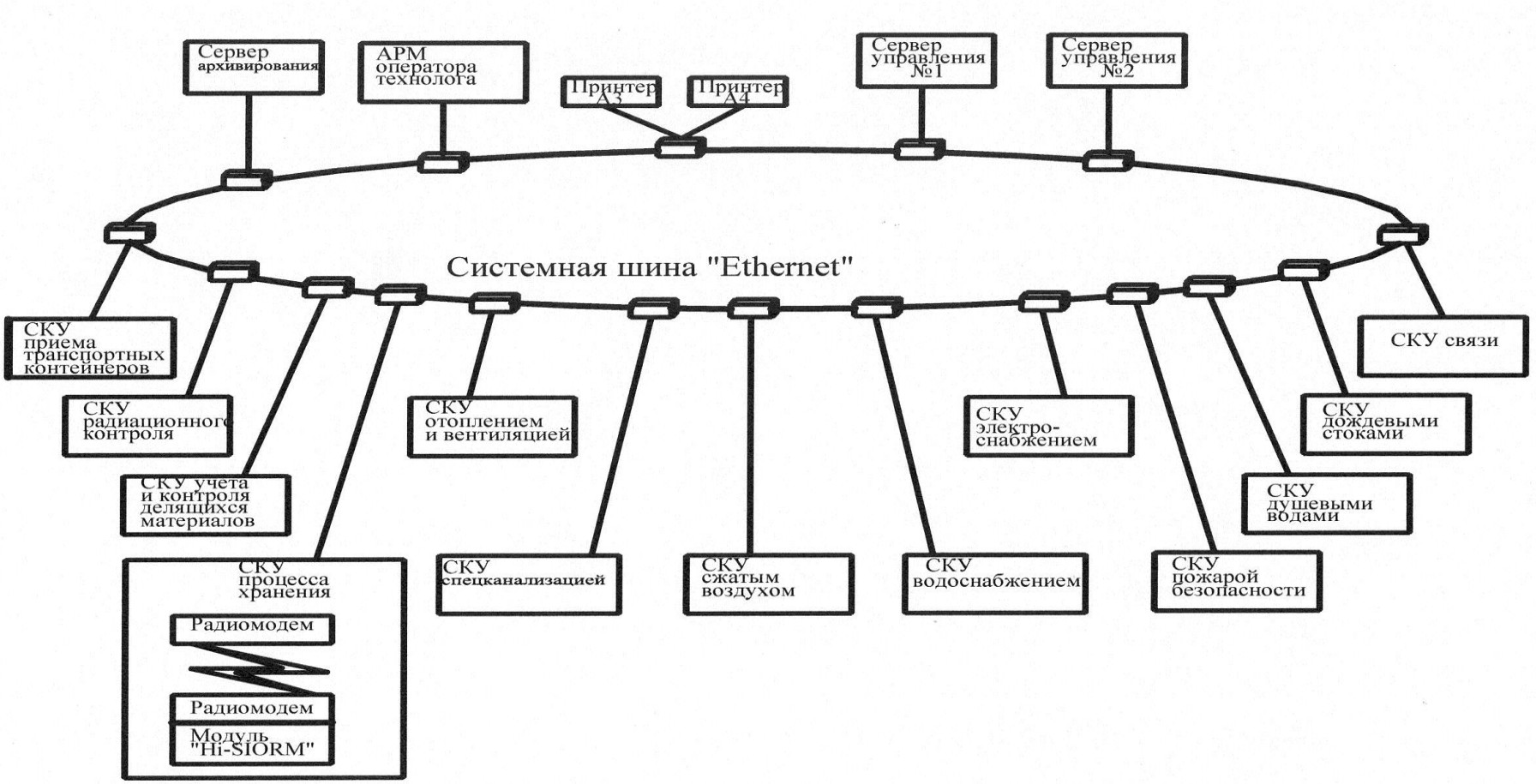


Figure 2.1.1– **Flow diagram of the CSFSF monitoring and control**

2.1.4 Radiation Monitoring System

The radiation monitoring system will be included into the MCS structure being its primary system. The detailed description of radiation monitoring system is given in Section 2.2.

2.1.5 Monitoring and Control System of Special Sewages

The system will ensure monitoring and control of special sewage system process equipment. The level in special sewage sumps will be monitored. Specific activity of special sewage water before its removal is monitored by sampling.

2.1.6 Monitoring and Control System of Shower Water

The system will ensure monitoring and control of shower water system process equipment. The following will be performed:

- monitoring of the level in shower water reference tanks;
- monitoring of pressure at pump intake and head;
- remote control of the electric drive valve.

2.1.7 Monitoring and Control System of Ventilation Installations

Monitoring and control system of ventilation installations will ensure keeping of the given climate conditions in the rooms of the restricted and free access area of the receiving building and auxiliary buildings. Control systems of ventilation installations will be delivered as complete units with the main ventilation equipment. The ventilation system will be controlled from both the local control rooms and from the central monitoring and control room in the on-line mode.

2.1.8 Compressed air Monitoring and Control System

The system will ensure monitoring and control of the compressed air compressor system in a computerized mode. Installation will be controlled from the local room delivered as complete units with the compressor. The signals “operating system”, the generalized signal “failure” will be displayed at the central control and monitoring room.

2.1.9 Fire Safety Ensuring System

The fire safety ensuring monitoring and control system will switch fire protection water supply pumps on in a computerized mode after the signal “fire” and pumps will be switched off in emptying of fire water-supply tanks. In overfilling and emptying of tanks, appropriate signals will be displayed at the CCR. The pressure will be monitored as well in the discharge header of fire water supply pumps.

2.1.10 Monitoring and Control System of Rain Drains

The monitoring and control system of rain drains should control in a computerized mode switching on and switching off of the immersed pumps installed in retaining tanks of rain drains. The pumps for rain drains pump-down will be switched by blocking from the level sensors installed in the retaining tanks. In emptying of tanks, pumps will be switched off. In overfilling of the retaining tanks, the signal “flood” will be displayed at the CCR. The pressure will be monitored in the discharge header of rain drains pump-down pumps.

2.1.11 SPS Monitoring and Control System

The SPS monitoring and control system will control, in a computerized mode, switching on and switching off of the immersed pumps installed in the pump station retaining tank. Pumps will be switched on for pumping domestic drains by blocking from the level sensors installed in the retaining tank. In emptying of tanks, pumps will be switched off. In overfilling of the retaining tanks, the signal “flood” will be displayed at the CCR. The pressure will be monitored in the discharge header of domestic drains pump-down pumps, and the temperature of outer air will be monitored as well.

2.1.12 Water Supply Monitoring and Control System

Water supply monitoring and control system will control, in a computerized mode, switching on and switching off of the pump installed in the artesian well. The pump will be switched on for water drawoff by blocking from the level sensor installed in the elevated tank. In decrease of level in the elevated tank, the pump will be switched on, in tank filling; the pump will be switched off.

The power supply and communication monitoring and control systems on communication are described in appropriate Sections of the FS.

2.2 Radiation Monitoring System

The CSFSF radiation monitoring system (RMS) is a complex of technical means and organizational measures intended to ensure radiation safety standards with the view of:

- non-exceeding of the established dose limits (non-exceeding principle) for personnel and public;
- non-spreading of radioactive contamination in the environment.

2.2.1 Design Decisions of the Radiation Monitoring System

RMS provides for collection, processing and submission of information on radiation situation in rooms of the CSFSF receiving building and at the canister storage site, on radiation process parameters, personnel exposure doses, a value of gas-aerosol releases in the environment.

RMS belongs to the normal operation safety-related system.

The following design decisions constitute the RMS design basis:

- the system is designed using the high reliability elements and optimal design of the structure;
- the system has a possibility to detect defects during operation by means of diagnostics, inspection, sampling and periodical equipment tests.

RMS provides for measurement of parameters according to which an object's impact on personnel and environment is assessed, as well as measurement of parameters according to which the process system operation and the process equipment state are determined.

The RMS technical means provide for:

- radiation process monitoring;
- radiation dosimetric monitoring;
- individual dosimetric (health physics) monitoring;
- environmental radiation monitoring;
- radiation monitoring of radioactive contamination non-spreading.

The following is provided for to fulfill the abovementioned functions:

- continuous remote monitoring;
- monitoring by means of stationary local means;
- monitoring by means of portable devices;
- monitoring using sampling of mediums with subsequent treatment and measurement in laboratories.

A monitoring scope is determined by regulatory documents, requirements for the main equipment, the CSFSF process and arranging decisions.

The CSFSF RMS consists of the following subsystems:

- radiation process monitoring (RPM);
- radiation dosimetric monitoring (RDM);
- individual dosimetric monitoring (IDM);
- environment radiation monitoring (ERM);
- radiation monitoring of non-spreading of radiation contaminations.

2.2.2 Subsystem of Radiation Process Monitoring (RPM)

RPM subsystem is intended to monitor radioactivity of process equipment, ventilation systems, and efficiency of radioactive environment purification systems. RPM subsystem monitors gamma- and neutron- radiation dose rate from the HI-STAR, HI-STORM and HI-TRACK overpacks along the whole process chain in the receiving building that is a central facility component where HI-STAR modules arrive. Gamma- and neutron- radiation dose rates from the HI-STAR, HI-STORM and HI-TRACK overpacks and their possible surface contaminations are measured in this building.

RPM subsystem monitors the following as well:

- water volumetric activity in floor-drain tanks;
- water volumetric activity in reference tanks of changing room showers;
- efficiency of aerosol filters of the exhaust ventilation systems;
- gamma-radiation dose rates on filters of the exhaust ventilation systems.

Volumetric activity in floor-drain tanks and reference tanks of shower water is monitored by means of stationary detecting devices. The efficiency of exhaust ventilation system aerosol filters is monitored by means of analytical filters.

2.2.3 Subsystem of Radiation Dosimetric Monitoring (RDM)

RDM subsystem provides for monitoring of radiation situation parameters in attended and periodically attended rooms of the restricted access area.

Radiation situation is specified by the following:

- gamma-radiation dose rate;
- neutron radiation dose rate;
- volumetric activity of alpha- and beta-aerosols;
- surface contamination of equipment and walls of rooms.

Gamma-radiation dose rate is monitored by means of stationary detecting units in the following rooms of the receiving building:

- at the canister acceptance and reloading area;
- in “dirty” workshops;
- in the pump station of floor-drains and shower water;
- in the exhaust ventilation system rooms;
- at the SRW cask storage area.

Volumetric activity of alpha- and beta-aerosols is monitored by stationary and mobile (portable) facilities in the following rooms:

- at the acceptance and transfer area for HI-STAR, HI-STORM and HI-TRACK overpacks;
- at the SRW storage area;
- in “dirty” workshops;
- in the changing room and airlocks;
- in the pump station of floor-drains and shower water;
- in the ventilation center of the “dirty” area (in replacement of aerosol filters).

2.2.4 Subsystem of Radiation Monitoring for Non-Spreading of Radioactive Contamination

The radiation monitoring subsystem for non-spreading of radioactive contamination provides for monitoring of the radioactive contamination level of footwear, personnel hands and clothes, transport surfaces.

Contamination of coverlet and IPM with beta-active radionuclides is monitored by stationary monitoring facilities at the changing room entry and exit.

Contamination of hands with beta-active radionuclides is monitored by stationary devices in toilet rooms of the "restricted access" area.

Radioactivity release outside the CSFSF is monitored by a stationary monitoring facility installed in the check-point anteroom.

The radioactive contamination level of surfaces of room walls and equipment is monitored by means of portable radiometers and by sampling smears with subsequent measurements in the radiation monitoring laboratory.

The surface contamination level of transport is monitored by portable radiometers.

2.2.5 Subsystem of Individual Dosimetric Monitoring (IDM)

The IDM subsystem is intended for:

- monitoring and accounting of the personnel external exposure individual doses;
- monitoring and accounting of external exposure individual doses from incorporated radionuclides in human organism;
- calculation of the total dose loads for the personnel;
- estimation of personnel dose loads in admission to radiation hazardous activities on dosimetric work order.

Internal exposure individual doses from incorporated radionuclides in human organism are monitored and accounted in specialized laboratories (ChNPP SSE WBC laboratory or SSE "Ekocenter").

The IDM system of the personnel external exposure is implemented by technical means of the computerized accounting system of exposure doses and on the basis of on-line electronic direct reading individual dosimeters and thermoluminescent dosimeters (TLD).

2.2.6 Subsystem of Environment Radiation Monitoring (ERM)

The ERM subsystem monitors sources of possible environment radiation contamination.

The following parameters are monitored:

- activity and radionuclide composition of gas-aerosol releases into the atmosphere through the vent stack;
- activity and radionuclide composition of drain water with sewage;
- activity and radionuclide composition of the inspection well water.

Activity of releases into the atmosphere is monitored by alpha- and beta-aerosols.

Radiation monitoring of gas-aerosol releases into the vent stack is performed by a stationary system. This system measures specific activities of radionuclides and, considering the volume of released gases; the integration for the day is given.

A comprehensive analysis of the release isotopic composition is carried out periodically by means of the radiation monitoring object laboratory to determine an average monthly permissible release by individual radionuclides.

Radiation situation within the CSFSF site is monitored according to the gamma-radiation dose rate by means of the RPM subsystem located along the CSFSF site perimeter.

Activity of liquid effluents with the domestic sewage is monitored by RPM detecting units and is duplicated by sampling with a subsequent laboratory analysis by means of the radiation monitoring object laboratory.

It is provided for to monitor activity of subsoil waters from the inspection wells located along the CSFSF perimeter in order to monitor leakages of radioactive liquids into soil and prevent their ingress into groundwater. Monitoring is performed by sampling with subsequent laboratory analysis by means of the radiation monitoring object laboratory.

2.2.7 Technical Means of the Radiation Monitoring System

A technical equipping basis of the RMS subsystems as regards functions involving remote information transfer constitutes the radiation monitoring informational and measurement system (RMIMS).

Beside RMIMS, the RMS includes:

- monitoring facilities of personnel coverlet and IPM contamination in changing rooms;
- monitoring system of aerosol releases;
- monitoring devices of hands contamination;
- IDM computerized system (IDM CS);
- stationary and portable devices of the radiation monitoring object laboratory;
- set-up and repair equipment;
- graduation equipment including reference sources.

RMIMS includes:

- detecting units of gamma- and neutron radiation dose rate;
- monitoring installations of alpha-, beta-aerosols volumetric activity;
- detecting devices of liquid volumetric activity;
- local light and sound signaling devices;
- working stations of RMS operators.

RMIMS provides for:

- measurement of the monitored parameters value;
- signal processing;
- transfer of signals on the monitored parameters to the RMS central control and monitoring room (RMSCR);
- giving of warning and emergency signals on exceeding of the parameter values on-site and at the RMSCR;
- information documenting and archiving;
- verification of the RMS systems and devices operability.

2.2.8 Main Characteristics of Radiation Monitoring Technical Means

Stationary units for gamma-radiation detection

Stationary units of gamma- and neutron-radiation detection are intended for measurement of gamma- and neutron-radiation equivalent dose rate in the CSFSF attended and semi-attended restricted access area rooms within 10^{-7} - 10 Sv/h.

Gamma- and neutron-radiation detecting units are installed in the CSFSF rooms jointly with light and sound signaling devices to inform personnel on necessary evacuation of personnel from their working places.

Installations for monitoring volumetric activity of alpha- and beta-active aerosols

Installations for monitoring volumetric activity of alpha- and beta-active aerosols are stationary or portable devices assigned for measuring activity of alpha- and beta-aerosols in air of the attended and semi-attended restricted access area rooms within, Bq/m^3 ($\mu Cu/cm^3$):

- for beta-emitting aerosols – 1… 106 (2.7 10-11 … 2.7 10-5);
- for alpha-emitting aerosols - 10-2 … 104 (2.7 10-13 2.7 10-7).

The installations are equipped with light and sound signaling devices to inform personnel about exceeding of permissible levels of air contamination and built-in pump units for sampling.

Liquid volumetric activity detecting units

Liquid volumetric activity detecting units are assigned to monitor liquid effluents within 10^{-10} - 10^{6} Bq/m^3. Detecting units are installed in monitoring tanks for sewage and in floor-drain tank.

Values of the monitored liquid volumetric activity parameters are displayed at the RMS CR.

Aerosol releases monitoring system

Aerosol releases into the vent stack are monitored by means of the following technical means:

- an isokinetic sampler with a pump unit;

- a radiometric installation for measuring volume activity of alpha- and beta-aerosols;
- a flow meter of the air released into the vent stack;
- a working station that collects, processes the data and gives the information at the CR RMSCR.

Radiometers of coverlet and IPM surface contamination with alpha- and beta-active substances

Radiometers are assigned to measure coverlet and IPM surface contamination with alpha- and beta-active substances and signal exceeding of the established threshold value.

Flux density range measurements, part./$cm^2 \times$min:

- beta-particles from 5 to 15000;
- alpha-particles from 0.1 to 1000.

Neutron- and gamma-radiation radiometers

Neutron and gamma-radiation radiometers are intended to detect activity of radioactive materials outside the CSFSF in the following measurement ranges.

- gamma-radiation flux density with 660 keV power from 0,5 to 50 sec^{-1} cm^{-2}
- gamma-radiation flux density from 0.1 to 10 sec^{1} cm^{-2}

Radiometer measures total neutron- and gamma-radiation flux during continuous monitoring of flux density form natural radioactive background at the site of detecting units and signals exceeding of flux above the background level.

Individual dosimetric monitoring system

IDM CS ensures measuring, reading and processing of individual personnel gamma-radiation doses by means of electronic direct reading dosimeters within:

- dose rate - from 0,1 μSv/h to 10 Sv/h;
- accumulated dose - from 0,001 to 9999 mSv.

The system consists of personal electronic dosimeters, non-contact readers and work station of health physicist on-duty (WSDD),

Working station includes:

- a computer connected with the system of data storage at RMSCR;
- a printer.

IDM CS system includes also the IDM subsystem equipment based on thermoluminescent dosimeters (TLD) including:

- TLD dosimeters;
- computerized reader of TLD dosimeters;
- calibrator of TLD dosimeters.

Storage of RMS information

All the information on the radiation situation incoming to RMSCR is archived at the RMS system specialized server.

Radiation monitoring laboratory

The radiation monitoring object laboratory is created in the CSFSF whose functions provide for determination of activity and radionuclide composition of liquids from the changing room tanks, floor-drains tanks and water of inspection wells by sample spectrometry.

Activity and nuclide composition of the air discharged through the vent stack are determined also by spectrometry of the vent stack system analytical filters.

The laboratory is equipped with a necessary set of stationary and portable devices – gamma-spectrometer, dosimeters-radiometers etc.

The laboratory equipment includes also equipment for sampling/taking smears, devices for equipment calibration and testing, reference gamma-, beta- and alpha-sources.

3 PHYSICAL PROTECTION ENGINEERED BARRIER

CSFSF physical protection is directed on prevention and termination of nuclear terrorism, theft or any other unlawful withdrawal of spent nuclear fuel and radioactive wastes.

3.1 Determination of Protection Objectives

3.2 Principles of Protective Measures

3.3 Physical Protection Engineered Barriers

3.3.1 Access Control System

3.3.2 Intrusion Detection System

3.3.3 TV Monitoring System

3.3.4 Communication, Warning and Alarm System

3.3.5 Power Supply System

3.3.6 Guard Lighting System

3.3.7 Restricted Access Area, Module Site and Access Control Point Engineered Barriers

3.3.8 Physical Protection Control Panel

4 BASIC ARCHITECTURAL AND CONSTRUCTIONAL DECISIONS

4.1 Basic Architectural Decisions

4.1.1 Receiving Building

Receiving building is a set of process, auxiliary and office rooms.

Building dimensions, presented in the layout, make 39,0x42,0 m, main process volume (transfer tube) height makes 13,66 m up to the crane track head level and 19.55m up to the bottom of roof cover.

Receiving building is designed of cast-in-place reinforced concrete structures.

Fire resistance degree – I, explosion and fire hazard category– D.

Four-storied block of auxiliary and office rooms is attached to the main process volume along B axis.

At this block elevation, which makes 0,000, there are located both free-access area rooms – electrical control room, compressor room, heat point and input ventilation point, and controlled area rooms – "dirty" repair stations, laboratory, premise for shower and change room control water tanks. Also there is a freight lift with lifting tacking of 2000 kg for servicing of a set of fresh air ventilation center rooms at 11,100 elevation.

Besides, there is a set of sanitary barrier rooms at 0,000 elevation.

At elevations of 4,200 and 7.800 there are located only free access area rooms – Administration Building, MCP, etc.

At 11.100 elevation there are located free access area rooms – fresh air ventilation center, water-supply tank room and restricted access area rooms – exhaust ventilation center.

Free access area personnel are served in accommodation rooms at elevation of 4,200. It is stipulated to arrange a shower room and a change room in these premises. Servicing of the restricted access area personnel takes place in changing room module at elevation of 4,200.

This module includes change rooms for clean and dirty working clothes, storerooms, shower rooms, RM stations. Personnel, who perform the work in transfer tube, undergo additional service at sanitary barrier at 0,000 elevation.

Vertical connection between stories is arranged by means of the staircase located in the free access area (1-2/B-V axes) and by means of the staircase located in the restricted access area (7-8/V-G axes). Also this staircase is used in case of accidents for personnel evacuation from 11,100 elevation. Both staircases are located in closed stairwells.

Building cover is common, the drain is internal, the roof is flat covered with waterproof membrane sheet.

With the purpose of power supply it is stipulated to insulate building face walls with subsequent facing with a metal compacted sheet.

To finish free access area rooms, it is proposed to apply finishing materials with high decorative and aesthetic parameters.

In restricted access area rooms the finishing materials, except of the mentioned above factors, possess the following properties: easy decontamination and low rate of radioactive substance sorption.

Floors in restricted access area rooms are stipulated to be covered with liquid composition of MAKRO-AST-type, in the free access area – covered by the linoleum, ceramic tile and inlaid make-up.

4.1.2 Maintenance Building with MPC Storehouse

In layout the building with dimensions of 21,0x57,7m consists of three blocks:

1. A two-storied block with walls designed of concrete panel with regards to reinforced concrete framing with dimensions of 21,0x12m and with height of 7,8m. The block includes electrical and mechanical workshops, laboratory of concrete and offices.

The roof is flat with internal drain, waterproof membrane is of roll-type.

Fire resistance degree - II, explosion and fire hazard category– D.

2. A one-storied block with dimensions of 21,0x33,0m with a single-span metal framing and external frame structures made of heat-insulated metal panels. This part of building includes the storehouse of new HI-STORM overpacks and new MPCs.

The roof is of dual-slop with external water drain.

Fire resistance degree - IIIa, explosion and fire hazard category– D.

3. The shelter-outhouse is made of the metalwork with a cage with dimensions of 12,0x21,0m.

Under area there is a site for concreting and storing HI-STORM overpacks.

4.1.3 Administrative Building

Administrative building is a five-storied brick building with a basement, the fifth floor is a service floor. Building dimensions in the layout - 42,0x15.0 m, height with regards to parapet - 18,0 m, cover plate bottom elevation - +16,300.

Fire resistance degree – II, explosion and fire hazard category– D.

The building ground floor includes: a dining room for 100 persons; a first-aid post; communication room; an electrical control room; a heat point.

First, second and third floors include the following CSFSF services: administration; offices; conference hall; personnel training center; public relation service; SNRCU inspection service, archive.

The service floor contains a ventilation center, the basement contains a set of civil defense rooms (blockhouse).

For vertical connection between stories and for personnel evacuation the building contains two closed staircases with ferroconcrete flight of stairs. The exit directly outdoors is stipulated from one staircase and the exit through the entrance hall is provided for from another.

The roof is flat with internal drain and covered with a waterproof membrane sheet.

Room finishing, floor topping and false ceiling design are stipulated to be made of the advanced modern finishing materials.

4.1.3.1 Civil Defense Rooms (Blockhouse)

Civil defense protective structures are intended to protect personnel from accident consequences, catastrophes and natural disasters which threaten population with mass affection. And also in the wartime - for protection from contemporary weapons of mass destruction. With this purpose, there is stipulated the blockhouse.

Basic technical and economic indices of the blockhouse:

- capacity, persons 100;
- blockhouse class ..... AIV;
- penetrating radiation loss degree …(A) 1000;
- shock wave (ΔP), kgs/cm^2 ..... 1;
- people gathering radius, less than, m 500;
- continuous attendance time, day 2;
- moding (ventilation mode) ..... 2.

The blockhouse for sheltering of the “storage” personnel is arranged in a basement part of the administrative building. Dimensions in the layout - 24,0x21,0 m, room height – 3,0 m. Blockhouse fire resistance degree – II, explosion and fire hazard category– D.

A blockhouse external building envelope is stipulated to be made of cast-in-place concrete structures, internal walls and partitions – of cast-in-place concrete and 100 mark bricks with reinforcement.

Two exits are provided for from the blockhouse at the distance from the building that is equal to the height of the administrative building (18,0 m).

Blockhouse includes main and auxiliary rooms:

- room for people for whom the shelter is provided;
- first-aid post;
- ventilation room with c prechamber;
- regenerative facility room;
- DES turbine hall;
- cooldown unit;
- electrical control room;
- air control room;
- tank room;
- flashbox;
- gravel cooler;
- Storage room (room for plank-bed metal frame storage);
- gentlemen;
- ladies;
- entrance tambours and pre-tambours.

Main and auxiliary room finishing – smoothing and painting of walls and ceiling what meets the requirements for finishing of civil defense rooms.

4.1.4 Electrical Device Building

Electrical device building is a one-storey building with brick walls on reinforced concrete framing. Dimensions in layout make 9,0x36.0 m. height - 4, 8 m up to the cover structure bottom.

The building includes main and standby transformer, DES.

Cover – is designed of precast floor slabs over single-pitch beams.

Drain is outside and roofing is roll.

The building fire resistance degree – II, explosion and fire hazard category– D.

4.1.5 Garage for Crawler

The garage for crawler is a one-storey brick building with layout dimensions of 24,0x12,0 m, with height of 9,0 m up to the bottom of roof slab. Pitched roof with internal water drain and a waterproof membrane sheet.

The building is purposed for crawler repair and holding.

The building fire resistance degree - II, explosion and fire hazard category - V.

4.1.6 Garage for Four Automobiles

The garage for four autos is a one-story building with layout dimensions of 30,0x18,0 , with height of 4,5 m up to the bottom of the roof slab.

External frame filling – brick walls and precast reinforced concrete roof slab. Roof is plane with internal water drain and with a waterproof membrane sheet.

The building is purposed for maintenance of autos which belong to CSFSF:

- autocrane;
- travelling cradle;
- auto for guards;
- snow-remover.

The building fire resistance degree - II, explosion and fire hazard category - V.

4.1.7 Pump Station for Fire Water Supply

The pump station for fire water supply is a one-storey brick building with layout dimensions of 6,0x6,0 m, with height of 3,0 m up to the overlap bottom.

Pitched roof with external water drain and waterproof membrane sheet.

The building contains pumps for CSFSF site fire water supply.

Building fire resistance degree - II, explosion and fire hazard category - D.

4.1.8 Guard Building

Guard building is a two-storied building with layout dimensions of 12,0x36,0 m, with height of 7,2 m, with brick walls and with reinforced concrete overlaps and slabs.

The building includes the CSFSF physical protection control unit, a room for arms, a room for physical protection service personnel.

There are stipulated two closed staircases with ferroconcrete flight of stairs for vertical connection between floors and for personnel evacuation.

The roof is plane with external water drain with waterproof membrane sheet.

The building fire resistance degree - II, explosion and fire hazard category - D.

4.1.9 Access Control Point, ACP-1

Access Control Point (ACP-1) is a one-storey building with layout dimensions of 12,0x24,0 m, with height of 3,0m up to the bottom of the roof slab.

Frame structures - aerated concrete wall panels over reinforced concrete framing and reinforced roof slabs over metal beams.

The building is intended to admit personnel and autos. The building includes the following rooms:

- permit access control point;
- rooms for personnel.

It is provided for to arrange turnstiles with a radioactive material detection device.

The roof is plane with internal water drain and waterproof membrane sheet.

Building fire resistance degree - II, explosion and fire hazard category - D.

4.1.10 Access Control Point, ACP-2

Access Control Point (ACP-2) is a brick building with layout dimensions of 6,0x8,0 m, with height of 3,30m up to the roof slab bottom.

A building design provides for a check-point hall, a duty room and an individual examination room.

The cover is combined, the roof is plane with external water drain with waterproof membrane sheet.

There is stipulated room finishing with the help of water-emulsion solutions, floors are tiled and covered with linoleum.

4.2 Basic Construction Decisions

This subsection describes building structures of each CSFSF building indicating its specific function and design basis applied to it.

4.2.1 Design Criteria

Design life-time

CSFSF building design life-time makes, years:

- receiving building 100;
- cask storage site ..... 100.

According to the life-time, structures and materials of building components shall be designed for normal operation conditions and for deviation from normal operation conditions. For the receiving building and for the cask storage site shall be used the constructional materials (concrete, steel, etc.) with high indicators of strength and life span which shall preserve required properties during 100 years.

Loading conditions

CSFSF buildings and structures are designed taking into account loads and impacts accepted according to the Ukrainian regulatory requirements [10, 18] and according to classification of [8, 18].

In accordance with the fulfilled functions, the buildings and structures are classified with regards to the responsibility for nuclear and radiation safety. Classification, made according to the requirements of [8, 18] is given in Table 4.2.1

Table 4.2.1 – **Classification of buildings and structures**

Number in general layout	Building/structure/part of a building	Category according to PiN AE 5.6	Seismic resistance category according to PNAE G-5-006-87
1	Receiving building	I	I
2	CONTAINER STORAGE SITE	I	I
3	Maintenance Building with MPC storehouse	III	III
4	Administrative Building	III	III
5	Electrical device building	III	III
7	Garage for crawler	III	III
8	GARAGE FOR FOUR AUTOS	III	III
9	Rail car maintenance building	III	III
10	Gasoline station		
18.1	Pump station for fire water supply	III	III
18.2	Tanks for fire water storage	III	III
20	Drain pump station	III	III
21	Rainwater retaining tanks	III	III
29.1	Guard building	III	III
29.2	ACP 1		
29.3	ACP 2		

4.2.2 External Input Data

Seismic loads

Seismic risk for the given site relates, in general, to the impact of seismic regions of the Romanian Carpathian Mountains (Vrancha Mountain) and to the local earthquakes of the Ukrainian Platform. ChNPP site seismicity, approved in the regulatory documents of Ukraine [49], corresponds to:

- the operating basis earthquake (OBE) of 5 magnitudes according to MSK-64;
- the safe shutdown earthquake (SSE) of 6 magnitudes according to MSK-64;

SSE corresponds to the periodicity of once in 10 000 years. OBE corresponds to the periodicity of once in 100 years.

Wind loads

The following wind loads will be used for the CSFSF according to the requirement [10, 18]:

Wind pressure standard value	0,3 (30) kPa (kg/m^2); for the second wind area (Map 3, Appendix 5, SNiP 2.01.07-85;
Design load	0,42 (42) kPa (kg/m^2) is specified by multiplication of the standard value by reliability factor that makes 1,4;
Extreme (design) load	0,75 (75) kPa (kg/m^2) is specified by multiplication of the design value by overload (reliability) factor that makes 2,2 according to PiN AE-5.6;

Snow loads

The following snow load has been accepted according to the requirements of [10, 18], and also taking into account historical climatological data, based on repetition frequency of once in 10 000 years:

Snow cover weight standard value	0,7 (70) kPa (kgs/m^2) – for second snow area (Map 1, Appendix 5, SNiP 2.01.07-85;
Design load	1,0 (100) kPa (kgf/m^2) is specified by multiplication of the standard value by reliability factor that makes 1,4;
EXTREME (DESIGN) LOAD	1,4 (140) kPa (kgf/m^2) is specified by multiplication of the standard value by overload (reliability) factor that makes 2 according to PiN AE-5.6.

Extreme design value was clarified based on the results of statistical processing of meteorological watch data, there was obtained the value that makes 2,1 (210) kPa (kgf/m^2).

Glaze-clear ice

With regards to glaze-clear ice loads, the developed land is included to the second glaze-clear ice area for which the wall thickness of the glaze-clear ice with repetition frequency of once in 5 years makes 5 mm for the height of 10 m, for the height of 200 m - 35 mm, for the height of 400 m - 60 mm.

Tornado

In accordance with Order of the Gosstroy of Ukraine No. 64 21 October 2002, the regulatory document was put into force that specifies "Basic regulatory requirements and design characteristics of tornados at the ChNPP site":

- tornado design class 3;
- 30-km exclusion zone annual probability ..... 1,0 x 10-6;
- tornado wall rotation rate, m/s 81;
- tornado linear motion rate, m/s 20,3;
- distance, km 28,6;
- width, m 290;
- differential pressure between periphery and whirlpool center, GPa 81.

Air temperature

According to [10], there were accepted the following air temperature values:

- temperature standard value, ^{o}C:
  - minimum ..... - 20;
  - maximum..... +26;
- temperature design value, ^{o}C :
  - minimum ..... - 22;
  - maximum..... +29°C;.
- reliability factor with regards to load ..... 1,1.

As for calculated temperature extreme value regulations [18], do not contain instructions but indicate that it should be specified at the periodicity of once in 10 000 years.

There was accepted the extreme-conservative temperature value, ^{o}C:

- minimum ..... - 43;
- maximum ..... +45.

Lightning action

For CSFSF there is stipulated a lightning protection system according to the Regulations on design and operation and according to the "Design instruction on lightning protection of buildings and structures" [41] indicating necessary characteristics of the system".

Underflooding and flooding

A site leveling elevation is 138,500 m. Groundwater was detected at different depths from the surface: from 15,0 up to 21,0 m (the absolute marks make 123,300 – 124,100 m correspondingly). A groundwater table slope is in the north-the east (towards Pripyat river). Height of the site leveling over Pripyat river maximal water-level is 26,7 m.

The aquifer main makeup source are atmospheric precipitations. A mode is stipulated by meteorological factors, groundwater level fluctuation is up to 1,5 m.

Issuing from the leveling mark and from groundwater level fluctuation within the CSFSF site, it is supposed that specific measures are not required that compensate underflooding by rainfalls and by emergency leakages from water distribution pipelines.

Precipitations

Annual precipitation total makes 604 mm, 211 mm of them relate to the cold period and 393 mm to the warm period. The stated daily precipitation maximum makes 95 mm.

Explosion

The nearest different purpose operable industrial facilities are located at the distance of more than 10 km from the site and consequences of their potential accidents could not effect CSFSF safety and vice versa.

The combustible oil products may be transported by on-site highways, however, explosion impacts on the CSFSF, related to car accidents, are considered in the EIR.

4.2.3 Loads and Their Combinations

4.2.3.1 Normal Operation Loads

Load values, in normal operation of a facility, are given in Table 4.2.2

Table 4.2.2 – **Loads in CSFSF normal operation**

Load name	Load value	Overload (reliability) factor	Dynamic index	Notes
1 DEAD WEIGHT		1,1 (0,9)	-	See notes to item 2
2 Design loads, including: - cranage load; - construction loads			-	See notes to item 1
3 Snow load, kgf/m^2	70	1,4	-	SNiP 2.01.07-85

4 Wind load, kgs/m^2	70	1,4	-	SNiP 2.01.07-85

Notes:

1 According to the installed equipment in compliance with the task of technologists.
2 Based on the design documentation.

4.2.3.2 Extreme (Design) Loads

Values of design extreme loads for I category structures and design loads for II category structures are given in Table 4.2.3.

Table 4.2.3 – **Extreme design loads**

Load type	Load design value depending on construction category	
	I	II
1 Snow, kgf/m^2	210	100*
2 Wind, kgf/m^2	75	42*
3 Climate temperature, C°		
- in winter	- 45	- 22*
- in summer	45	29*
4 Tornado class	3,0	-
- wind speed, m/sec	81	-
- wind pressure, kgf/m2	150	-
- pressure drop, kgf/m2	800	-
Seismic, magnitudes	6	5,0**

* Design loads, according to [10]
** Loads in compliance with [8].

I category structures are designed with regards to the extreme loads with repetition frequency of once in 10 000 years.

II category structures are designed with regards to the seismic load with repetition frequency of once in 100 years and the rest – with regards to the loads that are in compliance with the General regulations on industrial construction design.

4.2.3.3 Construction Load Combinations

Construction load combinations are given in Table 4.2.4

Table 4.2.4 - **Preliminarily combinations of loads on structures and foundations**

Combination name		Combination No.	Dead loads	Imposed loads								Notes
				Sustained loads	Short period loads	Specific loads						
						Extreme snow	Extreme wind	Temperature extreme values	Tornado	Seismic S_{SSE}	Air shock wave	
Basic		1	+	1 sustained	-	-	-	-	-	-	-	
		2	+	-	1 short period	-	-	-	-	-	-	See item 1
		3	+	0,95(∑ sustained)	0,9(∑short period)	-	-	-	-	-	-	See item 3
Specific	Seismic	1	0,9 dead	0,8∑sustained (except for snow)	0,5(snow+mont)	-	-	-	-	+	-	
	Extreme snow	1	+	0,95(∑ technological)	-	+	-	-	-	-	-	
		2	+	-	0,8 ∑ short period (except for snow)	+	-	-	-	-	-	
		3	+	0,95(∑ technological.)	0,8 ∑ short period (except for snow)	+	-	-	-	-	-	
	Extreme temperature	1	+	0,95(∑ sustained)	-	-	-	+	-	-	-	
		2	+		0,8 ∑ short period	-	-	+	-	-	-	See item 1
		3	+	0,95(∑ sustained)	0,8∑ short period	-	-	+	-	-	-	
	Extreme wind	1	+	0,95(∑ sustained)	-	-	+	-	-	-	-	
		2	+	-	0,8 ∑ short period (except for snow)	-	+	-	-	-	-	See item 1
		3	+	0,95(∑ sustained)	0,8 ∑ short period (except for snow)	-	+	-	-	-	-	
	Tornado	1	0,9 dead	-	-	-	-	-	+	-	-	
		2	0,9 dead	0,95(∑ sustained)	-	-	-	-	+	-	-	
		3	0,9 dead	-	0,8 ∑ short period (except for snow)	-	-	-	+	-	-	
	Air shock wave	1	+	0,95(∑ sustained)	-	-	-	-	-	-	+	See item 1
		2	+	-	0,8 ∑ short period	-	-	-	-	-	+	
		3	+	0,95(∑ sustained)	0,8 ∑ short period	-	-	-	-	-	+	

Notes:

1 Snow load is taken into account with K=0,3 factor in considering the sustained load or, with K=1,0 in considering a short period load.

2 In calculation of specific combination of loads with regards to seismic the snow load value is accepted according to [10].

3 In consideration of the crane load, as imposed and sustained, there are taken into account the loads from crane with 0,5 factor according to [10] item 7 and during CSFSF design development there shall be considered the most unfavorable, physically possible crane positions.

4.2.4 Receiving Building

Receiving building (position 1 according to the general layout) consists of two building blocks:

- central block;
- auxiliary many-storied block (room 117).

Building dimensions in the layout make 39,00×42,00 m, height of the main process volume (transfer tube) -20,5 m, of auxiliary one – 16,2 m.

The receiving Building is designed in cast-in-place reinforced concrete structures.

The receiving building design life-time – 100 years.

Building loads.

The receiving building is designed for normal operation and extreme (design) loads. Load combinations are accepted according to Table 4.4.

4.2.4.1 Description of Structures

Central block

Central block is a transfer tube equipped with electrical bridge crane whose carrying capacity is 140/25 tons and with railway railing.

The central part is a cast-in-place reinforced concrete structure with dimensions of 42×24 m in axes A-B, 1-8, and with height of 19,5 m up to the bottom of the roof slab.

Central block foundation (

Draawing 4.2.1

~~Draawing 4.2.1~~), that includes heavy loads caused by bridge crane posts and by the railway railing, shall represent a solid cast-in-place reinforced concrete slab with thickness of 1,5 m, what makes possible to limit the impact of the foundation initial settlement during facility operation. The structure stability will be calculated for the foundation in the impact of the most unfavorable combinations of loads, including seismic load taking into account the data on the surface load-carrying capacity from the safety viewpoint both for static and dynamic load conditions. The most part of load on foundation shall be presented as static and the most serious settlement shall take place during construction.

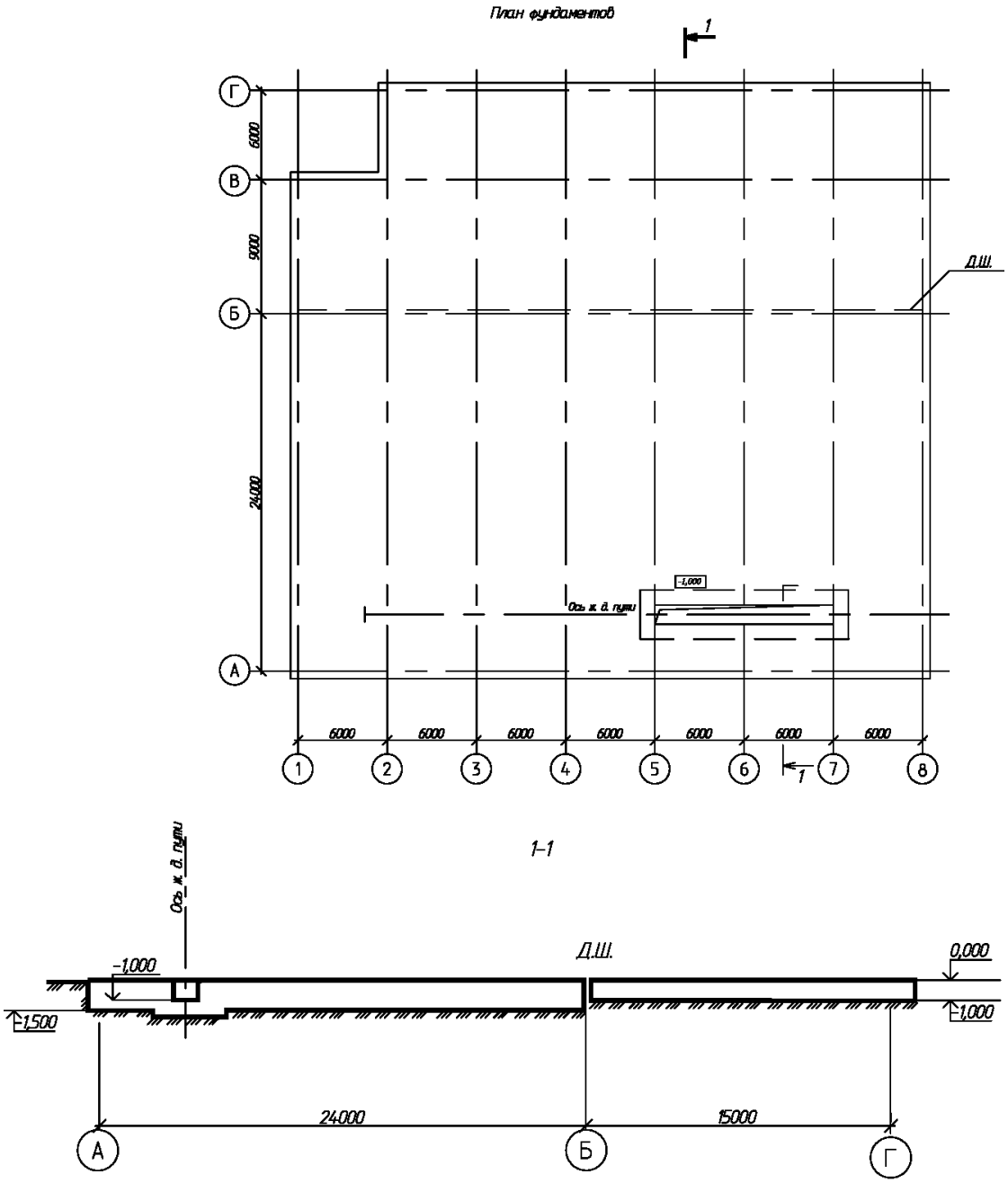
Variable cross-section cast-in-place columns:

- under-crane part- 1500×1000 mm;
- over-crane part - 600×600 mm.

The cover plate is a cast-in-place reinforced concrete structure with thickness of 300 mm along the cast-in-place reinforced concrete blocks that are supported by the columns.

Bridge crane with carrying capacity of 140/25 tons is supported by composite under-crane beams that are supported by under-crane part at the elevation of 13,600 m.

Under-crane beams shall be provided with grouted metal towers. Crane railing is bonded to the embedded parts of the under-crane beams.



Draawing 4.2.1 – **Central block foundation**

The walls are cast-in-place and reinforced concrete with thickness of 300 mm.

Additional requirements for biological shielding are not made for the central block walls.

Auxiliary many-storied block

The auxiliary many-storied block is a cast-in-place reinforced concrete four-storied building with dimensions of 42×15 m and with floor height: ground floor – 4,2 m, first floor – 3,6 m, second floor – 3,3 m, and third floor – 5,1 m.

Walls are cast-in-place, reinforced concrete with thickness of 300 mm, with pilasters of 200×400 mm, with spacing of $\approx 6{,}0$ m. Walls includes the bearing structures, monolithic beam ceilings with plate thickness of 300 mm and with spans of 3, 4, 5, 6 m which are supported by the walls and cast-in-place pilasters.

A cast-in-place reinforced concrete plate with thickness of 1,0m equipped with necessary connections that isolate it from the central block base plate serves as an auxiliary block foundation. . This shall ensure the possibility of the settlement during construction and shall help to avoid overstress caused by foundation arranged nearby.

Staircases and lift shafts are arranged in the corners.

The partitions are cast-in-place with thickness of 100 mm.

4.2.4.2 Corrosion Prevention Measures

Building structures should be protected according to [11], applying noncorrosive, for the given environment, materials and fulfilling the design requirements (primary protection), applying metal, oxide, lacquer, metallizing-lacquer and mastic coatings, lubricants, film, covering and other materials to construction surfaces (secondary protection), and also using electrochemical means.

In operation concrete should withstand the corrosive medium and also should ensure protection for reinforcement.

The climatic conditions are such that it is necessary to take into account freezing-defrosting effect. Usually, it is reached with the help of low water-to-cement ratio application. The damage caused by freezing-defrosting effect is the strongest when the concrete is saturated with water. This risk could be reduced by designing surfaces in a way that they contribute to the water drain (arrangement of inclinations).

Concrete in the ground could be damaged by corrosion sulfates, however, the available information shows that sulfate level is low and, in any case, groundwater level is situated lower than the base plate dropped ceiling.

As for the reinforcement corrosion, the steel natural protection, ensured by alkali medium in the concrete, could be lost in case of concrete saturation with the carbonic acid or in case of chloride sufficient amount penetration at the depth of concrete protective layer. Saturation with the carbonic acid is not considerable for the concrete in the open air at the reasonable concrete class and at reasonable concrete protective layer depth (50 cm). In view of absence of the chloride in the atmosphere, the reinforcement protection should be ensured on condition that there is no erosion of the protective layer under the influence of weather factors.

Based on the abovementioned data, there is no need in specific sealing. For all concrete surfaces, which contact with the ground, there shall be used simple lubrication flashing.

Metal structures or components, which could undergo corrosion as a result of natural environment impact, should be made of non-corrosive materials (stainless steel), or covered with zinc (galvanized). In the last case to the minimum required thickness there is added twofold 3-millimeter tolerance with regards to corrosion in case of possible corrosion.

4.2.4.3 Settlements and Lists

From the viewpoint of construction science and according to [18] strict requirements are applied for the buildings and structures of I and II seismic resistance category with regards to deformation parameters. These requirements relate both to structures as a whole and to structure separate elements.

The limit values of nuclear power structure bedding joint deformation are specified issuing from the necessity to meet the following marginal states:

- maximum permissible deformations of structures that are specified issuing from process equipment operation conditions;
- marginal state by strength and stability and crack growth resistance of structures, including overall stability of structures.

For the CSFSF, the central part of building shall mainly represent a heavy concrete structure. Central and auxiliary blocks shall be designed with different baseplates with thickness of approximately 1,0 - 1,5m. Dead load shall cover the main part of the baseplate load and most of settlement shall take place during construction.

The geotechnical data, which include the ground data, indicate availability of not all-round technical man-made ground of 2,0 – 2,5m deep. It is considered unacceptable material for the foundation and, therefore, in man-made grounds, it is supposed this ground be excavated. After this the ground, composed of compact granular bulk material, shall be added to the assumed level. Below there is sandy soils (IGE 4, 5, 6, 7 layer) – from fine tight sands up to the semisolid and hard loams with characteristics that will not cause the relatively high settlement after the certain period of time.

For proposed foundations – the base plates there is not expected that bearing capacity shall cause any problems even at loose ground.

However, taking into account the above-described geological-and-engineering assessment, the foundation design conception was developed based on the following:

- it is possible to expect substantial immediate settlements during shallow footing load;
- long-term settlement consolidation shall be light;
- it is accepted that soil liquefaction shall not take place in case of the earthquake.

For calculation of settlement there should be taken into account buildings/soil and foundation/soil static interaction and any building/soil/building static interaction between separate foundations.

Settlements, presented in calculations of structures, shall be compared with the results obtained during settlement analysis presented in the geological-and-engineering report.

There is supposed to carry out additional investigation of the site, what shall eliminate any uncertainty in foundation design.

4.2.5 Cask Storage Site

The cask storage site includes 15 cast-in-place plates at which the casks are arranged. Plates are arranged at the east with the space of 18 m. Traffic ways of 9 m width for transport maneuver are provided for between plates. Plates and traffic ways are designed at one elevation of 138,500m with inclinations for rainwater drain.

Cask storage site design life-time is 100 years.

Building loads.

Cask storage area is designed for normal operation and extreme (design) loads. Load combination is accepted according to Table 4.4.

4.2.5.1 Description of Structures

The cask storage site plates are designed as cast-in-place reinforcement with dimensions of 9×105m, and with thickness of approximately 800-1000 mm. Plate structures shall be designed according to [23], taking into account process loads, and according to [18] as the structures of the first category of responsibility for nuclear and radiation safety and of first seismic resistance category according to [8].

The functional and expansion joints are provided for the cask storage site according to the requirements of [23].

Corrosion prevention measures and also settlements and lists are specified based on the data on the receiving building (items 4.2.4.2; 4.2.4.3).

4.2.6 Maintenance Building with MPC Storehouse

The maintenance building with MPC storehouse (position 3 according to General Layout) with layout dimensions of 21×57 m with regards to both design and function consists of three blocks:

- MPC storehouse;
- Laboratory building;
- Covered roofing-area.

MPC storehouse

The MPC storehouse is a building with dimensions of 21×33 m, with height of 14 m up to the topping girder equipped with an electric bridge crane with carrying capacity of 125/21 tons.

The building is not heated. A building frame consists of two-leg metal columns with dimensions of $1{,}25 \times 0{,}7$ m (h=16.5 m), a topping girder – a metal lattice truss made of rolled angle units, with height of 2,1 m at the support with inclination along the top chord.

Under-crane metal beams of 6 m length and of 1,2 m height. A coupling block is arranged in the central span between axes "5-6". The walls are made of "Sandwich"- type multicore panels that consist of compacted sheets with heat insulation.

Slab is made of compacted overlay along metal beams with the space of 3 m along the topping girders.

Foundations for columns are columnar, cast-in-place and reinforced concrete. Floor is an independent cast-in-place reinforce concrete plate that ensures cask support and crawler moving in.

Laboratory building

The laboratory building is a two-storied casting reinforced concrete building with dimensions of 21×12m and with floor height of 3 m.

Building frame consists of casting reinforced concrete columns, girders and diaphragm plates. The overlaps are casting reinforced concrete, panels are ribbed along the girders with thickness of 220 mm. Staircases are casting and reinforced concrete.

Roof is flat with internal water drain. Baseplates – cast-in-place under columns with casting reinforced concrete foundation girders under walls.

Walls – precast panels made of aerated concrete. Brick partitions with thickness of 120mm.

Covered roofing area

Covered roofing area with dimensions of 21×12 m and with height of 14 m is a roofing made of steel zinc-coated compacted sheets which are piled along the bearers over slab beams.

Steel columns support slab beams. Central span is unloaded by the vertical strut along the columns and by the lateral strut along the slab beam bottom chord. To the slab beam bottom chord there are reinforced the under-crane rails for crane with carrying capacity of 1,0 t.

Under the columns there are arranged cast-in-place reinforced concrete separate foundation posts.

Columns – built-up, made of rolled channel bars.

Beams – welded I-beams.

Bearer – rolled-steel joist.

Couplings – made of finished L-steel.

Floor around the rail tracks is designed as cast-in-place reinforced concrete over the compacted soil with thickness of 200 mm.

The maintenance building and MPC storehouse bearing structures shall be designed for process loads and also for loads in compliance with [10, 23], and also as buildings of the third seismic resistance category according to [8].

4.2.7 Administrative Building

The administrative building (position 4 according to the general layout) is a five-storied brick building with layout dimensions of 45,6×15,0 m and with floor height of 3,60; 4,20 m.

Building external brick walls are of 510 mm thick, building internal brick walls of 380 mm thick. Building partitions are made of plaster blocks with thickness of 80 mm and of bricks with thickness of 120 mm.

Foundations are stripped. In the foundation bottom part there is a cast-in-place reinforced concrete strip with cross-section of 2,0×0,5 (h) m, in the top part there are FSB prefabricated concrete blocks.

Overlaps and slabs are made of precast reinforced concrete hollow-core slabs with thickness of 220mm which are supported by overlap metal beams.

Building bearing structures shall be designed according to the general industrial regulations of Ukraine.

4.2.8 Electrical Device Building

The electrical device building (position 5 according to General Layout) is a one-storey square building with dimensions of 9×36 m in axes with brick walls of 380 mm thick. Building height up to the roof slab bottom makes h=4,8 m.

The building frame consists of reinforced concrete columns with the space of 6 m and with cross-section of 300×300 mm over which precast reinforced concrete single-pitch beams of 900 mm height are arranged.

Roof slabs are precast, reinforced concrete and ribbed.

Foundations for the columns are cast-in-place reinforced concrete, post with reinforced concrete foundation girders under walls.

Building bearing structures shall be designed according to the general industrial regulations of Ukraine.

4.2.9 Garage for Crawler

The garage for crawler (position 7 according to General Layout) is a square brick building with dimensions of 24,0x12,0 m. Building height up to the roof slab bottom makes 9,0 m.

Strip foundations consist of precast foundation plates and precast concrete blocks.

Floor is an independent cast-in-place reinforced concrete plate for transport moving in.

Roof slabs are precast, ribbed, reinforced concrete.

Crawler garage loads and impacts are accepted according to the general construction regulations of Ukraine (SNiP 2.01-07-85).

4.2.10 Garage for Four Autos

The building of the garage for four autos (position 8 according to General Layout) is a one-storey building with layout dimensions of 30,0×18,0 m, with height of 4,5 m up to the roof slab bottom.

External and internal walls are made of bricks. External wall thickness - 510 mm, internal wall thickness - 250 mm, 380 mm.

Strip foundation. Foundation bottom part – cast-in-place reinforced concrete strip of 500 mm, foundation top part – FSB precast concrete blocks.

Roof slab – precast, reinforced concrete, ribbed pre-stressed plates arranged along the cast-in-place reinforced concrete chord of 400 mm height.

Roof is heated. Floors are covered by acidproof ceramic tile – concrete polymer-cement cover – bottom concrete layer.

The garage building includes two repair pits with layout dimensions of 8,3×1,5 m, of 1,2 m deep, designed in cast-in-place concrete, with monorail and metal service floor.

Building bearing structures shall be designed according to the general industrial regulations of Ukraine.

4.2.11 Rail Car Maintenance Building

The rail car maintenance building (position 9 according to the general layout) is a roofing protection structure with layout dimensions of 42,0x12,0 m and of 9,0 m height. The roofing is made of steel compacted zinc-coated sheets which are laid along bearers over slab beams.

Steel columns support slab beams. A central span is unloaded by a vertical strut along the columns and by the lateral strut along the slab beam bottom chord. To the slab beam bottom chord there are reinforced the under-crane rails for crane with carrying capacity of 1,0 t.

Under the columns there are arranged cast-in-place reinforced concrete separate foundation posts.

Columns – built-up, made of rolled channel bars.

Beams – welded I-beams.

Bearer – rolled-steel joist.

Couplings – made of finished L-steel.

Floor around the rail tracks is designed as cast-in-place reinforced concrete over the compacted soil with thickness of 200 mm.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.12 Gasoline Station

The gasoline station consists of two gasoline pumps (position 10 according to the general layout) and of two fuel tanks with the volume of 5 m^3. A diesel fuel tank is a 4 mm thick sheet steel welded cylinder with diameter of 2,2 m. The tank is embedded to the ground per 3,5 m. The packing, which is placed to the bottom plate, serves as a base for diesel fuel tank. The bottom plate, with layout dimensions of 2,8x2,5m, is made of cast-in-place reinforced concrete in the form of plate with thickness of 150 mm with collar. Along the bottom plate top there are arranged inclinations towards the delivery tray with the help of concrete footing.

The tank is equipped with process well structures with well walls and base plate made of cast-in-place reinforced concrete. He well is covered with metal cover. The tank is covered with the compacted ground. Asphalt riprap is arranged on the macadam base over the covering.

Cast-in-place reinforced concrete foundation is arranged for gasoline station.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.13 Pump Station for Fire Water Supply

The pump station for fire water supply (position 18.1 according to the general layout) is a square building with dimensions of 6,0x6,0m along the axes. The building is equipped with a chain hoist with carrying capacity of 1,0 t. Brick walls with thickness of 510 mm.

The roof is heated, the water drain is external. Building height up to the roof slab bottom makes 3,0 m.

Strip foundation is made of FBS concrete blocks (GOST 13579-78). Slab plates – precast, reinforced concrete and hollow-core (Lot1.141-1). The foundation for equipment is cast-in-place.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.14 Tanks for Fire Water Supply

The building for fire water supply (position 18.2 according to the general layout) is designed in the form of two tanks embedded to the ground per 1,5 m with each tank layout dimensions of

6,0x6,0 and with height of 3,79 m from the tank bottom to the slab plate bottom. The tanks are covered with the ground layer of 0,5 m.

Tank walls are made of plant manufactured, precast, reinforced concrete panels with thickness of 200 (250) mm (lot 3.900-3).

Wall panels are placed to the housing of foundation reinforced concrete plate bottom with variable thickness starting from 140 up to 350 mm.

Tanks are covered by precast reinforced concrete ribbed floor slabs with the height of 400 mm (Lot 1.442.1-1).

Foundation mat is arranged under the tank bottom.

Man access penetrations are arranged in tank covering.

Collars, made of cold asphalt mastic, are arranged along the tank structure outer surface.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.15 Residential Waste Water Collecting Pump House

The residential waste water collecting pump house (position 20 according to the general layout) is a receiving tank, embedded to the ground up to the elevation of minus 6,270 m, which is made of precast reinforced concrete wall rings with thickness of 90 mm and with diameter of 1500 mm. Tank bottom is precast and reinforced concrete with diameter of 2000 mm and with thickness of 120 mm and with regards to crushed-stone concrete – of 100 mm thick. Process equipment is installed above reinforced concrete wall rings.

Precast reinforced concrete wall rings and bottom plate are designed according to Lot 3.900.1-14.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.16 Rain Waste Water Retaining Tanks

Rain waste water retaining tanks (position 21 according to the general layout) are made of plant manufactured semi-detached tanks embedded to the ground per 4,5 m. Section dimensions - 6,0x6,0m, height - 5,0 m.

Walls are made of precast reinforced concrete panels with variable cross-section starting from 150mm up to 250 mm with cantilevers for overlap arrangement according to Lot 3.900-3.

Tank bottom is made of cast-in-place reinforced concrete over the foundation mat with thickness starting from 140 mm up to 350 mm.

Tanks are covered with metal panels.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.17 Guard Building

The guard building (position 29.1 according to the general layout) is a two-storied building with layout dimensions of 12,0x36,0 m. Floor height - 3,3 m.

Walls are made of brick. Foundation is stripped, reinforced concrete made of precast slabs and blocks.

Floor slabs and covers are cellular, precast and reinforced concrete.

Staircases are precast and reinforced concrete.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.18 Access Control Point, ACP-1

ACP-1 building (position 29.2 according to the general layout) is a one-storey building with layout dimensions of 12,0×24,0 m (along axes), with height of 3,0 m up to floor slab bottom and with internal water drain.

Outer walls are made of aerated concrete wall panels (thickness - 250 mm).

Internal partitions in the rooms with normal humidity are made of plaster blocks with thickness of 80 mm, in the rooms with excessive humidity partitions are made of brick with thickness of 120, 250 mm.

Frame columns – precast, reinforced concreter with dimensions of 0,40×0,40×4,30 (h) m.

Foundations – glass-type, precast reinforced concreter with dimensions of 1,80×1,80×1,50 (h) m, cross-section binding concrete strip with dimensions of 0,40×0,60 (h) m is made of B15 class concrete.

Precast reinforced concrete cellular floors are arranged over the metal channel beam.

Roof is heated.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

4.2.19 Access Control Point, ACP-2

ACP-2 building (position 29.3 according to the general layout) is a one-storey building with layout dimensions of 6,0×8,0 m, with height of 3,3 m up to the floor slab bottom and with the external water drain.

Internal and external walls are made of brick. External wall thickness makes 510 mm, internal wall thickness – 250 mm.

Foundation is stripped made of reinforced FSB concrete blocks.

Roof slabs– precast, reinforced concrete, cellular with thickness of 220 mm. Roof is heated.

Building bearing structures shall be designed in compliance with the general industrial regulations of Ukraine.

5 BASIC DECISIONS ON WATER SUPPLY, DRAIN SYSTEM AND FIRE EXTINGUISHING

5.1 Water Supply Systems

The following water supply systems are provided for at the CSFSF site:

- drinking and utility water pipeline;
- fire line;
- watering pipeline.

All designed water supply systems relate to not safety-related normal operation systems. System classification designation is made according to the requirements of [4] - 4H.

With regards to seismic resistance, the designed systems relate to the third category according to [8].

Water supply systems undergo the requirements of construction regulations.

Design decisions were taken according to the requirements of [27, 28].

A subsurface pipelining is provided for all designed water supply systems.

5.1.1 Drinking and Utility Water Supply

Drinking and utility water supply is stipulated for personnel drinking and utility water supply. Drinking water supply is stipulated for the following buildings and structures:

- administrative building;
- receiving building;
- maintenance building with MPC storehouse;
- garage for four autos;
- rail car maintenance building;
- ACP-1;
- ACP-2;
- guard building;
- reinforced concrete plant.

Available drinking and utility water supply “Vector” complex is a source of CSFSF site drinking and utility water supply. An artesian well with anticipated discharge of 8 m^3/h represents the given system water supply source, from which the water is supplied to the tank tower (capacity of 50m^3, borehole height – 24m) and then to drinking and utility water line and to industrial house (mainly for concrete tempering) and for filling of “Vector” Complex fire water tanks.

The project provides for construction of an additional standby artesian well with anticipated discharge of 8 m^3/h at the “Vector” complex water intake facility site.

Industrial site inlet estimated water flow is stipulated by the required flow head at the administrative building inlet and makes 22 m and is ensured by the available flow head of 24m in “Vector” complex drinking and utility water mains.

Industrial site water supply takes place with the help of conduit of ∅89x4,0mm.

Industrial site water use is controlled by the flow meter installed in ACP-1 building at auto moving in point.

Site drinking and utility water mains are designed as pipes made of steel.

Site water supply by “Vector” complex is stipulated by terminal main in one pipe run. Pipe material – steel with corrosion protection covering of "very intensive" type.

Drinking water pipe internal main is laying by terminal main with installation of the stop valves and plugging to this main.

Capacitive electric hot-water heaters are provided to be constructed for hot water production.

Drinking and utility water flow is given in Table 5.1.1

Table 5.1.1- **Drinking and utility water flow.**

№ o/r	Name of consumers	Unit measure	Number of consumers		Water consumption norm, l/shift	Hour irregularity factor	Water flow			Note
			Per 24 hours	Per shift			m^3/day	m^3/h	l/s	
Active period										
1	Cold store operation personnel	persons	208	173	25,0	3,0	5,2	1,56	0,44	
2	Shower mains		19 mains	19 mains	500	1	9,5	9,5	2,63	
3	Dining hall and café per 60 persons	dish	60	60	16.0	1	1,92	1,92	0,53	
4	Production of semi manufactures	kg	120 kg of semi manufactures			1,5	0,24	0,18	0,05	
						Total	16,86	13,16	3,65	
Passive period										
5	Cold store operation personnel	persons	87	87	25,0	3,0	2,17	0,65	0,18	
6	Shower mains		8 mains	8 mains	500	1,0	4,0	4,0	1,1	
7	Dining hall and café per 60 persons	dish	60	60	16,0	1	1,92	1,92	0,53	
8	Production of semi manufactures	kg	120 kg of semi manufactures		2 m^3 per 1 t of semi manufactures	1,5	0,24	0,18	0,05	
						Total	8,33	6,75	1,86	
Industrial needs (mainly for concrete tempering)										
							60,0	6,0	1,66	

Note: with regards to the separate concrete work types, the concrete tempering is possible to perform with the help of purified storm flows that could help to reduce the drinking water flow rate.

Thus, drinking water total flow, including industrial needs, in active period makes 19,16 m^3/h, and in passive period - 12,75 m^3/h.

B1 drinking and utility water pipeline system is given at

Top-down: IC "Vector" infrastructure (left side), cold water treatment, electric water heater, ACP for auto-car entry (ACP-1), Administrative Building, Guard-house, MPC maintenance and storage building, garage for four auto cars, Receiving Building, electric water heater, ACP-2, building site needs, concrete-mixing plant needs.

Drawing 5.1.1

~~Top-down: IC "Vector" infrastructure, cold water treatment, electric water heater, ACP for auto-car entry (ACP-1), Administrative Building, Guard-house, MPC maintenance and storage building, garage for four auto cars, Receiving Building, electric water heater, ACP-2, building site needs, concrete-mixing plant needs.~~

~~Drawing 5.1.1~~

5.1.2 Fire Water Supply

A fire water line is designed to provide the CSFSF industrial site buildings and structures with internal and external fire extinguishing. For the industrial site there is designed the circular high pressure fire line. Fire line mains are laid towards a building equipped with internal fire line. Hydrants are stipulated for external fire extinguishing.

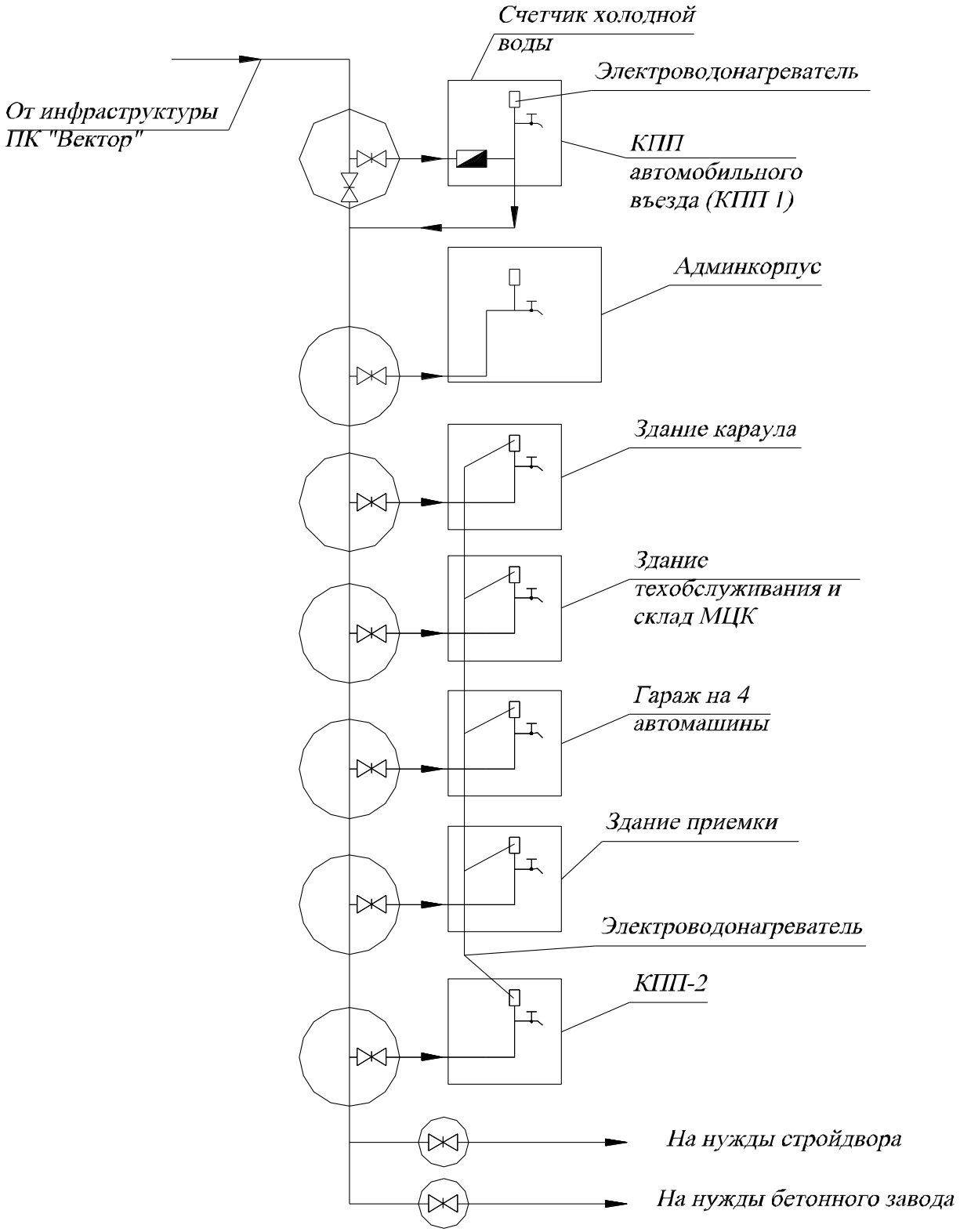
The estimated water flow makes 129,6 m^3/h. It is specified by the required water flow for external and internal fire extinguishing of the most fire risk building (maintenance building with MPC storehouse):

- external fire extinguishing - 10 l/s;
- internal fire extinguishing - 2 jets of 5,0 l/s.
- fire extinguishing in the most large cable drum compartment -16 l/s.

The required fire line system water head makes 62 m.

Fire water is stored in two fire water storage tanks with capacity of 200 m each.

Tank filling is stipulated by means of the pipeline supplied with water by the “Vector” complex drinking and utility water supply artesian well.



Top-down: IC "Vector" infrastructure (left side), cold water treatment, electric water heater, ACP for auto-car entry (ACP-1), Administrative Building, Guard-house, MPC maintenance and storage building, garage for four auto cars, Receiving Building, electric water heater, ACP-2, building site needs, concrete-mixing plant needs.

Drawing 5.1.1– **B1 drinking and utility water pipeline system**

Site mains water is supplied by means of pumps of the detached fire pump station. Pumps are started up with the help of the buttons situated near fire hydrants and internal fire cocks. Site fire mains constant pressure support takes place with the help of a pneumo-tank installed in fire pump station rooms.

Site fire water supply mains are designed as pipes made of steel.

Mains are circular equipped with fire hydrants with the distance between them of not more than 100m. Mains are laid mainly at the distance of 2,5m from the traffic way edge.

B2 fire line system layout is given at Drawing 5.2.1

5.1.3 Watering Pipeline

Territory watering and sprinkling water flow makes 0,4-0,5 l per $1m^2$ in frost-free seasons (SNiP 2.04.01-85, Annex 3). For such climatic conditions it is sufficient to water and sprinkle the site once per 24 hours. The rain water accumulator tank is the sprinkling water supply source. For watering and sprinkling there is selected the purified rain water from the middle part of accumulator tank volume where the purified part of storm discharge is accumulated.

The required head makes 20 m and is ensured by drain system Wilo - Drain TP 40 S/25 drowned pumps installed in accumulator tanks. Wilo - Drain TP 40 S/25 pump technical specification: Q=2-10 m^3/h; H=12-23 m; N=1,5 kW; voltage - 230/400 V.

CSFSF territory watering and sprinkling takes place with the help of hosepipes connected to each other by threaded-end heads. Site sprinkling water supply mains are designed as pipes made of steel.

Watering pipeline system layout is given at Drawing 5.2.2.

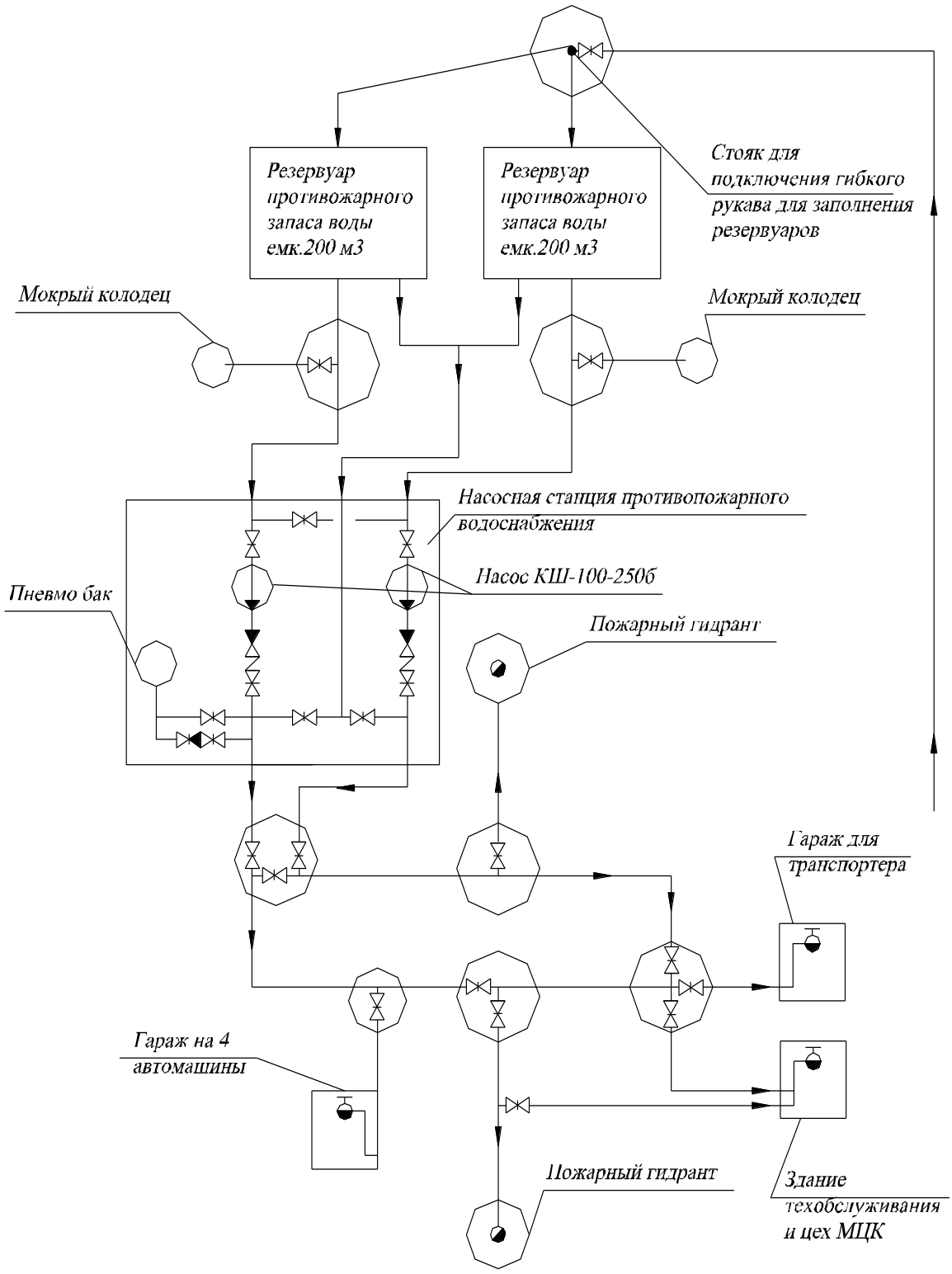
5.2 Drain System

The design provides for equipment for a set of CSFSF buildings with the following drain systems:

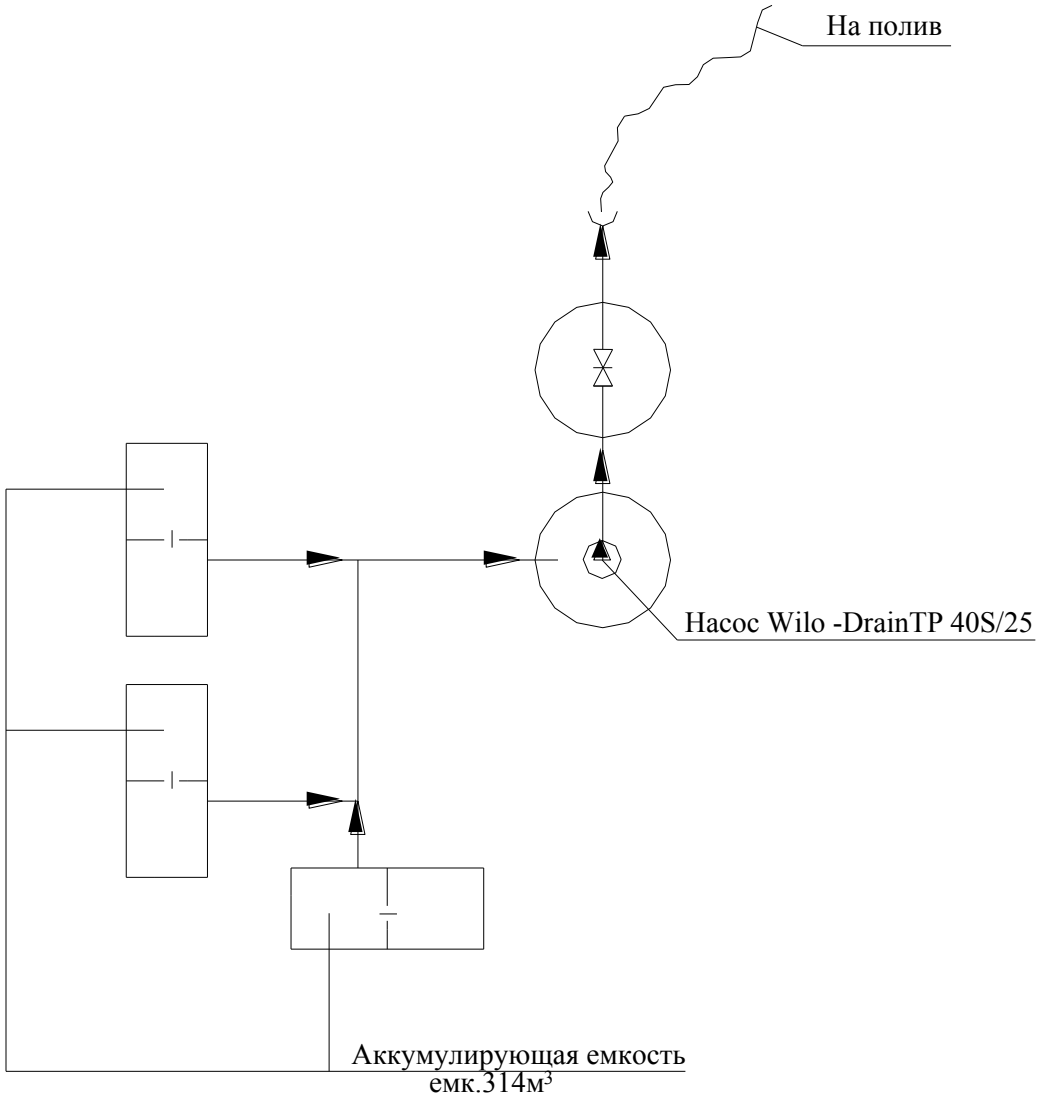
- house drain;
- rainwater drain;
- system of drains polluted by mineral oil;
- dining hall and café wastewater drain.

CSFSF site industrial processes do not stipulate industrial wastewater generation.

All processes, which relate to concrete tempering at the site, the concrete-mixing plant and at the construction site, should be carried out in specific places without wastewater discharge to the drain system.



Drawing 5.2.1–**B2 Fire line layout**



Top-down: for watering, Wilo-DrainTP40S/25 pump, storage tank (314m^3 capacity)

Drawing 5.2.2– **Watering pipeline system layout**

All the designed drain systems relate to not safety-related normal operation systems. System classification designation is made according to the requirements of [4] - 4H.

With regards to seismic resistance the designed systems relate to the third category according to PNAEG-5-006-87. All drain systems undergo the requirements of the construction regulations. Design decisions were accepted according to the requirements of [27], SNiP 2.04.03-85. A subsurface pipelining is stipulated for all drain systems.

5.2.1 House Drain System

The house drain system is designed for building wastewater drains at the CSFSF site.

House wastewater estimated flow makes 11m^3/h in active period and 4,65 m^3/h in passive period.

Site external mains are designed as gravity mains. It is provided for to install underground pumping to remove house wastewaters outside the site.

The pump station is equipped with Wilo-Drain TP 40 S/25 pumps (1-under operation, 1-standby). Pump technical specifications are:

- output, m^3/h…….. 10-12;
- head, m…… 12-23 m;
- capacity, kW……. 1,5;
- voltage, V……... 230/400.

Wastewaters are pumped through the discharge manifold from the pumping station to the waste-water disposal plant for "Vector" Complex site complete biological purification.

Site house wastewater mains are designed as mains made of cast iron.

Dining hall and café industrial wastewater drain takes place by means of separate discharge to house drain system wells.

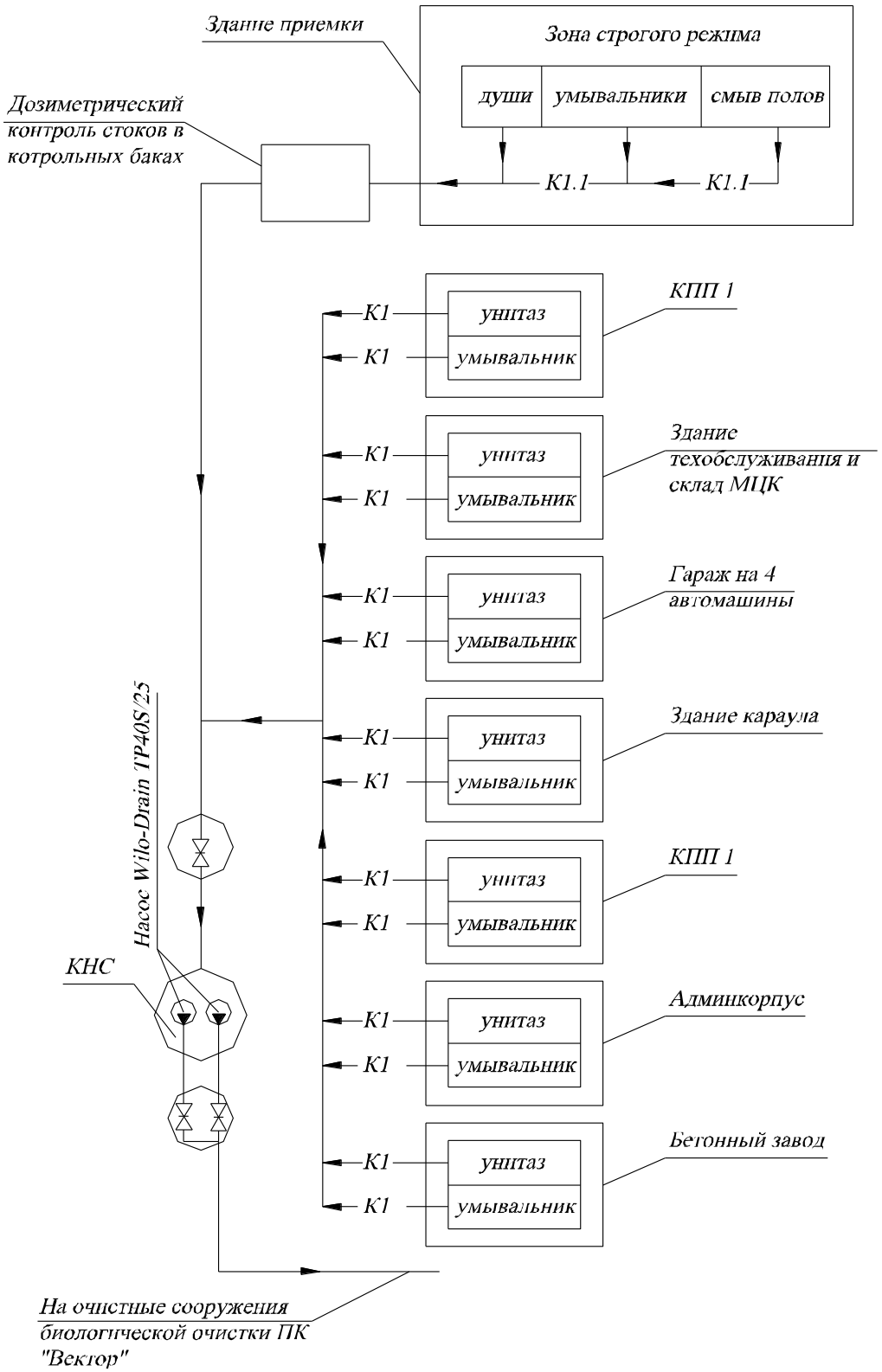
Since the number of places in dining hall and café does not exceed 200 persons (SNiP P -1.8-71, item 4.4), dining hall fat catch basin facility is not required. In-house and industrial wastewater drains have the following structure: KhPK - 400-500mg/l; BPK compl. - 200-mg/l; pH - 6,5-8,0, solid residue- not more than 1000mg/l. The given rates meet the regulations on drain water acceptance to the drain system mains and to biological purification facilities.

In-house wastewaters, caused by plumbing fixtures and shower rooms for washing out of floor in the rooms of receiving building, which is included to the restricted access area, are removed to house drain external mains after radiological control. At presence of radiological contaminations, which exceeds PDK, in-house wastewaters are removed from the control tanks with the help of special auto transport for processing.

House drain system layout is given of Drawing 5.2.3

5.2.2 Rainwater Drain System

The rainwater drain system is designed to collect and remove atmospheric precipitations from the CSFSF site traffic way covers and from building roofs. According to the calculations, the site storm flow makes 250l/s, (900m/h).



Drawing 5.2.3– **House drain system**

Storm discharge first part (20 minutes), which contains impurities, undergoes collection and subsequent treatment. Site external mains are designed as gravity mains.

For rainwater collection there is stipulated facility consisting of eight accumulator tanks with dimensions of 6x6 m, which are blocked by two. One block consists of two tanks with volume of 314m^3 designed for collection of impure part of the rainwater. At collector, for separation of the impure part of the drains and prior to ingress to the accumulator tanks, there is stipulated separation chamber. Pure part of the drains is removed to other three tank blocks. There is stipulated radiological control of the accumulated rainwater. Storm discharge with high ionizing radiation background is transferred to SVO with the help of specific transport.

Impure rainwater is transferred to the "Vector" complex site rainwater drain purification facilities. Pure rainwater, which was not used for territory watering, is transferred to the collector of purified rainwater after the "Vector" complex purification facilities. With this purpose, in each accumulator tank block, there is stipulated installation of Wilo-Drain TP 40 S/25 drowned pump (standby pump is stored in the storehouse). Sludge stirring-up pipeline is stipulated in accumulator tanks. Site rainwater drain mains are designed of cast-iron and reinforced concrete pipes.

Internal drains are stipulated in the Main Building for atmospheric precipitations collection and removal from the roof.

Collection of atmospheric precipitations at the roof is ensured by cesspool. Lift lines of the internal drain, arranged in rooms with possible radiation contamination, are laid as buried lines. Internal drain projections are connected to rainwater drain external mains. Rainwater drain system layout is given on

Drawing 5.2.4

~~Drawing 5.2.4~~.

5.2.3 Drains Polluted by Petroleum Products

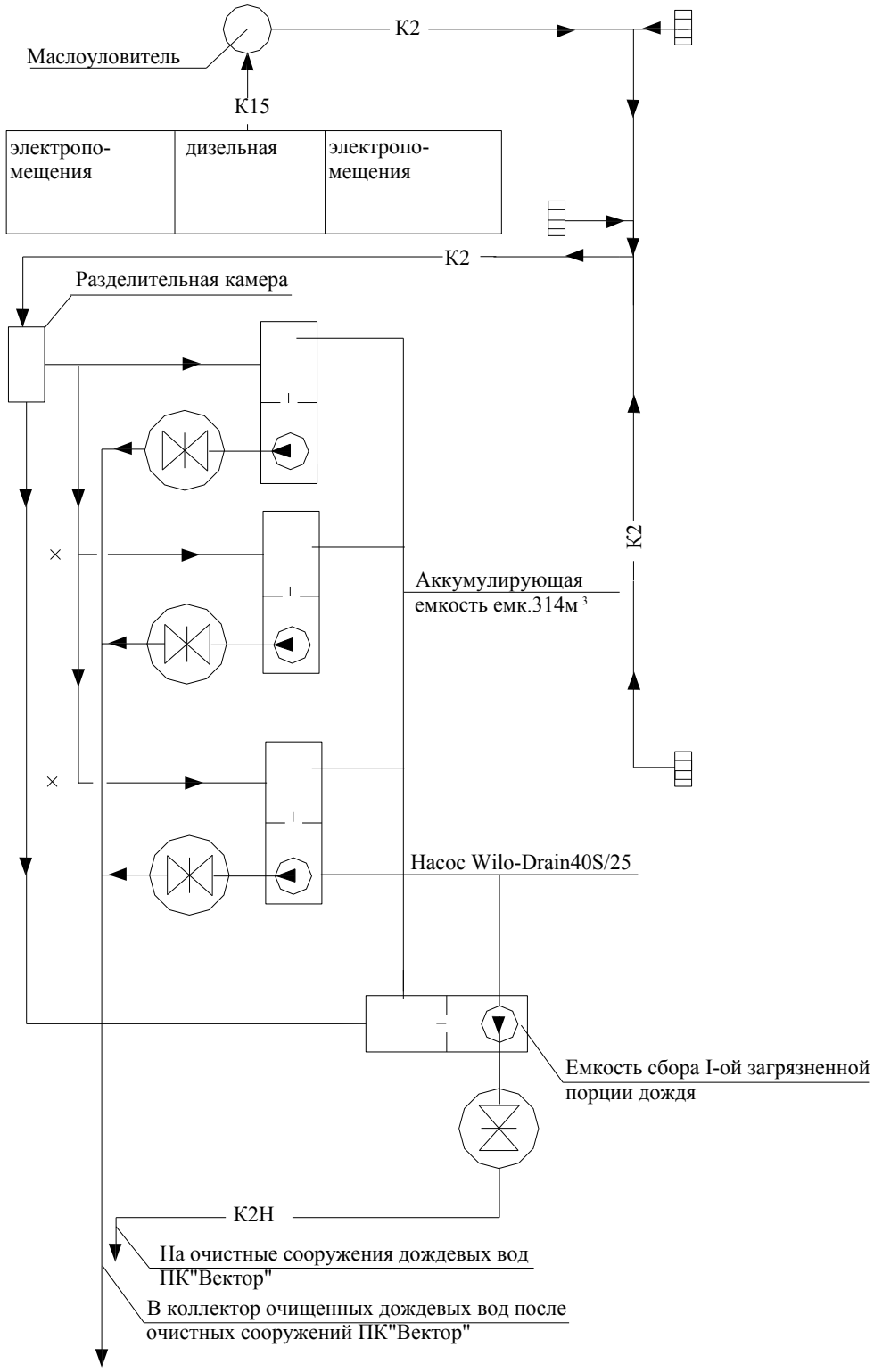
The drain system, polluted by petroleum products, is stipulated for removal of drains caused by floor washing in the diesel building, which is blocked to the electric device building. Floor drains are discharged to oil collector from which partially purified drains are removed to the rainwater drain external mains.

The diesel building drain estimated flow is 0,3 l/s. Without pre-treatment the storm discharge and site washing discharge ingresses to the storm discharge mains from the sites where the probability of oil product presence in storm discharge is very insignificant and the drain could contain only the signs of oil products (garage, gasoline station). Then, this discharge is purified at the "Vector" complex purification facilities.

Oil product polluted drains system layout is given at

Drawing 5.2.4

~~Drawing 5.2.4~~.



Условные обозначения

К2.Н-напорная сеть дождевой канализации

Drawing 5.2.4 – **Rainwater drain system and oil product polluted drain system layout**
Top-down: oil collector, electric device rooms, diesel station, electric device rooms, separation chamber, storage tank (314m^3 capacity), Wilo-Drain40S/25 pump, storm discharge first part accumulator tank, to IC "Vector" rainwater purification facility, to purified rainwater collector after IC "Vector" purification facility.

6 MAIN DECISIONS ON POWER SUPPLY

A power supply system is purposed for power supply to all CSFSF complex customers under normal operation conditions, under normal operation violation and during design basis accidents.

The power supply system includes equipment for support of operability of all systems that ensure SF process steps, SF storage, technological process control, physical protection, lightning, communication, radiation monitoring and ventilation.

This system stipulates timely switch to the standby or emergency power supply system in case of bulk power supply failure.

The power supply system includes a normal operation system (4H class according to [4], third seismic resistance category according to [8]) and an emergency power supply system purposed for systems and equipment power supply in case of standby and bulk power supply failure and, in particular, for normal operation safety related loads power supply.

With regards to safety influence, the emergency power supply system relates to safety related normal operation system (3-d class according to [4]).

6.1 Characteristics of Power Customers

Technological process, heating, lighting and ventilation systems are the main electrical customers. Table 6.1.1 gives the detailed list of CSFSF electrical customers with indication of the total consumed power.

Table 6.1.1 – **Detailed List of Power Customers**

System (facility, equipment) name	Total consumed power, kW
Technological process	730
Heating and ventilation	2833
Interior lightning of Administrative Building, Receiving Building, Electrical Device Building, garage for four auto cars	130
Lightning of the territory	30
Guard lighting	30
Auxiliary buildings (blockhouse, maintenance building with MPC storehouse, rail car maintenance building, garage for crawler, guard building, ACP, SDS)	200
Fire water supply pump station	55
Communication devices, industrial television, multicomputer system	15
Physical protection hardware	5
Fire alarm automatics	5,5
Radiation monitoring	19
Normal operation system control and monitoring system	20
TOTAL	**4073**

Table 6.1.2 gives electric customers categorization with regards to power supply reliability ensuring (consumed power is indicated).

These categories are specified according to the document “Regulations on Electric Facility Design” (sixth edition) current in Ukraine [17].

I category electric receivers are powered from two independent mutually redundant power supply sources and power supply failure of these sources could take place only for the time of power supply automatic renewal in case of one power supply source failure.

Among I category electric receivers there is specific group of electric receivers which undisturbed operation should be ensured in case of both independent mutually redundant sources failure; for this specific group power supply there should be stipulated auxiliary power supply from

the third independent source. It is recommended to supply II category electric receivers with power from two independent mutually redundant power supply sources with possible power supply failure in case of operable power supply source de-energization for the time necessary for actuation of the standby power supply source with the help of personnel actions.

III category electric receivers could be supplied with power from one power supply source and power supply failure should not exceed 24 hours.

Table 6.1.2 – **Categories of Electrical Customers with Regards to Reliability Ensuring**

System (facility, equipment) name	**Categories of power supply reliability ensuring**							
	1 category		**1 category specific group**		**2 category**		**3 category**	
	W		**W**		**W**		**W**	
Technological process	46	0			82,5	5	01,5	5
Heating and ventilation							833	00
Interior lightning of administrative building	0	3			00	7		
Guard lighting			0	00				
Lightning of the territory					0	00		
Auxiliary buildings					00	0	00	0
Fire water supply pump station	5	00						
Communication devices, industrial television, multicomputer system			5	00				
Physical protection hardware				00				
Fire alarm automatics		0	,5	00				
Radiation monitoring			9	00				
Normal operation system control and monitoring system					0	00		
TOTAL	**36**		**9,5**		**32,5**		**334,5**	

In accordance with Table 6.1.2, at the CSFSF there is a group of safety-related electrical consumers whose undisturbed operation should be ensured in case of both independent mutually redundant sources failure; these loads relate to the specific group of I category reliability consumers.

Such consumers include those that relate to safety-related normal operation systems:

- Process equipment in Receiving Building (total power consumption – 77 kW);
- Radiation monitoring (power consumption – 19 kW);
- Physical protection hardware (total power -5 kW);
- Engineered communication means (total power - 5 kW);
- Industrial television and multicomputer system (total power - 10 kW);
- Guard lighting (total power - 30 kW).

Rated voltage of all three-phase electrical consumers makes 380 V, one-phase electric consumers - 220 V of alternating current, power frequency - 50 Hz.

Control circuit and 0,4/0,23 kW main switchgear automatics circuit, which should be designed for direct or rectified current (voltage –220 V), make an exclusion.

Based on the data given in this Section, it is possible to make the following conclusions:

- total consumed power of the CSFSF electrical consumers - 4073 kW;
- at the CSFSF there is a group of safety-related system consumers that require an emergency power supply system.

6.2 Power Supply of Electrical Consumers

6.2.1 Decisions with Regards to Electric Circuit Diagram

In order to supply power for the CSFSF costumers, there is stipulated a main switchboard with the voltage of 0,4/0,23 kV, which is located in the electric device building and in the receiving building.

The electric device building house switchboard (HSB of 0,4 kV) consists of four buses. To each bus there is connected one transformer with voltage of 10/0,4-0,23 kV and with rated output of 1600 kVA.

The receiving building house switchboard (HSB of 0,4 kV) consists of two buses. To each bus there is connected one operable transformer with voltage of 10/0,4-0,23 kV and with rated output of 1600 kVA.

HSB 0,4kV buses are connected to each other by two with the help of normally cutoff circuit breakers; sectionalizing circuit breaker is automatically activated in case of one of two transformers cutoff.

All transformers are serviceable (implicit reserve circuit). Along the high side the transformers are connected to two 10 kV buses of “Buryakovka” 110/10 kV substation located at the distance of 1km from CSFSF. At existing “Buryakovka” 110/10 kV substation there are installed two transformers with unit capacity of 6,3MV A, 110/10 kV; along 10 kV side each transformer is connected to its own 10 kV bus; both 10 kV buses are connected to each other with the help of switch breaker.

“Buryakovka” substation power supply along 110 kV side is carried out along two 110 kV high-voltage lines, one of which is a branching from ChNPP (Pripyat’) 110 kV high-voltage line and the second one is a branching from Polevaya-Lubyanka 10 kV high-voltage line.

“Buryakovka” substation 110 kV HSB is designed according to bridge-type balancing circuit with circuit breakers in transformer circuits with access jumper bridge between 110 kV high-voltage line.

Taking into account that, at the “Vector” complex full capacity reaching, its output shall make 11200 kV A, for CSFS loads power supply there is stipulated replacement of “Buryakovka” substation existing 6300 kV·A transformers by new 110/10 kV transformers with unit capacity of 16 MV·A.

For connection of CSFSF 10/0,4-0,23 kV transformers there should be installed six new 10 kV HSB cubicles (in twos for each bus) at the existing “Buryakovka” substation.

Connection of the “Buryakovka” substation with CSFSF (10 kV voltage) is carried out with the help of six 10 kV cables with aluminum conductor 95 mm^2 cross-section each.

In order to ensure transformer protection in case of possible short circuit at each transformer high side there is stipulated installation of a high-voltage bushing cabinet with safety a device and a load-break switch (or power circuit breaker).

According to reliability conditions such circuit of 0,4/0,23 kV main switchboard ensures I, II an III category reliability loads power supply according to the Rules on electric installation design.

Each transformer accepted capacity of 10/0,4-0,23 kV and 1600 kV·A and their number is sufficient to cover all loads both under normal operation mode and under emergency and repair at cutoff of one of two transformers from each pair.

In order to exclude reactive power consumption from the power system there is stipulated connection, to each bus of the main switchboard of 0,4/0,23 kV, of one 120 kV·A jet power compensation capacitor.

For all switchboards there is accepted the 0,4/0,23 kV voltage system with dead-earthed neutral and with a joint neutral and protective conductor (TN-C system).

Diesel generators are stipulated for power supply to CSFSF reliability consumers, which require non-interruptible power supply under condition of all 10/0,4-0,23 kV in-house transformers failure (specific group of I category reliability collectors), and also to safety-related normal operation electrical consumers. With this purpose, along with six buses of the mentioned above 10/0,4-0,23 kV main switchboards, there are arranged two reliability load vital buses.

Each reliability vital bus power supply takes place with the help of two sources:

- 10/0,4-0,23 kV main switchboard bus;
- diesel-generator (second source).

Directly to this bus there is stipulated connection of below specified electrical consumers that require non-interruptible power supply but which allow short-time power supply failure during diesel-generator start-up:

- radiation monitoring (19 kV);
- guard lightning (30 kW);
- one of two fire pumps (55 kW).

Each diesel-generator capacity is stipulated to be equal to 160 kW.

Automatic fire alarm equipment power supply is ensured by means of own uninterruptible power supply (UPS) source equipped with accumulator battery.

Also, from other uninterruptible power supply source, there is stipulated physical protection hardware, communication facilities, industrial television and computers power supply.

Each UPS power supply is carried out both by normal operation HSB 0,4/0,23 kV bus and by reliability consumers vital buses.

For control circuit and automatics direct current power supply there are stipulated two 48V direct current installations equipped with accumulator battery and charger-eliminator.

Power supply circuit diagram is given on Drawing 6.2.1

6.2.2 Decisions with Regards to Layout

As it was specified above in subsection 6.2.1, 0,4/0,23 kV, main switchboard is located in the electric device building and the receiving building. These buildings include six dry transformers with 1600 kV·A of unit capacity, high-voltage bushing cabinets of these transformers and direct current installations.

Distribution units and lightning control panels are decentralized in corridors and process rooms.

It is proposed to carry out cabling directly in process rooms with arrangement of cables in specific zinc-coated structures fixing these structures to walls and/or ceilings.

Power cables are laid in open cable trays and control cables – in closed boxes.

All cables are accepted as fire non-stretching cables with a cover made of polyvinylchloride materials.

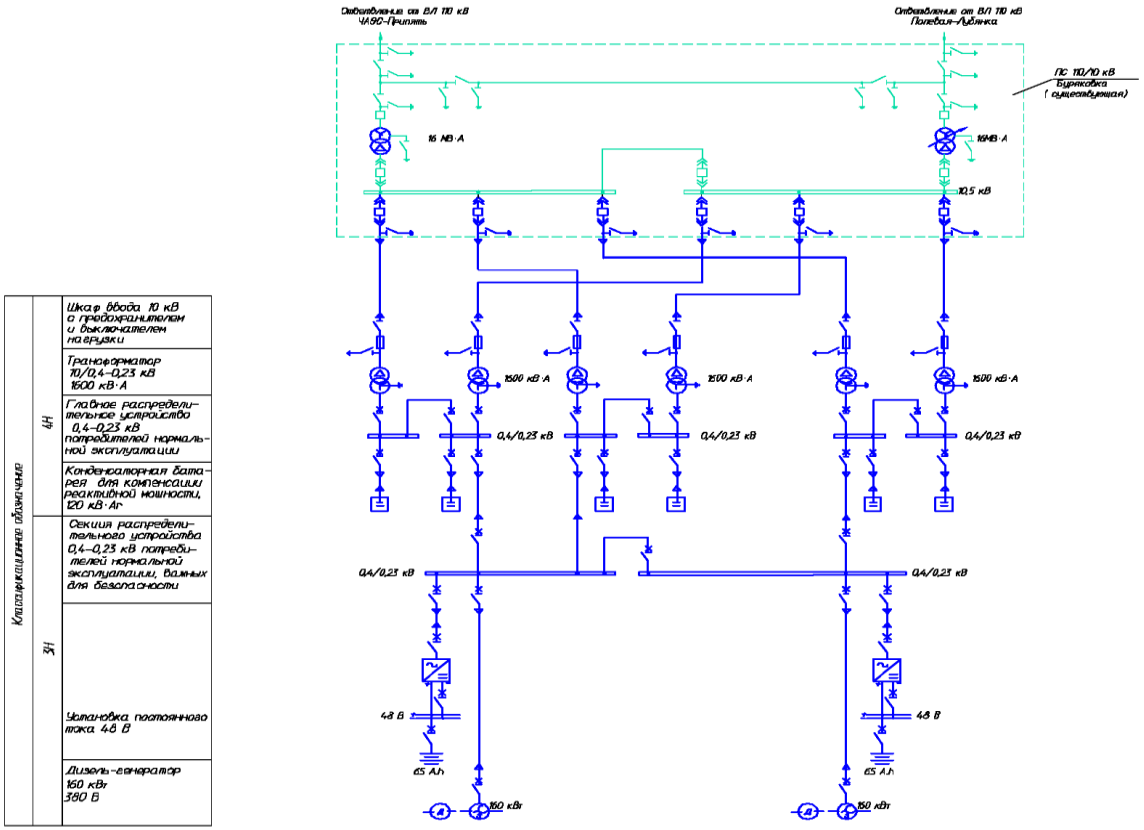
All power cables with voltage up to 1 kV and control cables are designed with copper conductors. Zero conductor section is equal to the phase conductor section.

There are stipulated fire-resisting partitions in case of cable penetrations through the walls and overlaps and also after each 30 m of cable routing length.

All not live metal parts of electric equipment are connected to the ground grid and also undergo grounding.

Electric equipment routine repair is stipulated to be performed directly at site of its installation mainly by replacing equipment failed elements by new elements.

Electric equipment major repair is stipulated in special repair stations outside the CSFSF.



Drawing 6.2.1 – **Power Supply Circuit Diagram**

6.3 Lighting

Artificial electric lighting is designed according to [16].

There is stipulated routine and emergency (safe and evacuation) lightning. Routine and emergency lighting control panels are supplied with power by 0,4/0,23 kV main switchboard different buses. Electric lighting circuit voltage - 380/220 V of direct current with dead-grounded neutral, light voltage - 220 V, general purpose socket circuit voltage - 220 V, repair lighting circuit – 12 V. Evacuation lighting is arranged by means of lights equipped with integral accumulator batteries.

Room lighting is accepted according to [16] with increase, based on the requirements of technological process peculiarities.

Lighting mains are designed with the help of double-wire cables with aluminum conductors and in all administrative and accommodation rooms – with the help of three-wire cables with copper conductors (1ф+N+PE).

Table 6.3.1gives the list of main rooms with indication of lighting.

Table 6.3.1 – **List of Main Rooms with Indication of Lighting**.

Room name	Lighting, lux
Corridors	50-100
Sanitary air lock	200
Staircases	100
Electric rooms, I&C	200
Local panels	300
Workshops	200
Fan rooms	100
Cask area (receiving, transfer)	600
Container transfer, assembly treatment, container monitoring, maintenance	300-500
Offices	300
Pump, diesel and compressor stations	150
Radiation monitoring rooms	150
Water closets	100

There is stipulated territory guard and outside lighting.

Guard lighting is arranged by means of 250 W, 220 V sodium lights arranged at 10 m supports with ensuring the restricted access area 15 lux lighting.

Road outside lighting is arranged by means of 80-150 W sodium lights arranged at 10 m supports with ensuring of 2 lux lighting.

Guard and outside lighting mains are provided by means of AVVGng cable laid in trench along the roads and in boxes along the fence.

Guard and outside lighting monitoring is carried out automatically by means of photoswitch signal and manually.

Outside lighting is supplied with power by 0,4/0,23 kV main switchboard buses, guard lighting mains - by 0,4/0,23 kV reliability vital buses which have independent power supply source – diesel-generator.

Cask storage site outside lighting is arranged by means of floodlight with 400 W sodium lamps arranged at 20 m floodlight tower sites with ensuring of 30 lux lighting.

Storage site lighting control –is manual, from lighting control panels installed to the floodlight towers.

6.4 Lightning Protection and External Ground

According to [41] there is stipulated necessary set of measures and devices purposed to ensure the safety population and personnel, building and structures protection from explosions, fire and destruction which are possible during lightning action.

For lightning direct stroke protection there are stipulated building grid lightning conductors with the use of metal cover and frame.

Detached lightning conductors are stipulated for the outside container facility and the gasoline station. Number and height of detached lightning conductors at the cask storage site is specified during the detailed design.

There is designed an external ground loop with ground grid resistance that does not exceed 4 Ohm in any season.

Round the buildings, along the perimeter at the depth of 0,7 m from the ground surface, there is a laid loop which includes 40×4 steel strips and vertical electrodes with diameter of 12 mm and with the height of 5 m. Loops are bound to each other not less than in two directions.

6.5 Outer Power Supply for Construction and Operation Period

As was mentioned above, with the purpose of CSFSF consumers power supply, there is designed 0,4/0,23 kV voltage in-house main switchboard that should include six buses. To each bus there is connected the transformer with rated power of 1600 kV·A, and with rated voltage of 6(10)/0,4-0,23 kV.

Power is supplied by different HSB 10 kV buses (at presence of 10 kV voltage) designed for this section of 110/10 kV substation with replacement of both 6300 kV·A unit power transformers by 16 MV·A transformers.

There is stipulated laying of six three-core cables of 10 kV voltage; aluminum core-section-95 mm^2; each cable length is about 1 km.

It is proposed to undertake site construction load offside power supply with the use of one of six cable lines purposed for CSFSF power supply during operation period.

At the same time, at the CSFSF construction site there should be installed a packaged transformer substation of 6(10)/0,4-0,23 kV voltage with one transformer with capacity of 1000-1600 kV·A.

6.6 Communication Networks

In order to provide CSFSF with dispatcher and process control means, external and intercommunication systems are arranged.

In order to arrange the CSFSF and Ukrainian NPPs external telephone communication of the SNRCU and other Departments, which ensure building safe operation, national communications network output terminals, information transfer (including video information) to the top management levels, should stipulate laying of optical couplers with digital data transmission system from CSFSF site up to SSE ChNPP and Chernobyl town communications center. Digital communications drive is arranged with the help of existing cable lines through nearest Ukrtelecom network communication center.

For communications in the process of SF shipment, there should be arranged permanent mobile connection between the sender, recipient, SF transportation means, attendant groups and support subdivisions along the transportation rout. This shall take place by means of creation of the Ministry of Fuel and Energy detached radio net based on the “Tetra” (“Dimetra”) trunking communication digital system. This system base stations shall be arranged at the SSE ChNPP and “Vector” sites.

There are stipulated the following types of intercommunications:

- CSFSF subscriber automatic telephone communications. There is stipulated arrangement of CSFSF intercommunications with installation located in Digital Exchange Center (capacity - 100 numbers) communication rooms. DEC connecting arrangement allows to solve different

telecommunication tasks with possibility to create voice and data transmission integrated complex structures, other applications in the sphere of broadband commutation with data transmission rate of up to 2 Mbit/s and with integral service digital network (ISDN). DEC is supplied with power by direct current power facility which ensures patching facility operation during 4 hours with the help of the standby accumulator battery;

- in-house on-line radio communication system. With this purpose there is stipulated purchasing of stationary, mobile and portative radio stations which should be operable in "Tetra" system base station, installed at the "Vector" complex covering area;
- radio broadcasting network with installation of subscriber loudspeakers in places of personnel permanent attendance and also installation of an announcing circuit and of a command-search network in all accommodation, service and process rooms, at evacuation routes and within the CSFSF territory. The command-search and personnel announcement network monitoring is carried out from the MCP dispatcher control board. "VELLEZ" announcement system equipment is used as a broadcasting center. At the same time, the announcing circuit is subdivided into areas that meet the process equipment coverage area. Announcement loudspeakers are arranged in disperse, in order to obtain the required level of area annunciation. Loudspeakers are connected to the announcement circuit without audio-volume control and connectors. If necessary, the announcement circuit is used for local broadcasting.

"VELLEZ" broadcasting instrumentation provides:

- automatic mode recorded announcement transmission from automated fire alarm station signal;
- transmission (by the operator) of other announcements with the help of built-in microphone;
- broadcasting center manual control;
- transmission of announcements within necessary coverage areas (up to 24);
- transmission of attention attraction signal prior to announcement;
- connection of up to five transmitter announcement panels with announcement area remote control. Each panel has its own data transmission priority level. Fire alarm broadcasting is of the most high priority level;
- if necessary, arrangement of double-channel transmission systems from which the first system is used for transmission of announcements and the second one is reserved for non-stop music, commercial and other data transmission. First system is of the most high priority level;
- connection to evacuation direction light cursor transmission line;
- automatic check of the absence of transmission line fault or short circuit with light indication of line state;
- power amplifier serviceability control and automatic switching to the standby amplifier ("hot" sparing).

The announcing system is supplied with power by a reliable power supply source that ensures equipment operation with the help of the standby accumulator battery during four hours.

A communication center cross is the telephone distribution circuit main electrical interlock board. Network capacity along the cross is 300 pairs. the telephone distribution circuit includes TPP and TPV cables with corresponding capacity. Within the territory and in process buildings the communication cables are laid, mainly, along the structures designed for electric and control cabling.

7 MAIN DECISIONS ON FIRE SAFETY ENSURING

7.1 Fire Safety System Purpose and Functions

At the design stage, the CSFSF fire safety is ensured according to the requirements of the current Ukrainian regulatory acts on fire safety issues (FSRA), taking into account their application scope.

The CSFSF relates to the group of facilities at which possible fire could cause population, personnel and environment mass affection by indirect manifestations of fire hazard, first of all at radioactive substance and materials release beyond engineered barriers. In this connection, according to the requirements of [29], the considered object should include fire safety systems that prevent or minimize the possibility of fire.

CSFSF fire safety at the design stage is ensured by fire prevention or fire protection systems including organizational and technical measures. The CSFSF fire safety peculiarity is that the facility fire safety systems are target systems and, first of all, they should ensure facility radiation and nuclear safety.

Fire prevention should be achieved by prevention of combustible medium generation and of inflammation source generation in combustible medium (or inflammation source inlet to the combustible medium).

Combustible medium generation is prevented by combination of the following means:

- maximum possible usage of nonflammable and hardly-flammable substances and materials;
- limitation of the mass of flammable substances and materials, which are compactly arranged, by means of their arrangement in the most safe way;
- flammable substance isolation (providing of fire modules and sections);
- installation of fire risk equipment in the isolated rooms (in fire modules and sections);
- maximal mechanization and automation of spent fuel treatment technological process;
- application of protection facilities for plant equipment which contains combustible substance in order to protect it from damage and accidents;
- installation of cutoff and tripping devices (including the ventilation system air ducts).

Generation of combustible medium inflammation source is prevented by combination of the following means:

- use of electric equipment which correspond, in the framework of design, to conditions of equipment application in fire and explosion unsafe areas in compliance with the Rules on electric facility design;
- use of fast-acting means of safe cutoff from possible inflammation sources;
- keeping to the requirements of electrostatic safety;
- building and structures lightning protection device;
- elimination of conditions for reversing combustible substance thermal, chemical and (or) microbiological spontaneous combustion.

Flammable substances and materials mass limitation and also the safest way of their arrangement is achieved by combination of the following means:

- mass decrease of the combustible substances which are simultaneously occur in rooms;
- maximum possible substantiation of combustible fluids with non combustible.

Fire safety is ensured by combination of the following means:

- use of corresponding fire extinguishing means and equipment and of corresponding fire engineering;
- use of automated fire alarm and fire extinguishing facility;
- use of noncombustible building structures and materials with fire hazard standardized indicators;

- use of planning-special decisions and devices which restrict fire spreading: subdivision of constructions into fire modules and sections, arrangement of fire barriers, fire –resistant elements in equipment, equipment emergency tripping, etc.;
- ensuring of timely personnel notification and evacuation with the help of planning-special decisions and hardware;
- use of collective and individual protection means (personnel, fire-brigade) which are used for protection from dangerous fire factors and radiation;
- application of smoke protection means.

Organizational and technical measures on CSFSF fire safety at the design stage include:

- verification of fire safety correspondence to the requirements of Regulations on construction;
- use of fire safety product with regards whose has the technical documentation that is certified in the order established in Ukraine;
- regulation of a personnel number at the facility according to the fire safety conditions taking into account nuclear and radiation safety.

7.2 Facility Brief Characteristic

CSFSF brief characteristics and main process decisions on spent fuel treatment are given in Section 1.

7.3 Architectural and Constructional Part

7.3.1 Decisions on Fire Prevention Decisions on General Layout

The territory, proposed for CSFSF siting, is adjoined from the east to the "Vector" complex site and from the west - to 110 kV HVL, from the south, the territory is restricted with the access highway to the "Vector" complex site and from the north, the industrial site is adjoined to the forest.

The site is at 5 km distance from the Shepelechi railway station, of 1 km from the RWDS "Buryakovka", and 12 km from the ChNPP.

The industrial site and the construction site territory are completely occupied with pine forest that shall be cut down during preparatory works.

During development of a site general layout, the following functional areas were specified:

- MPC receiving and transfer building;
- MPC storage site;
- maintenance building with MPC storehouse;
- crawler and auto transport storage and maintenance buildings and structures;
- electrical device building;
- water supply and drain system;
- guard buildings and structures;
- administrative building;
- holding and maneuvering railway lines.

Fenced industrial site general dimension - 644x182 m.

Requirements of [13]were fulfilled at specification of a distance between buildings and structures depending on their fire resistance degree and fire and explosion hazard category and also at car driveways design.

The main car driveway at the site with a car pack is stipulated from the south part of the administrative building siting. Car driveway is adjoined to the existing highway to the "Vector" complex.

The second car driveway is stipulated from the north part, it is adjoined to the road that leads to the Chistogalovka village.

In the north part of the site the railway entry there is designed (along which holding and maneuvering lines are arranged) by means of which spent fuel is transported. .

On-site roads system stipulates the road concrete slab cover and ensures free access of fire engines to all buildings and structures at the same time, the receiving and transfer building has the circular by-pass.

7.3.2 Classification of Buildings, Fire Resistance Characteristics

Special-planning-and design decisions of the CSFSF buildings and structures are developed according to the requirements of the current construction standards and rules.

Fire resistance degree of CSFSF buildings, minimum fire resistance limits and maximum fire spreading limits of the main structures are specified according to the requirements of [30, 31, 46]. Classification of buildings and structures is given in Table 7.3.1.

Table 7.3.1 - **Classifications of CSFSF buildings and structures**

Position on general layout	Name	Fire and explosion hazard category	Fire resistance egree
Main construction facilities			
1	Receiving Building	D	I
2	Container storage site	-	-
Service Buildings and Storehouses			
3	Maintenance building with MPC storehouse	D	II, IIIa
4	Administrative building	-	II
	Blockhouse for sheltering of the “storage” personnel arranged in the basement part of the administrative building	D	II
30	Concrete-mixing plant	-	-
Power economy facilities			
5	Electrical device building	D	II
Transport management facilities			
7	Garage for crawler	V	II
8	Garage for four autos	V	II
9	Rail car maintenance building	-	-
10	Gasoline station	-	-
11	Rail transport holding lines	-	-
Water supply and drain system structures			
18.1	Pump station for fire water supply	D	II
18.2	Tanks for fire water storage	-	-
20	Drain pump station	-	-
21	Rainwater retaining tanks	-	-
Physical protection engineered barrier structures			
29.1	Guard building	-	II
29.2	ACP 1	-	II
29.3	ACP 2	-	II

Arrangement of evacuation routes, staircases and a number of evacuation exits should meet the requirements of [30, 31, 46]. Staircases shall be designed with natural lighting.

7.4 Electrical Part

7.4.1 Fire Safety of Electrical Installations

The power supply system is purposed for power supply to all CSFSF consumers including fire protection systems under normal operation conditions, under violation of normal operation and

during design basis accidents. This system stipulates timely connection to the standby or emergency power supply system in case of bulk power supply failure.

The CSFSF electrical system, including fire protection assurance, should be designed according to [39]. At the same time, it is necessary to meet additionally the requirements of [33], which relate to electrical installations.

All CSFSF cables should be designed as fireproof cables.

In cable routing design and in cabling in one cable structure (cable shelf, gutter, cable box bottom, etc.) it is recommended not to permit the total volume of polymeric combustible mass, which is included to cable insulation and sheath, to be more than 7,0 liters per routing running meter.

In case when, issuing from layout and design considerations, the total volume of polymeric combustible mass of cables, arranged in one cable structure, reaches 7,0 liters and more pet cable routing running meter, then these cables are to be covered with fire retardant agent. Cable fire resistant cover is designed according to the requirements of [43].

7.4.2 Fire Protection System Power Supply

The total power consumption of the automatic fire alarm devices and automatics total makes 5,5 kW, and power consumption of the fire water pump station makes 55 kW.

According to [39], fire protection system electric receivers are related to the collectors of the following categories:

- I category electric receivers (fire water pump station, automatic fire alarm devices and automatic fire extinguishing system automatics);
- I category specific group (automatic fire alarm devices for CSFSF rooms with safety-related normal operation systems and also for spent fuel treatment rooms).

I category electric receivers should be supplied with power by two independent mutually redundant power supply sources and power supply failure of these sources could take place only for the time of power supply automatic renewal in case of one power supply source failure.

Among I category electric receivers, a specific group of electric receivers rises whose undisturbed operation should be ensured in case of both independent mutually redundant sources failure; for this specific power supply group, there should be stipulated auxiliary power supply from the third independent source.

Each reliability vital bus power supply takes place with the help of two sources:

- 10/0,4-0,23 kV main switchboard bus;
- diesel-generator (second source).

7.4.3 Evacuation Lightning

There is provided the emergency (safe evacuation) lighting.

It is provided for to arrange emergency evacuation lighting circuit along the main passageways, corridors and staircases. Also “Exit” light cursors are arranged in all main process and cable rooms.

Evacuation lightning takes place with the help of lights equipped with integral accumulator batteries.

There is ensured possibility to keep the evacuation lighting and “Exit” light cursors in switched on position during the whole time of routine lighting keeping.

7.4.4 Characteristic of Lightning Protection for Buildings and Structures and External Ground of Electric Equipment and Buildings

According to [41] there is stipulated the required set of measures and devices designed to ensure protection of population and personnel safety, buildings and structures from explosions, fire and destruction which are possible in lightning.

For lightning direct stroke protection there are stipulated building grid lightning conductors with the use of a metal cover and a frame.

Detached lightning conductors are stipulated for outside container facility and gasoline station. A number and height of the detached lightning conductors at the cask storage site is specified during detail designing.

There is designed an external ground loop with ground grid resistance that does not exceed 4 Ohm in any season.

Round the buildings, along the perimeter at the depth of 0,7 m from ground surface, there is laid a loop which includes 40×4 steel strips and vertical electrodes with the diameter of 12 mm and with the height of 5 m. Loops are bound to each other not less than in two directions.

7.5 Ventilation System

A centralized de-energization of ventilation installations that ventilate fire and explosion risk rooms is provided for in fires. Ventilation system de-energization signal is generated in actuation of the automatic fire alarm (AFA).

The ventilation system air lines are designed as metallic. For the "free" access area there are stipulated the airlines made of light-gage galvanized steel, for the "restricted" access area – made of ungalvanized steel with a corrosion-resistant cover.

Class "P" air lines (tight) are used independently of the system assignment and fan head; airlines type and component connection technique is specified on subsequent stages.

Fire suppression floats of automatic, remote and manual (in place of their installation) control, are installed at "B" fire hazard category [32] room boundaries and to ventilation system airlines.

After fire suppression, taking into account the peculiarities of the receiving building as regards radiation safety ("restricted" access area), gaseous burn-up products are removed by exhaust ventilation regular systems with removed air radiation monitoring. The air is removed to the metallic vent stack placed on the building roof.

At subsequent design stages, after architectural design and after definition of room category with regards to fire and explosion hazard, there shall be clarified a ventilation system general layout and a place of fire suppression float arrangement according to [32].

7.6 Fire Water Supply

7.6.1 External Fire Water Pipeline

7.6.1.1 Characteristics of Water Sources and Fire Water Pipeline External Mains

For CSFSF there is stipulated a high-pressure firewater pipeline which ensures inner and outer fire suppression of buildings and structures and also operation of the fire extinguishing water automatic installation. The on-site firewater pipeline system is an off-line system.

According to item 2.22 of [28], the estimated number of fires is accepted as equal to one, since the site area is considerably less than 150 ha.

The off-line firewater suppression system includes:

- fire water reserve tanks;
- fire water pump station;
- fire water pipeline mains along the territory with fire hydrant installation;
- internal fire water pipeline.

Two firewater reinforced concrete reserve tanks of 200m^3 each serve as fire water supply sources. There is prohibited to use for other purposes the fire water tank reserve, stipulated by fire extinguishing design.

The required water flows and heads for inside and outside fire suppression needs, including automatic water fire suppression systems, are ensured by fire water pumps installed in the detached fire water pump station. In the pump station, there are installed two pumps (1 operable pump, 1 standby pump) of КШ 100-250b model, with capacity of 130 m^3/s and with the head of 0,64 MPa.

Constant pressure in fire water pipeline mains is supported by VEE1-2-1,0 water-air tank with capacity of 2,0 m^3.

Water-air tank air makeup is carried out by EPKU-02/10 movable compressor unit.

Firewater pump is controlled by:

- startup devices near fire cocks;
- startup devices in fire water pump station rooms;
- automatically from the fire-alarm box in the automatic water fire suppression system (cable vaults).

Firewater pipeline external mains are designed as circular mains with dead pipes for those buildings that require arrangement of an internal fire water pipeline. The mains are made of steel pipes ∅ 159x4 - 57x3 mm GOST 10704-91 [0] with "very tight"-type cover and tightness.

7.6.1.2 Inside and Outside Fire Suppression Water Flow and Head Calculation

Flows are determined according to the maximum possible option, in particular:

- fire fighting flows in the most large site cable vault of the receiving building (drencher and water fire extinguishing) ($q_{АУП\ К}$)

$q_{АУП\ К}$ = 16 l/s
(in sprinkling intensity of 0,2 l/s per 1 m^2);

- Fire fighting and inside fire cocks flow (building with MPC storehouse)

$q_{ПК}$ = 5 l/s (2 jets of 2,5 l/s + 5 l/s = 10 l/s
([27], volume 2; item. 6.3);

- Fire hydrant fire fighting flow

$q_{ПГ}$ = 10ll/s
([28], volume 7, D category, IIIa fire resistance category and volume of up to 5000 m^3)

$Q_{общ.} = q_{АУП\ К} + q_{ПК} + q_{ПГ}$ = 16 l/s + 10 l/s + 10 l/s = 36 l/s.

7.6.1.3 Fire Water Reserve Calculation

a) Cable vault extinguishing (fire duration - 10 min with water reserve for 30 min)
16 l/s x 60 sec x 10 min =9,6 m^3;
9,6 m^3 x 3= 28,8 m^3
b) other flows (inside and outside fire suppression, fire suppression duration – 3 hours
(10 l/s + 10 l/s) x 3,6 x 3 = 216 m^3
Total fire suppression water flow makes:
28,8 m^3 + 216 m^3 = 244,8 m^3
In feasibility study there are accepted two reinforced concrete tanks with V = 200 m^3 each.
The estimated water flows and heads for fire extinguishing of buildings and structures at the CSFSF site are given in Table 7.6.1

Table 7.6.1 - Estimated Water Flows and Heads for Fire Extinguishing

Name	Water flow, l/s		Fire suppression estimated time, hour	Water quantity for the fire suppression estimated time, m^3	Required head, m
	In inside fire suppression	In outside fire suppression			
Maintenance building with MPC storehouse, fire-cocks	5,0 (2 x 2,5) +5,0=10,0	10,0	3,0	216	30,0

Garage for crawler, fire-cocks	5,0 (2 x 2,5)	10,0	3,0	162	30
Garage for four auto cars, fire-cocks	5,0 (2 x 2,5)	10,0	3,0	162	30
Receiving building cable vaults	16,0	-	0,16 (10 min.)	9,6	40÷50
Name	Water flow, l/s		Fire suppression estimated time, hour	Water quantity for the fire suppression estimated time, m^3	Required head, m
Administrative building, fire-cocks	2,5	10,0	3,0	135	30

7.6.2 Internal Fire Water Pipeline

The internal firewater pipeline is designed in CSFSF site buildings that undergo fire extinguishing (see Table 7.6.1).

In the maintenance building with MPC store the firewater pipeline is designed taking into account sprinkling of each room point by two jets with capacity of 10 l/s each ([27], item 6.3).

In the garage for crawler and in the garage for four auto cars (B,II) the inside fire water pipeline is designed taking into account sprinkling of each room point by two jets with capacity of 2,5 l/s each.

In the maintenance building the firewater pipeline mains are designed as circular mains with arrangement of not less than two water lines.

The mains are equipped with stop valves. The firewater pipeline inside mains are designed as mains made of steel electric-welded pipes with diameter of ∅ 57x3 - 89x3 mm [33].

Fire cocks are installed at the height of 1,35 m from the floor level or the maintenance area.

Fire cocks arrangement, especially in distribution devices, is stipulated in heated staircases, corridors and lobbies.

7.7 Fire Detection Automatics

7.7.1 Automatic Fire Alarm

Automatic fire alarm system (AFAS) is a component of the CSFSF fire protection system.

The necessity to install the fire alarm in CSFSF building rooms is stipulated based on the requirements of [35]. Automatic and manual fire-alarm box and fire detection and control device arrangement is accepted in accordance with the requirements of [37].

Automatic fire alarm is a fire protection installation that ensures:

- early detection of fire seat;
- generation of signal on fire origin by means of fire detection and control device in the duty personnel room;
- generation of building equipment control command pulses which allow to provide conditions for personnel safe evacuation and for fire seat suppression and fire spreading limitation.

According to its design and application scope all AFA equipment, accepted to be installed at the CSFSF, should be certified by the State Certification Center of the Ministry of Emergencies of Ukraine which certifies production in compliance with the requirements on fire safety.

CSFSF automatic fire alarm should be functionally connected to its engineering systems, such as:

- 220 V, 50 Hz alternating current power supply system;
- 220 V, 50 Hz standby alternating current power supply system from the diesel station;
- ventilation systems;
- ventilation system fire suppression float control system.

In the “restricted” and “free” access area rooms of the transfer building all input and exhaust ventilation systems should be automatically tripped in case of fire.

In the ventilation system air ports, there is stipulated installation of fire suppression floats which, in case of fire, should separate ventilation of fire affected rooms from other rooms and modules.

In fire all fire suppression floats should be automatically closed based on AFA command.

The standby diesel-generator station should also be automatically tripped in case of fire in the room.

Fire detection and control device

For fire alarm cable control and for receiving of signals from automatic and manual fire alarm boxes there was accepted a fire detection and control device (FDCD) for twenty cables.

The fire detection and control device ensures:

- receipt and displaying of information (event type, address, etc.), incoming form fire alarm boxes, on a liquid-crystal and symbol display or with the help of light indicators;
- the priority of fire alarm signals with regards to "warning", "failure" and other process signals of installation operation;
- generation of command pulses, general or for each area, and with regards to the control room for signaling device, fire extinguishing startup devices, fans, ventilation dampers and valves , etc.;
- generation of fire and failure common signals for their transfer, if necessary, along the controlled lines to other control board rooms or to the fire department;
- possibility to display the data on events which could be recovered from nonvolatile memory and, if necessary, on the hard copy with the help of the printer.

The data displayed on the indication panel or on a personnel computer monitor should be presented in Russian.

The acceptance control device should be installed in the main control room with permanent duty personnel according to the instructions of the manufacturer.

Fire alarm installation includes the following equipment:

- optical smoke detectors;
- linear smoke detectors;
- thermal detectors;
- manual detectors;
- input/output relay modules.

Automatic fire alarm system equipment, including the fire detection and control device, alarm cables and control modules connected to them, should be used for automatic trip of the ventilation system and fire suppression floats automatic and remote control in case of fire.

In selection of a fire detector type for CSFSF room fire detection system, the following provisions have been followed:

- compliance of the operation principle (thermal, smoke, etc.) with probable initial inflammation signs (heat, smoke, fire) of combustible substances and materials stored and/or treated in building protected rooms in order to detect fire at the early stage;
- compliance of fire detector covers with environmental conditions.

As fire detection hardware in the protected rooms the following are accepted:

- smoke detectors – for industrial, electrical rooms and offices where the fire could be accompanied by smoke;

- thermal detectors –for workshops where the fire is accompanied by temperature increase;
- manual detectors – at staircases and along evacuation routes.

Covers and structures of fire detectors installed in the receiving building rooms should meet the requirements for protection degree as regards IP 54 for the “restricted” access area and IP 24 - for the “free” access area.

The design of smoke detectors should provide for an inbuilt optical operation indicator.

Automatic fire detectors are installed on ceilings, under sites and air ports with the width of more than 0,75 m, and manual detectors – attached to the walls of rooms, corridors and staircases of evacuation routes.

Fire detectors at the layouts of protected rooms are arranged according to the requirements and recommendations of [378], taking into account, for the automatic detectors, prominent parts of ceiling structures (slabs, cross-bars and beam ribs, etc.).

There is stipulated separation of AFA cables in the “restricted” and “free” axes area rooms.

Power supply.

the automatic fire alarm system and automatic fire extinguishers should be supplied with power by two independent I category reliability buses [39].

An accumulator should be provided for as a standby power supply source that ensures facility power supply during 24 hours under standby mode and during 3 hours in emergency mode at the main power feeder voltage failure.

7.7.2 Automatic Fire Extinguishing Facilities

7.7.2.1 Automatic Water-Type Fire Extinguishing Facilities of the Receiving Building Cable Vaults

According to the requirements of [0] and according to Appendix B of [33], fires of the cable structures (vaults) in the receiving building are extinguished with the help of automatic water-type fire extinguishing facilities (sprayed water). The specified facility is designed on the basis of the requirements of [44].

This automatic facility includes a water-type fire extinguishing facility and its automatic control system. The water estimated flow of the fire extinguishing facility is accepted with regards to the overall flow required for fire extinguishing of one protected and the largest vault.

DV-10 and DVM-10 sprinklers are installed to protection cable vaults. The water head necessary for cable vault fire extinguishing makes 04-05 mPa. Sprinkler pressure makes 0,3-0,4 MPa, one sprinkler flow - 1,7 l/s. Approximate distance between sprinklers makes 4 m. Final distance is specified based on the given sprinkler flow, pressure and jet.

In sprinkling rate of 0,2 l/s per 1 m^2, the water flow for vault fire extinguishing makes 16.0 l/s.

The fire extinguishing estimated time for cable rooms is accepted as equal to 10 min and water supply should ensure operation of the automatic facility during 30 minutes.

The fire extinguishing facility automatic startup should be duplicated by remote startup from the control board and also at place of pumps and stop valves installation. Actuation lag time of the automatic fire extinguishing facility does not exceed 3 min.

7.7.2.2 Automatic Powder Fire Extinguishing Facility of the Diesel Station

Taking into account the requirements of item 1.23 [0], it is provided for to apply UPPU-500PC local (by the are) automatic powder fire extinguishing facilities of the diesel station. With regards to the startup method, this is an automatic facility with backup manual (local and remote) startup. With regards to the design, this is a facility with distribution mains with an off-line working gas source. The specified facility is designed according to the requirements of [37].

Powder fire extinguishing facilities are unified with UPPU-500PC distribution mains. These facilities have the charge of fire extinguishing powder of 500 kg, fire extinguishing capacity (fire extinguishing area) of 64 m^2, storage and usage temperature range starting from 20 °C below zero

and up to 50 °C above zero. As fire extinguishing powder, there is used the powder of P-2AP-type (TU U 6-35-0576636-001-097) for A, B, C class fire extinguishing according to [36].

7.7.3 Smoke Protection Systems

Smoke protection systems (smoke removal and back air automatic facilities) should be designed according to the requirements of [42]. The necessity of smoke protection system installation shall be specified at the subsequent design stages, after specification of architectural-planning and layout decisions (identification of a room category, arrangement of structures, corridors, staircase, etc.) for each of the CSFSF buildings.

7.7.4 Fire Alarm System

According to the requirements of regulatory documents, the receiving building (category D with regards to fire and explosion hazard, two-storied building) is equipped with the I- type alarm system (Appendix F[30]).

The design provides for the fire alarm system in the main building rooms regularly attended by maintenance staff. At the same time, according to Table 6 [30], there is stipulated a sound alarm method (rings, toning signals) and “Exit” light cursors.

The external and internal communication systems are used additionally for fire alarm. Search-control communication and personnel announcement is controlled from MCP dispatcher control board. The “VELLEZ” announcement system equipment is used as a broadcasting center. At the same time, the announcing circuit is subdivided into areas corresponding to the process equipment coverage area. Announcement loudspeakers are arranged in disperse, in order to obtain the required level of area annunciation. Loudspeakers are connected to the announcement circuit without audio-volume control and connectors. If necessary, the announcement circuit is used for local broadcasting.

The fire alarm system, controlled from the duty personnel room (MCP dispatcher control board), should be operable during the whole estimated time of personnel evacuation.

7.8 Technical and Organizational Measures

Technical and organizational measures on CSFSF fire safety assurance are stipulated in compliance with the requirements of branch fire safety regulations [40].

CSFSF buildings and structures are provided with primary fire extinguishing means according to the standards on primary fire extinguishing means for power plants (Appendix 2 [40]).

Powder and carbon-dioxide fire extinguishers, boxes with sand along with fire extinguishing stuff – board with fire extinguishing tools are used as primary fire extinguishing means.

The required type and number of fire extinguishers is selected depending on their fire extinguishing capacity and also on combustible substance and materials inflammation class according to [36, 40].

Class A — fires of solid substances whose inflammation goes involving smoldering (woods, cotton, textile, paper, etc.).

Class B — fires of flammable liquids or melting solid substances.

Class C — gas burning.

Class D — metals and metal alloys combustion.

Class E – fire in electric facilities.

Primary fire extinguishing means are arranged in accessible and visible places.

Primary fire extinguishing means number and arrangement shall be specified at the subsequent design stage - R (operation documentation).

Fire prevention (arrangement of fire departments within the standard distance of 4 km) meets the requirements of construction regulations [41]. The distance from the most remote building and structure of the designed WWER ISF to the nearest fire station of the “Vector” complex makes not less than 1 km that is why the stipulated auxiliary station (fire station) is not required.

The design provides for the use of fire extinguishing products that have the technical documentation, which is certified by the State Certification Center of the Ministry of Emergencies of Ukraine in the established order.

8 MAIN DECISIONS ON HEATING, VENTILATION AND CONDITIONING

8.1 General Provisions

CSFSF buildings and rooms heating, ventilation and conditioning systems are designed in order to fulfill the following functions:

- prevent room and ambient air contamination (exciding of permissible values) with radioactive substances;
- support environment optimal conditions for process equipment operation;
- provide maintenance personnel with permissible air meteorological conditions of rooms during main processes and repairs .

Ventilation design stipulates the following basic provisions:

- exhaust air, released to the vent stack, undergoes radiation monitoring;
- a separate ventilation principle is met for the “free” and “restricted” access areas;
- rarefied air and directed air flows are generated according to the room assignment in the “restricted” access area rooms
- exhaust ventilation systems from the “restricted” access area rooms are equipped with aerosol filters;
- specified air temperatures and relative humidity are kept in rooms;
- ventilation in rooms of permanent personnel attendance is specified taking into account the outdoor air regulated (sanitary regulation) flow;
- ventilation of rooms is arranged taking into account room categories as regards fire and explosion hazard.

A centralized de-energization of ventilation installations that serve fire and explosion risk rooms is provided for in fires.

In order to ensure safe operation, ventilation systems of the “restricted” access area rooms should have 100% equipment stand-by. Ventilation systems should be equipped with automatic interlocks and remote control, the air cleanup system exhaust fans should be equipped with rotation frequency regulators at filters.

Operation of ventilation systems removing air through the vent stack is controlled by the operation service and activity of the exhausted air is controlled by the radiation monitoring service.

Air change by building rooms and air temperature inside them are accepted in accordance with the sanitary regulations and process requirements.

Heating of the CSFSF buildings is provided for with the help of plant and office heating ventilations.

The ventilation system airlines are designed as metallic. For the “free” access area, air lines are provided for made of light-gage galvanized steel, for the “restricted” access area – made of ungalvanized steel with a corrosion-resistant covering.

Class “P” air lines (tight) are used independently of the system assignment and discharge head ; a type of air lines and method for component connection are specified at the subsequent stages.

8.2 Input data

The following input data are used as a basis for air heating, ventilation and conditioning calculations:

Outdoor air parameters for cold season:

-the average temperature of the most cold five-day week (B parameter);	°C	-	+ 22
- specific enthalpy,	kJ/kg	-	- 20,7

• -wind speed,	m/s	-	4,2
Outdoor air parameters for hot season:			
- the most hot month average temperature	°C	-	+ 23,7
in 13 p.m. (A parameter),			
- specific enthalpy,	kJ/kg	-	+ 53,6
- wind speed,	m/s	-	1
- Design barometric pressure,	gPa	-	990

The heating period degree/days number makes 3572.

Electric power is a heat supply source for heating and ventilation systems.

The inside air parameters in design of ventilation and heating systems were accepted according to the requirements of [47] and make:

- attended rooms:
  - temperature: from +160C up to +280C ;
  - humidity: from 40% up to 75%.
- semi-attended rooms:
  - temperature: from +160C up to +300C ;
  - humidity: from 40% up to 75%.
- non-attended rooms:
  - temperature: from +50C up to +400C ;
  - humidity: from 0% up to 75%.
- “free” access are rooms:
  - temperature: from +160C up to +280C ;
  - humidity: from 40% up to 75%.

8.3 Basic Provisions of Ventilation and Conditioning

8.3.1 Receiving Building

8.3.1.1 Principle Decisions on Ventilation, Heating and Conditioning System

The receiving building is intended to ensure the CSFSF main process. The building is designed as a four-storied building equipped with service elevators and which is vertically divided into "free" and "restricted" access areas. In normal operation to get from the "free" access area to the "restricted" access area is possible through the changing room only. In the event of accident or fire, the direct emergency exit for the personnel is possible through fire escapes.

In the "restricted" access area at 0,000 m elevation there are arranged a transfer tube, changing room control tank premises (with sumps and pumps), "dirty" repair stations, a radiological laboratory, a sanitary barrier room set; an electrical control room, a compressor room, a heat point and an input ventilation point are arranged in the "free" access area.

"Clean" area rooms (changing room, "free" access area personnel accommodation rooms, electric device room) are arranged in the "free" access area at 4,200 m elevation.

Radiation protection system main control panel, ventilation control panels and administrative rooms are arranged in the "free" access area at 7,800 m elevation.

At 11,100 m elevation there are arranged input and exhaust ventilation rooms and water storage tank rooms.

The main building "free" and "restricted" access area heating, cooldown and ventilation systems (and their components) relate to not safety-related normal operation systems, except of the exhaust ventilation system filters that relate to safety-related normal operation elements.

A principle of separated ventilation for the "free" and "restricted" access area rooms makes the basis for the Main building ventilation system design.

Receiving Building ventilation system includes the following subsystems:

- the first subsystem of the "restricted" access area includes WW01 input and WW11 exhaust systems for transfer tube rooms where operations with containers are carried out– a system general layout is given on Drawing 8.3.1;
- the second subsystem of the "restricted" access area includes WW02 input and WW12, WW13, WW14, WW16 exhaust systems (separate for each room category) – a system general layout is given on Drawing 8.3.2 ;
- the third subsystem includes WW03 input and WW34 exhaust systems for the "free" access area changing rooms and accommodation rooms – a system general layout is given on Drawing 8.3.3;
- the fourth subsystem includes WW03 input and WW34 exhaust systems for the "free" access area – a "free" access area system general layout is given on Drawing 8.3.4.

For administrative rooms, MCP and ventilation panel rooms, a service unit, it is provided for inside air cooldown with the help of split-systems.

"Restricted" access area ventilation systems are designed in order to fulfill the following functions:

- prevent room and ambient air contamination (exciding of permissible values) with radioactive substances;
- support environment optimal conditions for process equipment operation;
- provide the maintenance staff with permissible meteorological conditions and air purity of rooms during main processes and repairs.

"Restricted" access area rooms are divided into:

- non-attended rooms;
- periodically attended rooms;
- attended rooms.

These rooms are characterized by excessive heat and radioactive dust in the air of some rooms. The objective of the ventilation systems in these rooms is:

- generate rarefied air in rooms;
- remove excessive heat;
- purify air removed through the vent stack, if necessary;
- create normal sanitary conditions for the maintenance staff.

Room ventilation systems ensure the principle of airflow from the more “clean” areas to the more “dirty” areas.

Fire suspension floats of automatic, remote and manual (at place of installation) control are installed at the boundary of the rooms of fire hazard category “B”. .

After fire suppression, taking into account the receiving building peculiarities as regards of the radiation safety (the “restricted” access area), the gaseous burn-up products are removed through the exhaust ventilation standard systems with removed air radiation monitoring.

The air is removed trough the metallic vent stack placed on the building roof.

Air changes in rooms are specified issuing from activity keeping that does not exceed the air permissible activity for process rooms and issuing from keeping of air regulatory parameters, as well as based on the conditions of rarefied air generation.

In order to ensure reliable operation, the ventilation systems of the “restricted” access area rooms should have 100% equipment stand-by. Ventilation systems should be equipped with automatic interlocks and remote control, the air cleanup system exhaust fans should be equipped with rotation frequency regulators at filters.

Operation of ventilation systems removing air through the vent stack is controlled by the operation service and activity of the exhausted air is controlled by the radiation monitoring service. .

“Free” access area rooms such as in-house switchboards rooms, control panel rooms and other rooms are characterized by great heat generations caused by electrical equipment. For heat removal, a combined extract and input ventilation with mechanical or natural impulse are provided for.

Ventilation in buildings and air temperature in them are accepted according to the sanitary standards and process requirements.

Since the “free” access area rooms do not have natural ventilation, the common ventilation equipment is accepted with 100% backup.

A centralized de-energization of ventilation installations, which ventilate fire and explosion risk rooms is provided for during fires.

Operable fans of the ventilation systems are the noise source. In order to localize the noise in its origin, the design stipulates the following measures:

- centrifugal fans are installed at antivibration mounts;
- flexible insertions are stipulated before and after ventilation fans;
- ventilation fans are installed in separate isolated rooms;
- supply chambers are provided with sound-suppressing sections.

Ventilation system airlines are designed as metallic. For the “free” access area there are stipulated the airlines made of light-gage galvanized steel, for the “restricted” access area – made of ungalvanized steel with a corrosion-resistant covering.

Class “P” air lines (tight) are used independently of the system assignment and fan head; a type of airlines and a method for component connection is specified at the subsequent stages.

8.3.1.2 Description of Ventilation System Operation

Transfer tube ventilation system - WW01, WW11

Input and exhaust, except for filters, subsystems are not safety-related normal operation systems with 4H classification designation according to [4].

WW11 exhaust ventilation subsystem filters are safety-related normal operation elements, with 4H classification designation according to [4].

A system general layout is given on Drawing 8.3.1.

The transfer tube combined extract-and-input ventilation is operated without interruption. In a cold season, under building normal operation, the input fan transfers filtered and heated air in order to keep corresponding temperature for the equipment reliable operation. .

Input fan capacity makes 20000 m^3/h, exhaust fan - 25000 m^3/h. Heat consumption of input air heating up to 10^0C makes 215 kW.

Transfer tube rarefied air is kept due to exhaust air consumption in comparison to exhaust air.

The input and exhaust ventilation subsystem equipment is designed with 100% standby. Standby equipment is actuated automatically in case when air consumption reaches the limit values or in case of operable equipment failure.

The input and exhaust ventilation subsystem, including control systems, is supplied with power from in-house busbars.

Ventilation system of the "restricted" access area rooms – WW02, WW12, WW13, WW14, WW16

Input and exhaust, except for filters, subsystems are not safety-related normal operation systems with 4H classification designation according to OPBU-2000.

WW12, WW14, WW16 exhaust ventilation subsystem filters are safety-related normal operation elements, with 4H classification designation according to [4].

A system general layout is given on Drawing 8.3.2.

"Restricted" access area combined extract-and-input ventilation is operated without interruption.

In cold season, under building normal operation, the input fan transfers filtered and heated air in order to keep corresponding temperature for equipment reliable operation and in order to keep the required temperature in the rooms of permanent personnel attendance – taking into account the regulated inside air consumption according to the sanitary standards.

Input fan capacity makes 5450 m^3/h, exhaust fan capacity makes:

- WW12 - 1000 m^3/h (taking into account changing rooms);
- WW13 – 5000 m^3/h (taking into account changing rooms);
- WW14 – 1000 m^3/h;
- WW16 – 1100 m^3/h.

.

Heat consumption of input air heating up to 18^0C makes 78 kW.

The rarefied air in the "restricted" access area not attended and semi-attended rooms is kept due to operation of pressurized valves (PV).

The input and exhaust ventilation subsystem equipment is designed with 100% standby.

Standby equipment is actuated automatically in case when air consumption reaches the limit values or in case of operable equipment failure.

Ventilation system for changing rooms – WW03, WW34

The input and exhaust subsystems of changing rooms are not safety-related normal operation systems with 4H classification designation according to [4].

Changing room ventilation system is operated together with WW12, WW13 exhaust subsystems regarding air removal from category "B" rooms that requires purification at filters prior to release to the atmosphere and "restricted" access area attended rooms.

A system general layout is given on Drawing 8.3.3.

The combined extract-and-input ventilation of the system is operated without interruption.

In cold season, under building normal operation, the input fan transfers filtered and heated air in order to keep the required temperature for personnel, taking into account the regulated inside air consumption according to the sanitary standards.

Input fan capacity makes 6100 m^3/h, exhaust fan – 4500m^3/h.

Heat consumption of input air heating up to 18^0C makes 82 kW.

The input and exhaust ventilation subsystem equipment is designed with 100% standby in view of natural lighting absence.

Standby equipment is actuated automatically in case when air consumption reaches the limit values or in case of operable equipment failure.

"Free" access area ventilation system – WW21, WW22, WW23, WW24, WW31, WW32, WW33, WW34

The input and exhaust subsystems of the "free" access area rooms are not safety-related normal operation systems with 4H classification designation according to [4].

A system general layout is given on Drawing 8.3.4.

Input and exhaust subsystems with mechanical (WW24, WW31, WW32, WW33, WW34) and natural impulses (WW21, WW22, WW23) are provided for the building "free" access area.

WW24 input fan capacity makes 8000 m^3/h, exhaust fan capacity makes:

- WW31 - 650 m^3/h;
- WW32 – 650 m^3/h;
- WW33 – 1000 m^3/h;
- WW34 – 4500 m^3/h.

Heat consumption for input air heating up to 18^0C makes 108 kW.

In cold season, under building normal operation, WW24 input fan transfers filtered and heated air in order to keep the corresponding temperature for equipment reliable operation and in order to keep the required temperature for personnel, taking into account the regulated inside air consumption according to the sanitary standards.

Equipment of input (WW24) and exhaust (WW34) general ventilation subsystem is designed with 100% standby.

Standby equipment is actuated automatically in case when air consumption reaches the limit values or incase of operable equipment failure.

Fans of heat point, electrical control unit and compressor unit rooms are automatically actuated depending on the inside air temperature.

Vent stack

A ventilation metal 21m-height stack at 0,000 elevation provided for air release into the atmosphere from the restricted access area rooms. The stack height is determined based on physical calculations of release impact on the environment.

A vent stack with 900 mm diameter is assigned for air release in the building operation normal mode Constructively, the vent pipe diameter is determined according to the maximum air flow-rate in normal and repair modes with air release speed into the atmosphere near 14,5 m/s.

Total amount of air released into the atmosphere through the vent stack is given in Table 8.3.1.

From the free access area rooms, air is discharged from the exhaust systems above the building roof.

Table 8.3.1 – **Amount of released air through the vent stack**

No.	System indication	Release through the vent stack		Note
		m^3/h	m^3/s	
1	System WW11	25000	6,95	
2	System WW12	1000	0,28	
3	System WW13	5000	1,39	
4	System WW14	1000	0,28	
5	System WW15	200	0,06	
6	System WW16	1100	0,31	
	Total:	33300	9,27	

8.3.1.3 Heating, Heat Supply and Hot Water Supply

The heating and heat supply system is a system of normal operation that does not impact on safety.

Power energy is accepted as a source of heat for heating, heat supply of ventilation and hot water supply systems.

Total energy consumption for the receiving building constitutes, kW:

- for heating needs……. 530;
- for heat supply of ventilation system 454;
- for ventilation…….…….…….115;
- for water heating for hot water supply needs ..... 180.

Heating is performed with the help of industrial and office heat ventilators.

For hot water preparation with consumption of 2,08 m^3/h, it is required an installation with productivity of 180kW. Direct-flow water heaters of instant heating are installed for this purpose.

Условные обозначения

- клапан

- гермоклапан с ручным приводом

- гермоклапан с ручным электроприводом

- фильтр грубой очистки

- фильтр тонкой очистки

- электро калорифер

- ценробежный вентилятор

- датчик температуры

- датчик и сигнализатор температуры

- индикатор и регулятор температуры

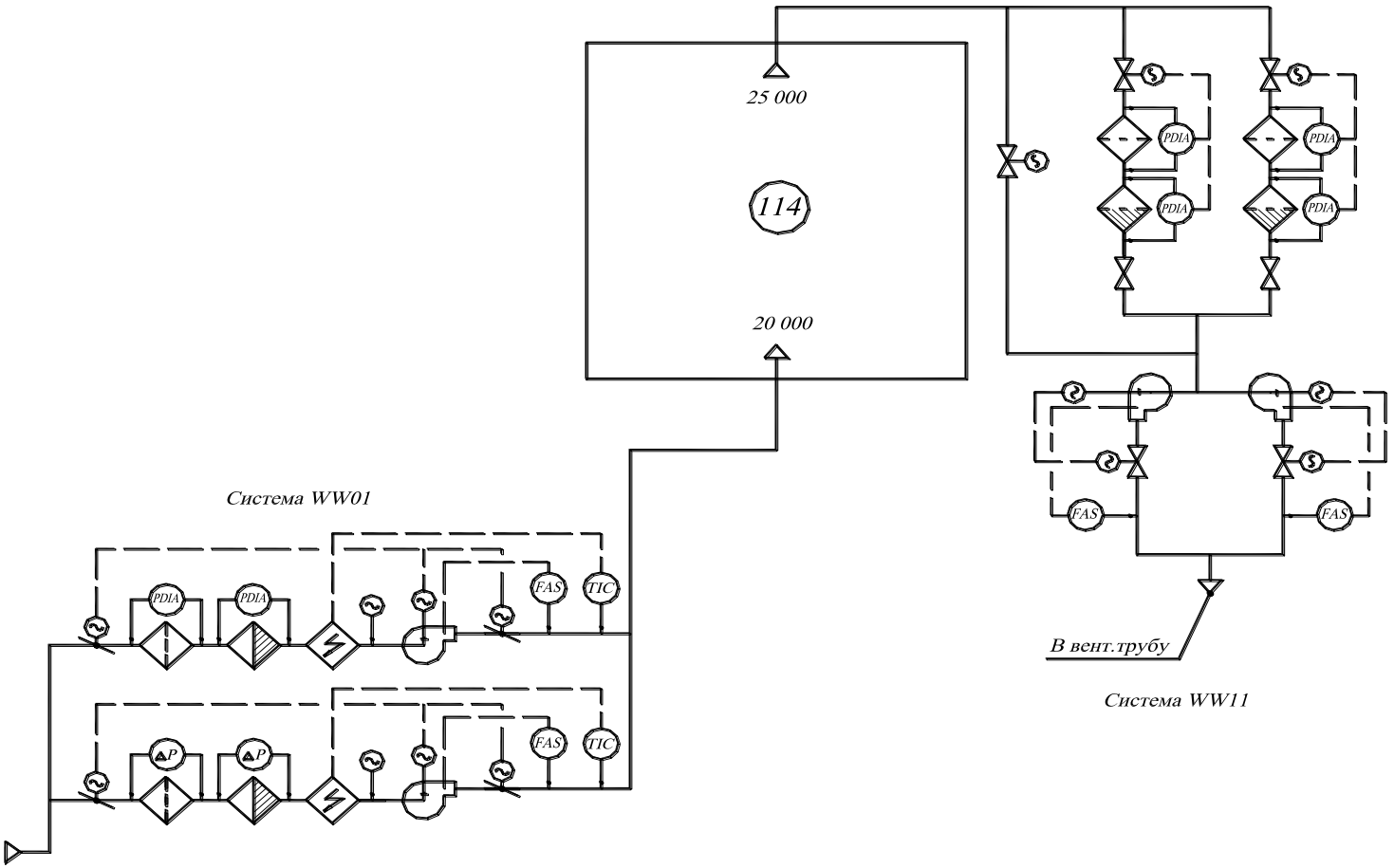
- датчик давления

- индикатор и сигнализатор перепада давления

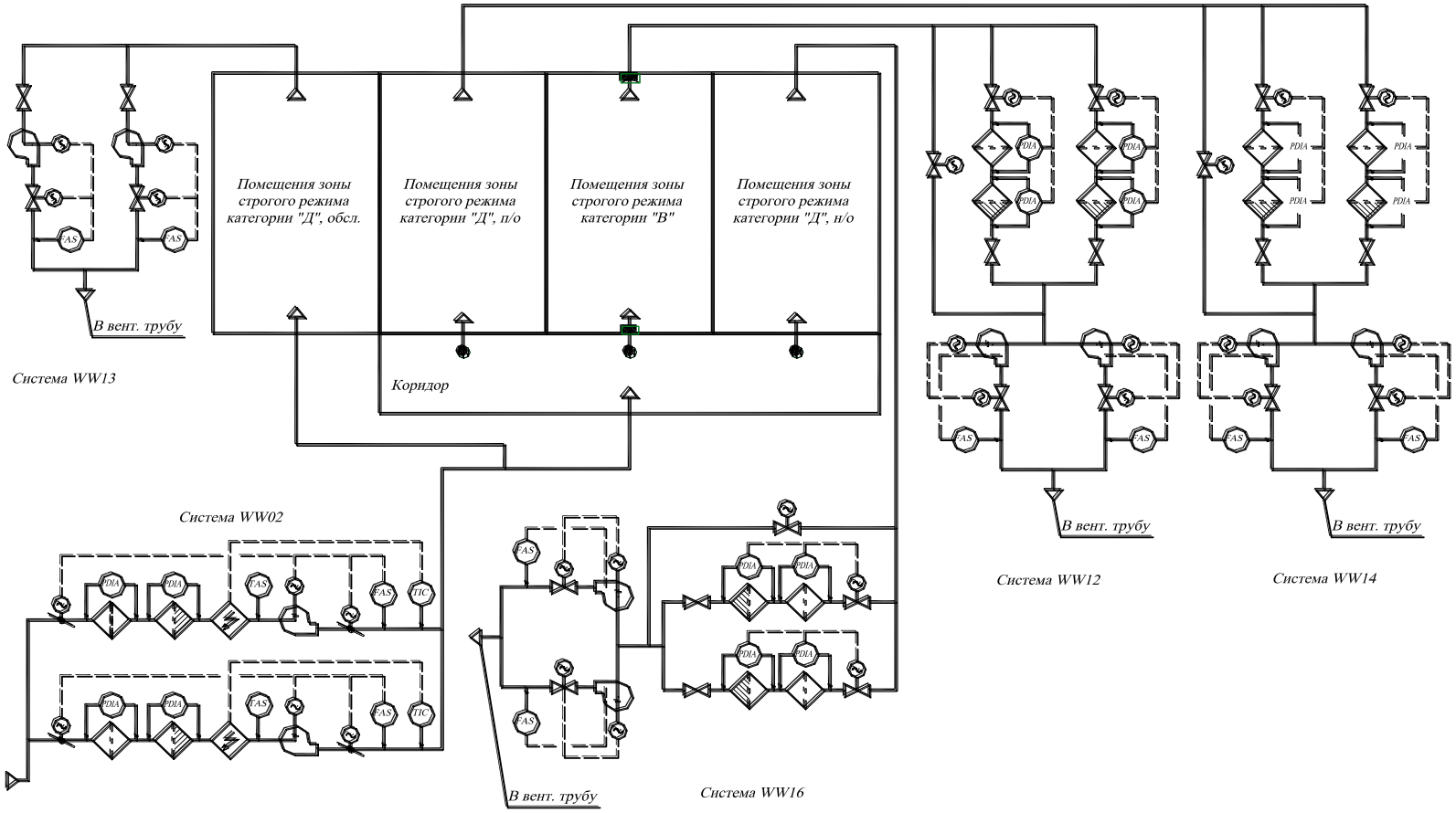
- датчик и сигнализатор расхода

- осевой вентилятор

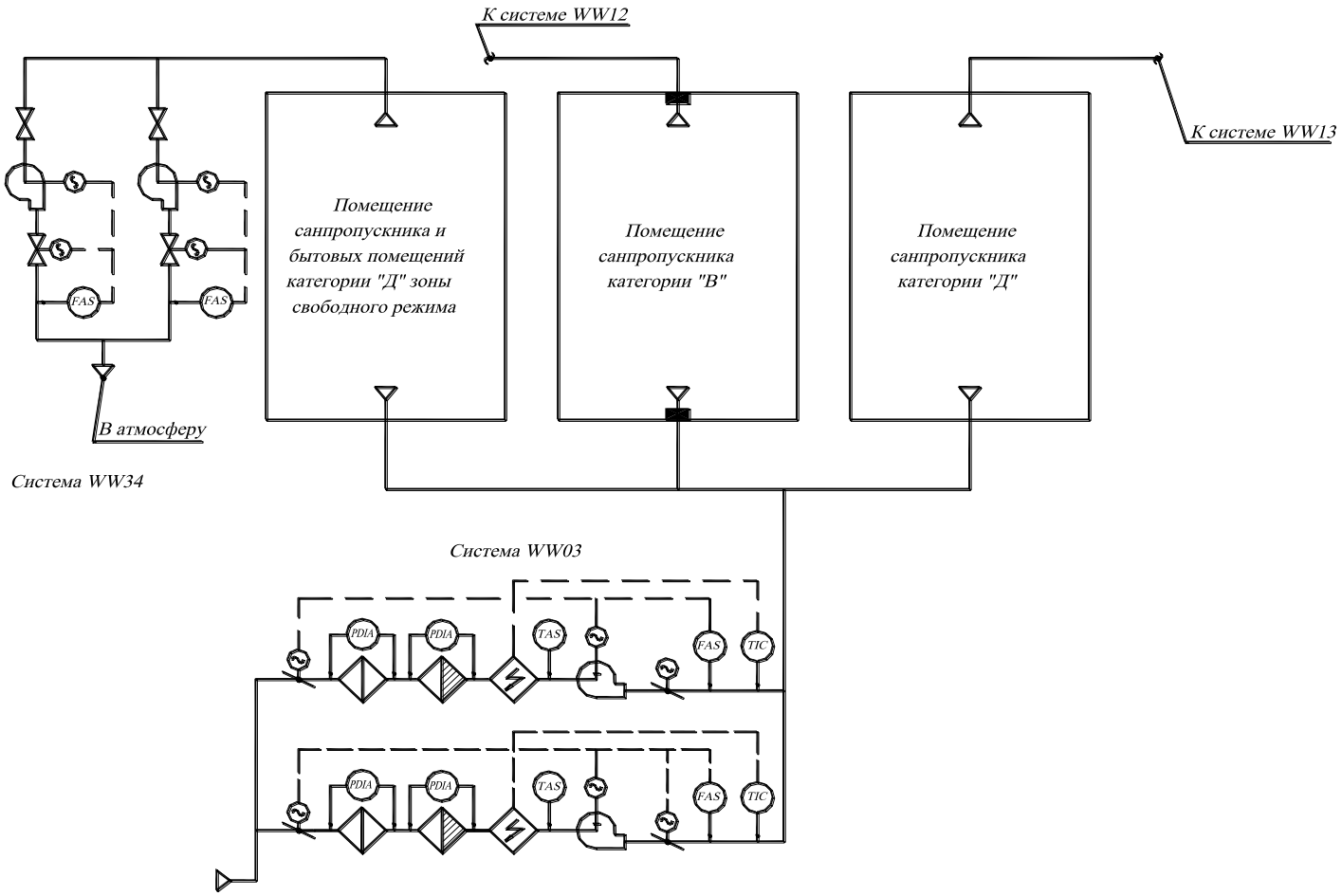
Top-down: reference designations, valve, pressure isolated valve with manual drive, pressure isolated valve with electric drive, primary purification filter, secondary filter, electric heater, centrifugal fan, temperature sensor, temperature sensor and alarm, temperature indicator and regulator, pressure sensor, pressure drop indicator and alarm, flow sensor and alarm, axial fan.



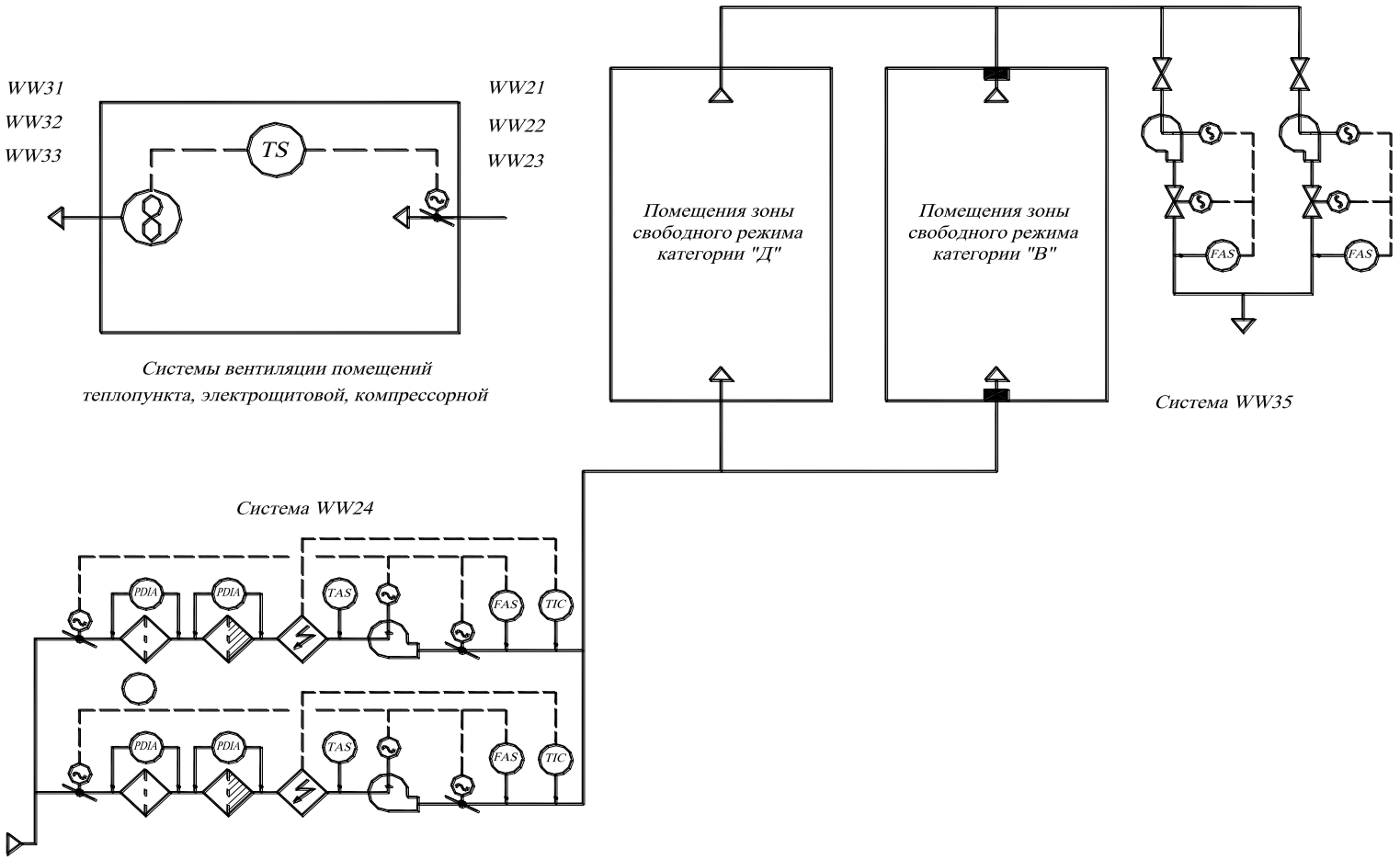
Drawing 8.3.1 – **Schematic diagram of the handling tube of the receiving building**



Drawing 8.3.2 – **Schematic diagram of the ventilation system of the receiving building restricted access are**



Drawing 8.3.3 – **Schematic diagram of the ventilation system of the receiving building changing rooms**



Drawing 8.3.4 – **Schematic diagram of the ventilation system the free access area rooms**

8.3.2 Maintenance Building with MPC Storage

All combined extract and input ventilation systems are not safety-related systems of normal operation; classification designation is 4H in compliance with [4].

A combined extract and input ventilation with mechanical and natural impulses is provided for in the maintenance building (that includes workshops, laboratories, amenity and office rooms) and the storehouse.

The input installation supplies filtered and heated air in cold period to ensure necessary temperature conditions, reliable operation of equipment and to keep necessary temperature conditions for personnel, considering regulated outlet air consumption according to the health and safety standards.

Electric power consumption for ventilation is 9 kW, electric power flow-rate for heat supply of input installations – 75 kW, heating – 25 kW.

8.3.3 Building of Electrotechnical Devices

All combined extract and input ventilation systems are not safety-related systems of normal operation; classification designation is 4H in compliance with [4].

A combined extract and input ventilation with mechanical and natural impetus is provided for in the building.

The input installation supplies filtered and heated air, in cold period, to ensure the necessary temperature conditions for reliable operation of equipment and to keep the necessary temperature conditions for personnel, considering regulated outlet air flow-rate according to the health and safety standards.

Ventilators of electrotechnical rooms are switched on and switched off automatically depending on the inside air temperature.

Electric power flow-rate for ventilation is 2 kW, electric power flow-rate for heat supply of the input installations – 22 kW, heating – 38 kW.

8.3.4 Administrative Building

All combined extract and input ventilation systems are not safety-related systems of normal operation; classification designation is 4H in compliance with [4].

Combined extract and input ventilation with mechanical and natural impulses is provided for in the building.

All rooms of the administrative building are specified by release of insignificant heat inside them, moisture and other hazard depending on the rooms' assignment.

Input and extract ventilation: natural with mechanical impulses and, in some cases, with additional cooling of inside air by means of split-systems is provided for depending on the requirements made for rooms.

Civil defense rooms for 100 persons are located in the building basement. Civil defense ventilation is provided for two modes in accordance with [12].

The input installations supply filtered and heated air, in cold period, to ensure necessary temperature conditions for reliable operation of equipment and to keep the necessary temperature conditions for personnel, considering the regulated outlet air flow-rate according to the health and safety standards.

Electric power flow-rate for ventilation is 30 kW, electric power flow-rate for heat supply of the input installations – 310 kW, heating – 240 kW, water heating for heat water supply - 456 kW.

8.3.5 Garage for Crawler

Combined extract and input ventilation with mechanical and natural impulses is provided for in the garage building. The main hazard in maintenance rooms is carbon oxide.

Electric power consumption for ventilation is 8 kW, electric power flow-rate for heat supply of the input installations – 90 kW, heating – 155 kW.

8.3.6 Garage for Four Automobiles

Combined extract and input ventilation with mechanical and natural impulses is provided for in the garage building. The main hazard in maintenance rooms is carbon oxide. Air exchange in maintenance rooms and auto parks is calculated according to conditions of simultaneous departure of all cars during an hour from the park and repair of one auto in the maintenance room. In the decontamination unit ventilation operates only in an emergency mode.

Electric power flow-rate for ventilation is 8 kW, electric power flow-rate for heat supply of the input installations – 110 kW, heating – 155 kW, water heating for hot water supply - 17 kW.

8.3.7 Pump Station of Fire Water Supply

The extract-input ventilation designed for heat excess assimilation is accepted in the building.

Electric power flow-rate for ventilation is 1 kW, electric power flow-rate for heat supply of the input installations – 27,2 kW, heating – 10 kW.

8.3.8 Sewage Pump Station

Input-extract ventilation is provided for in the pump station. Extract ventilation is mechanical from two areas (1/3 from the upper area and 2/3 from the lower area). Input – from the stack led to the height not less than 1,8 above the earth level. Electric power flow-rate for ventilation is 0,4 kW.

8.3.9 Guard Building

The extract-input ventilation with mechanical impulses is provided for in the building. The split-systems are envisaged to ensure the necessary air temperature in the guard building. Electric power flow-rate for ventilation is 20 kW. Electric power flow-rate for heat supply of the input installation is 5,2 kW. Electric power flow-rate for heating is 34,2 kW. Electric power flow-rate for hot water supply is 10 kW.

8.3.10 Access Control-Point 1 and Access Control Point-2

The extract-input ventilation with natural impulses is accepted in the access control points. The input is uncontrolled; extract is performed through vent ports arranged in structures. Each building has electric power supply with power rate of 11 kW.

8.4 Main Indicators on Ventilation and Heating

The main indicators on heating and ventilation are given in Table 8.4.1.

Table 8.4.1 – **The main Indicators on Heating and Ventilation**

Building	Electric power supply, operation/standby, kW					
	for ventilation (given)	for heat supply	for heating	for split-systems	for hot water supply	total

Receiving building	115/115	454/454	530	11	180*	1290/569
Building of elecrotechnical devices	2	22	38	-	-	62
Check-point	-	-	11	-	-	11
Check-point	-	-	11	-	-	11
Guard building	20	5,2	34,2	-	10	69,4
Shiftman's room	0,4	-	-	-	-	0,4
Pump house	1	27,2	10	-	-	48,2
Garage for crawler	8	90	155	-	-	253
Garage for four automobiles	8	110	155	-	17	290
Administrative building	30	310	240	-	456	1036
(including civil protection)	(10)	(10)	(70)		(-)	(90)
Maintenance building with MPC storage	9/6	75	25	2,5	-	112

The following issues will be specified during the following design stages:

- general ventilation plan after performing architectural drawings and determination of categories of rooms according to explosion and fire hazard;
- requirements for the ventilation systems functioning under normal operation and in emergency modes;
- air exchanges in rooms, equipment characteristics, requirements for protection covering and fire resistance limits of the air ducts etc.

9 RADIOACTIVE WASTE MANAGEMENT

9.1 Liquid Radioactive Waste (LRW) Management

LRW management system includes individual interconnected subsystems:

- special sewage system;
- reference tanks.
-

9.1.1 Assignment and Design Basis

LRW management in CSFSF operation consists in LRW collection, monitoring and delivery to the ChNPP processing powers and other powers of the ChNPP exclusion area.

The collection of generated LRW is performed by means of the special sewage subsystems. The special sewage subsystem includes the following components:

- special sewage access boards;
- special sewage sumps;
- drain pumps in special sewage sumps;
- pipelines of special sewage sumps.
-

The special sewage subsystem is a safety-related normal operation system. The subsystem is designed for receiving 530 m^3/hears of low-level LRW.

A schematic diagram of the special sewage system is given on Drawing 9.1.1.

A subsystem of reference tanks is assigned for acceptance, monitoring and delivery of ZSR shower and wash-stand water. The system is non-safety-related normal operation system. The system is designed for daily water supply up to 5,4 m^3. The intensity of water supply is 2,72 m^3/h. Water - low-level or not radioactive LRW.

A schematic diagram of the reference tanks system is given on Drawing 9.1.2.

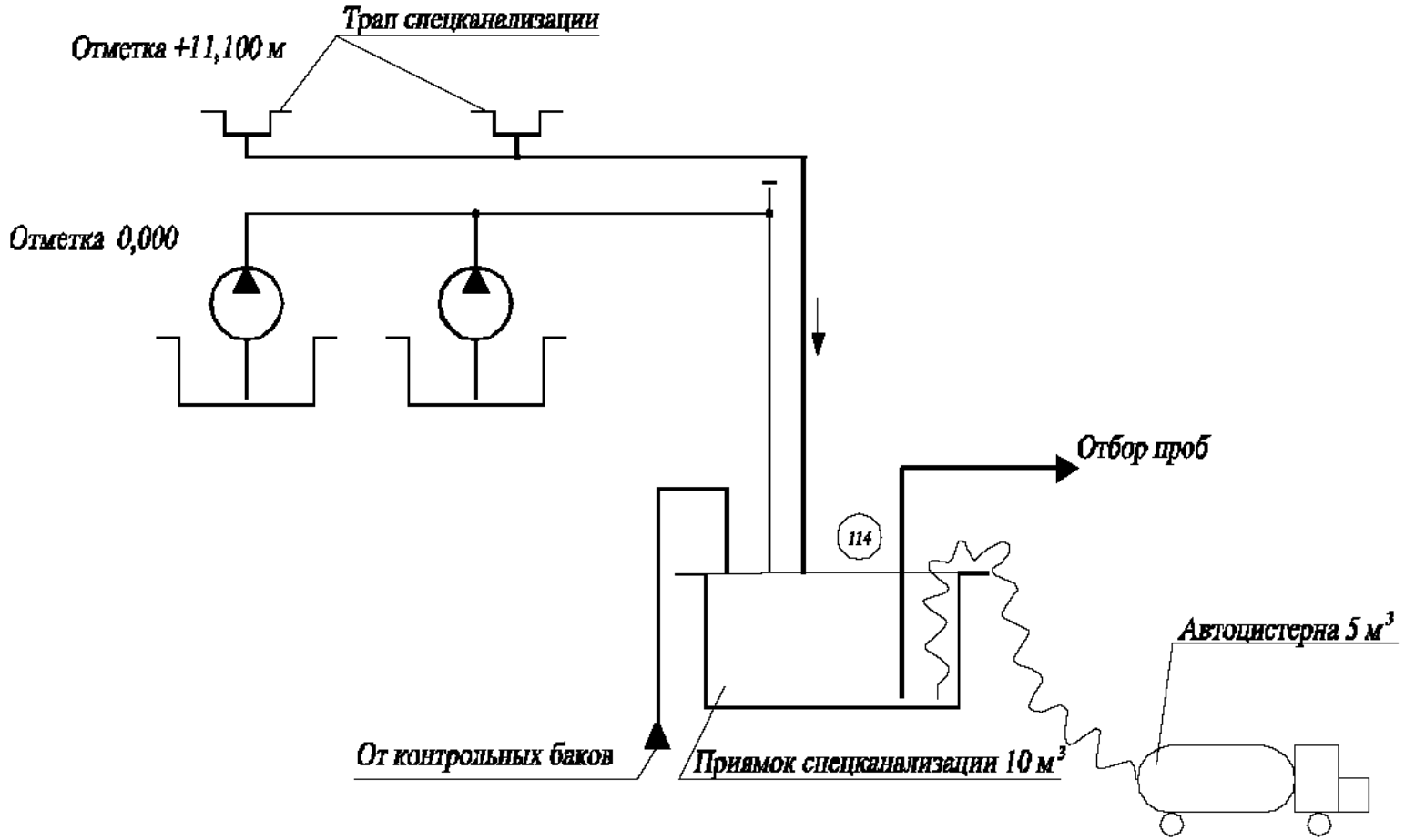
LRW amount and quality is determined by the following:

- number of shifts during a day and number of personnel in a shift;
- number and ways for decontamination applied in the CSFSF.
-

9.1.2 LRW Generation Sources

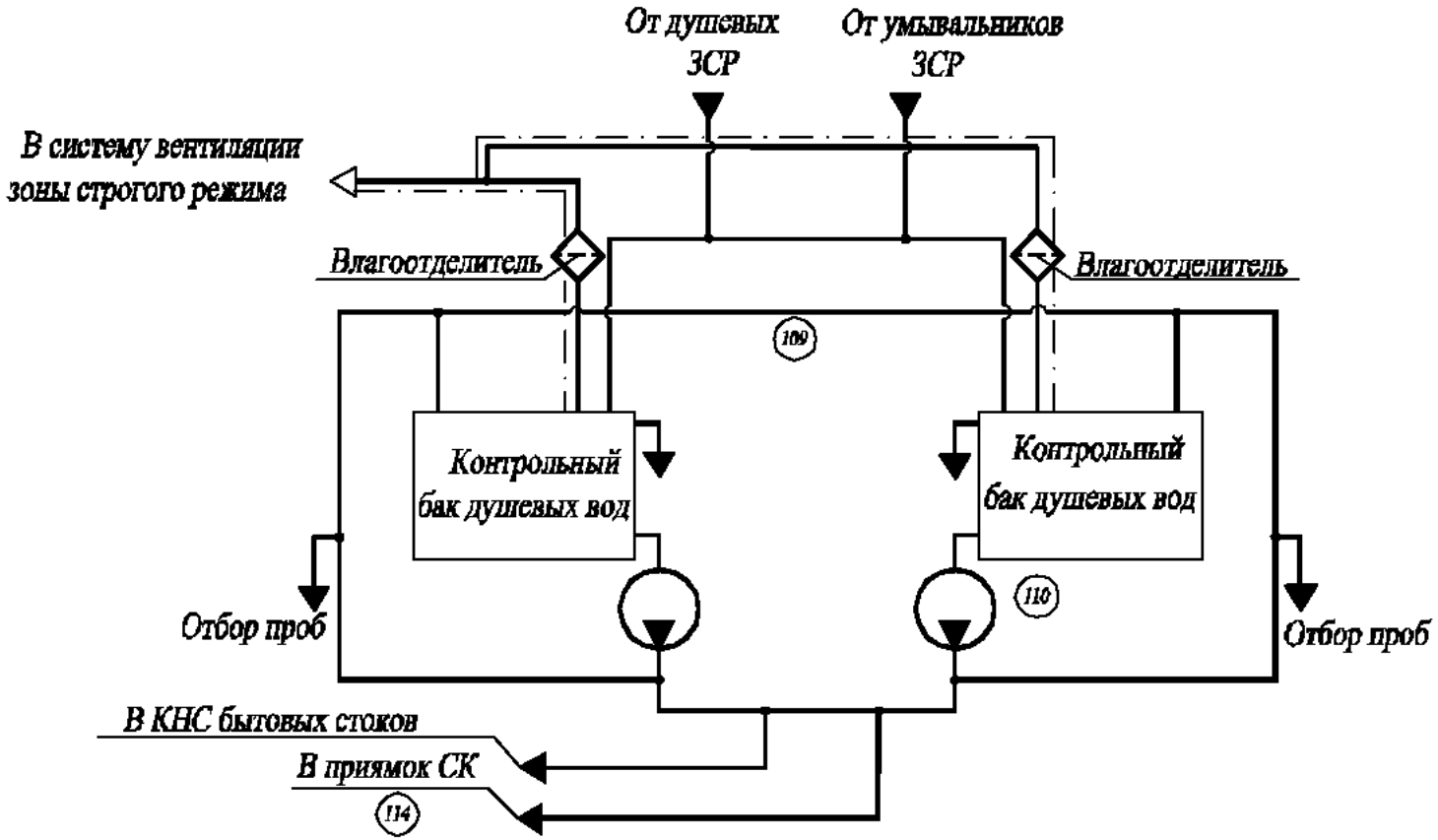
LRW generation sources in the CSFSF during normal operation are, potentially, waters resulted from:

- decontamination of the restricted access area rooms;
- ZSR wash-stands and showers, contaminated RW over DK_B permissible concentration for drinking water;
- drains of radiochemical laboratory;
- equipment decontamination.



Drawing 9.1.1 –**Schematic diagram of the special sewage system**

Top-down: Floor drain for contaminated liquids, elevation +11,100 m, elevation 0,000, sampling, from control tanks, radioactive drain sump of 10m^3, tank-car of 5m^3



Drawing 9.1.2 – **Schematic diagram of the reference tanks system**

Top-down: from ZSR shower rooms, from ZSR wash-stands, to restricted access area ventilation system, moisture separator, shower drains control tank, sampling, to shiftman's room sewage system, to DS sump.

Because of the CSFSF arrangement in the exclusion area, violation of normal operation caused by external contamination of rail cars and equipment with emergency ChNPP radionuclides is possible. For this case, an Emergency Response Plan will be developed for such a situation during CSFSF design. The required measures on decontamination of rooms, CSFSF equipment and movable trains will be developed within this Plan.

9.1.3 LRW Management in Operation

The special sewage traps are located in each room where decontamination is envisaged. The special sewage traps are combined into one pipeline that is led to the special sewage sump.

The special sewage sumps, where drain pumps are installed, are arranged in the restricted access area rooms at 0,000 elevation.

The sumps are faced with corrosion-resistant steel, floor slopes are made to the side of sumps.

Water exhaust from an equipment decontamination tray is envisaged beside the special sewage sump in the room of a “dirty” workshop.

A special sewage sump with volume capacity of 10 m^3 is located in a handling tube. Sampling from the special sewage sump is envisaged prior to delivery for processing.

Beside floor-drain water, a piping, lead from reference tanks with shower water to the special sewage sump, is provided for.

It is provided for installation of two reference tanks with volume capacity of 4 m^3 each. The volume capacity of each tank is determined according to the discharge to the sewage system during one shift.

Water discharge from reference tanks with shower water in the shiftman's room is provided for in the event of non-exceeding of volume activity in them above DK_B Discharge in the shiftman's room is performed in a pressure mode by means of the reference tank pump.

LRW management within the CSFSF envisages LRW collection, monitoring and delivery to the ChNPP and exclusion area processing capacities. It is supposed that LRW be transported using a tank truck rented at the “Vector” complex.

After arrival of a tank truck for LRW shipment, personnel pumps over water from the floor-drain water sump into the tank truck.

9.2 Solid Radioactive Waste (SRW) Management

9.2.1 Assignment and Design Basis

The CSFSF SRW management system is intended for SRW handling generated during CSFSF normal operation, violation of normal operation and design-basis accidents.

9.2.2 Sources of SRW Generation

During CSFSF operation, SRW may be generated in regulatory work on radiation situation monitoring and during decontamination work and equipment repair.

Approximate composition of generated SRW is the following:

- used materials;
- equipment failed (spent) and not subjected to repair;
- spent working clothes, IPM;
- rags, cleaning material, plugs;
- construction debris.

The estimated amount of waste during storage facility normal operation will not exceed 65 m^3/h of low-level SRW.

9.2.3 SRW Management

During the development of the current FSI it is supposed that:

- RW are not processed in the CSFSF ;
- Low- and intermediate-level SRW are transported for processing at ChNPP or later at central disposal facility building (CDF);
- ChNPP or CDF transport is used for SRW removal;
- CSFSF transport casks that should comply with the acceptance requirements at ChNPP or CDF are used for SRW transportation.

Low- and intermediate-level SRW management is a set of handling operations, including:

- collection at generation sites, dosimetric monitoring and initial packaging;
- delivery of initial packages with SRW to the installation site of the transport canister for SRW and loading into the transport canister;
- dosimetric monitoring of the canister external surfaces;
- decontamination of external surfaces (fixing coating), if necessary;
- temporary storage of SRW canisters at the cask storage area in the transfer tube of the receiving building;
- shipment on a transport mean and transfer to the site for further management.

An area for shipment casks is arranged in the receiving building. The area is marked on the floor and is equipped with a gamma-radiation dose rate sensor.

Prior to the transfer, the cask is monitored by means of the radiation monitoring system (dose rate, surface contamination). If there are any contaminations exceeding the regulated values, the canister is subjected to decontamination.

It is proposed to use KTZ-3,0 metal-concrete canister and KT-0,2 200 l drum as a shipment cask.

Technical characteristic of metal-concrete canister KTZ-3,0:

- volume capacity, m^3 ……3,0;
- assignment - transportation, long-term storage and SRW disposal of low- and intermediate-level;
- canister overall dimensions, mm……1940x1940x1650;
- wall thickness, mm……..150;
- mass of canister with lid, kg…..……..5470;
- gross weight, kg…….15130.

Technical characteristic of metal canister KT-0,2:

- volume capacity, m^3 …….0,2;
- assignment - transportation, long-term storage and SRW disposal of low- and intermediate-level;
- wall thickness, mm ……5;
- diameter, mm…….600.
- RW certification is provided for RW quality inspection and inventory monitoring.
-

Technical characteristic of RW certification of SKG-02 type:

- assignment – analysis of solid and liquid RW;
- measuring range of specific activity - from 25 to $6x10^6$ Bq/kg on cesium-137 and from 20 to $1,5x10^6$ Bq/kg on cobalt-60;
- range of gamma-radiation dose measuring, μSv/h …….from 0,1 to $1x10^5$;
- range of RW drum mass measuring, kg ……..……from 10 to 500 ;
- speed of pivoting floor, not more, rot./min…… ……2.;
- facility overall dimensions, mm……..…700x1200x1525;
- facility mass, not more, kg…….…… 350.

9.3 RAW Management in Passive Operation Period

RW generation related to sanitary and domestic service of personnel is expected in the passive period of the CSFSF operation.

The maximum expected amount of LRW, related to the fact that water in the shower reference tanks will be contaminated with RW above permissible values, is:

- 615 m^3/h;
- 2,46 m^3/day;
- 2,16 m^3/h.

Experience in facility operation in the exclusion area shows that shower water in most cases does not exceed permissible levels of drains into domestic sewage.

Expected SRW amount related to personnel attendance in the ChNPP exclusion area is 1,08 t/h (7,2 m^3/h). This waste includes spent individual protection means (IPM).

10 ARRANGEMENT OF OPERATION

10.1 Operation Stages

CSFSF life-time (operation) is divided into two following stages that differ from each other by engineering processes performed in them:

- first stage – active operation consists in transport and acceptance of spent nuclear fuel delivered from NPP according to the schedule for a long-term storage (100 years). The first stage duration is about 50-60 years and it is determined by duration – time of the whole storage site filling (installations of all HI-STORM overpacks assigned for SNF long-term storage);
- second stage – passive operation – CSFSF life-time period when SNF delivery from NPP is completely terminated and only SNF storage process in HI-STORM storage overpacks is performed.

Engineering process performed within the CSFSF at the first stage of its operation is, practically, a combination of subsequent operations on SNF acceptance delivered in canisters in railway transport, its transfer (installation) in canisters and transportation of HI-STORM storage overpacks with fuel at the area for long-term storage.

During the second stage of the CSFSF operation, the performed engineering process consists in monitoring of operation of the CSFSF equipment and systems assuring its safe operation.

10.2 Operation Readiness

CSFSF operation readiness is determined by the following constituents:

- loading in a power unit reactor compartment;
- transportation of SFA from NPP to the CSFSF site;
- reloading of MPC with SFA into HI-STORM storage overpacks;
- installation of HI-STORM storage overpacks for storage.

10.2.1 Transfer in Power Unit Reactor Compartment

Beginning of transfer of canisters is determined by the following:

- at NPP power unit with WWER-1000 – by terms of the scheduled preventive repair at a certain power unit;
- at NPP power unit with WWER-440 – by the NPP decision on SNF removal from the unit because discharge from WWER-440 cooling pools can be performed in unit operation.

10.2.2 Transfer of Loaded Canister from NPP to CSFSF Site

The transfer time from NPP to the CSFSF site within the ChNPP exclusion area does not depend on the CSFSF and, according to the preliminary data, the time of delivery will vary from three to four days.

10.2.3 Acceptance, Reloading and Transfer of Canisters for Storage

The input data for determination of a time for SFA acceptance and preparation for storage are the following:

- design loading of MPC canister:
  - WWER-1000 – 31 SFA;
  - WWER-440 – 85 SFA;

- NPP from which the SNF transfer to the SFSF is proposed:
  - WWER-1000 reactors:
    a) Khmelnitsky NPP – units 1, 2;
    b) Rivne NPP – units 3, 4;
    c) South-Ukrainian NPP - units 1-3;
  - WWER-440 reactors:
    a) Rivne NPP – units 1, 2;
- the minimum annual discharge from one unit (in compliance with the Client's data):
  - WWER-1000 – 48 SFA;
  - WWER-440 – 72 SFA;
- annual SFA amount in compliance with the data on the minimum annual discharge from one power unit:
  - WWER-1000 SFA – 336 per year;
  - WWER-440 SFA – 168 per year;
- the maximum annual discharge from one unit (in compliance with the Client's data):
  - WWER-1000 – 84 SFA per year;
  - WWER-440 – 168 SFA per year;
- annual SFA amount in compliance with the data on the maximum annual discharge from one power unit:
  - WWER-1000 – 516 per year;
  - WWER-440 SFA – 336 per year;
- standard discharge – loading of power units according to the current data:
  - WWER-1000 – 48 SFA;
  - WWER-440 – 72 SFA.

In accordance with the Client's data, the maximum discharge during the first three years is determined by the necessity to restore conditions to ensure core emergency unloading for each power unit. A conceptual schedule of spent nuclear fuel removal from RNPP, KhNPP and SUNPP to WWER CSFSF is given by the Client in Table 10.2.1.

Table 10.2.1 – Client's conceptual schedule for SNF removal from RNPP, KhNPP and SUNPP

NPP unit	2008	2009	2010	2011	2012	2013
RNPP-1 (WWER-440)	168	168	168	168	72	72
RNPP –2 (WWER-440)	168	168	168	72	72	72
RNPP –3 (WWER-1000)	84	84	84	84	48	48
RNPP –4 (WWER-1000)	-	-	48	48	48	48
KhNPP-1 (WWER-1000)	84	84	84	84	48	48
KhNPP –2 (WWER-1000)	-	-	48	48	48	48
SUNPP-1 (WWER-1000)	84	84	84	84	60	48
SUNPP –2 (WWER-1000)	84	84	84	84	60	48
SUNPP –3 (WWER-1000)	84	84	84	84	60	48
TOTAL:						
WWER-440 SFA	**336**	**336**	**192**	**168**	**168**	**168**
WWER-1000 SFA	**420**	**420**	**516**	**516**	**372**	**336**

Full cycle (days) of a train turn consists of the following five stages:

- transportation of an empty train from CSFSF to NPP ..... ……5;
- full loading cycle at NPP considering train delays…….20;
- transportation of loaded echelon from NPP to CSFSF……..5;.
- discharge of loaded MPC into the HI-STORM, loading of empty MPC, HI-STAR preparation to new cycle (conservatively)…… …5;
- time reserve…….……..5.

Thus, conservatively, the full train turn with three HI-STAR overpacks is 40 days.

Full service time for 8 units in such conservative assessments is 320 days that is enough to ensure the required CSFSF efficiency.

The main CSFSF activities (MPC transfer from the HI-STAR to the HI-STORM and installation on a storage area) will be performed during one shift per day, 5 days per week, 220 days per year. Duration of each shift will be 8 hours. Duration of the main activities depends mainly on availability of the loaded train from 5 loaded MPC in the HI-STAR transport modules at the CSFSF territory. It is expected that 2-3 working days per month will be used for scheduled maintenance of systems and components. Once a year the main activities at the CSFSF will be stopped for maintenance of the main process equipment.

10.3 Staff

In order to ensure the CSFSF operation it is provided for to create a separated subdivision NNEGC “Energoatom” whose preliminary management structural diagram is given at Figure 10.3.1.

A management structural diagram is given for the CSFSF active operation, considering that the most labor-consuming process is an engineering process at the first stage.

The given management structural diagram ensures the following:

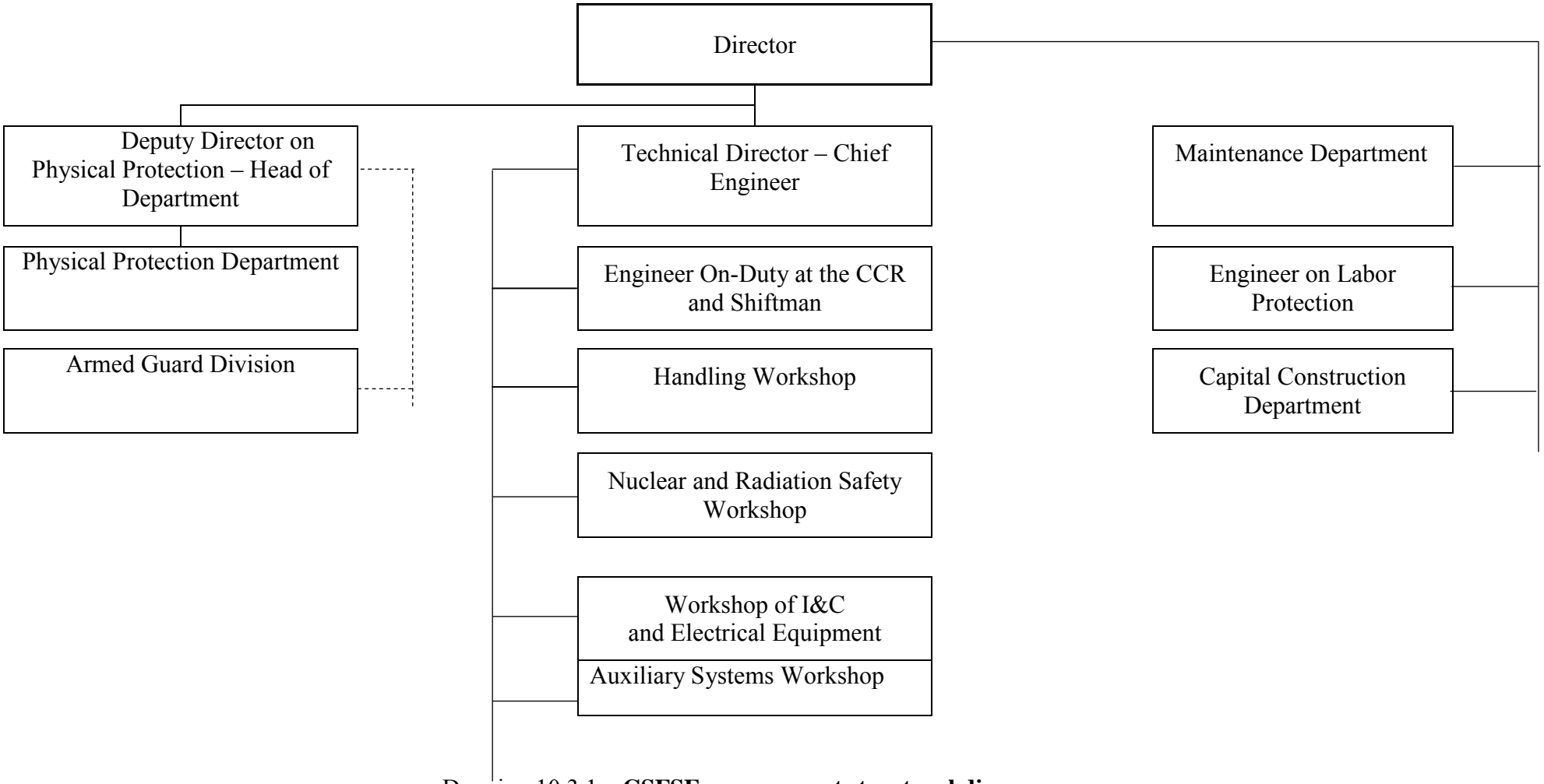
- CSFSF administrative management;
- engineering process;
- CSFSF buildings and structures operation;
- physical protection of nuclear material and radioactive waste at CSFSF;
- maintenance and minor repair of CSFSF systems and equipment.

The following admissions and assumptions have been accepted in determination of a preliminary staff list:

- SFSF guard functions should be performed by an armed subdivision that will be in operational subordination to the Deputy Director on Physical Protection and in administrative subordination to an organization with which contractual agreements on SFSF guard will be signed up;
- large-scale repairs of equipment should be performed involving specialized contracting organizations; current capital construction of a storage site should be performed involving specialized contracting organizations;
- CSFSF building structures should be inspected involving specialized contracting organizations;
- CSFSF fire prevention and supervision should be performed on a contractual basis with the nearest fire department of the “Vector” complex;
- current equipment maintenance will be performed by own maintenance personnel of the appropriate CSFSF subdivisions.

The staffing specifications for the CSFSF active operation period (the first stage) are given in Table 10.3.1 and passive operation (the second stage) - in Table 10.3.2.

At the second (passive) SFSF operation stage the management structure given at Figure 10.3.1 is preserved, except for the capital construction department. It is supposed that SFSF construction will be terminated before termination of the first operation stage. Thus, the personnel number at the second operation stage is reduced approximately by 30%.



Drawing 10.3.1 – **CSFSF management structural diagram**

Table 10.3.1 – CSFSF staff list in active operation (translation of this table see on p.207)

№ п/п	Наименование структурных подразделений, должностей	Кол. штатн. един.	Вахта, чел.	4 x 3
1	2	3		
1	**Руководство ЦХОЯТ**	**8**	**0**	**8**
2	**Бухгалтерия**	**3**	**0**	**3**
3	**Планово-экономический отдел**	**4**	**0**	**4**
4	**Отдел кадров**	**2**	**0**	**2**
5	**Режимно-секретный отдел**	**2**	**0**	**2**
6	**Административно-хозяйственный отдел**	**17**	**0**	**17**
	Итого по АУП	***36***	***0***	***36***
7	**Производственно-технический отдел**	**5**	**0**	**5**
8	**УКС**	**9**	**0**	**9**
9	**Отдел ЯБ, РБ и ООС**	**19**	**0**	**19**
10	**Отдел физической защиты**	**11**	**0**	**11**
11	**Цех транспортно-технологический**	**44**	**22**	
11.1	*Участок омоноличивания HI-STORM*	*6*	*3*	*0*
11.2	*Бригада вагон-контейнерного эшелона*	*18*	*9*	*0*
12	**Цех вспомогательных систем**	**59**	**24**	**11**
12.1	*Участок вентиляции, тепловодоснабжения, водопровода и канализации*	*10*	*0*	*10*
12.2	*Участок КИПиА, связи и сигнализации*	*8*	*0*	*8*
12.3	*Участок электротехнических устройств*	*8*	*0*	*8*
12.4	*Ремонтно-механический участок*	*13*	*0*	*13*
12.5	*Бетонный завод*	*12*	*6*	*0*
16	*Участок автотранспорта*	*5*	*0*	*5*
	Итого производственного персонала	***147***	***46***	***55***
	ИТОГО обслуживающего персонала	**183**	**46**	**91**
	Явочный состав максимальной рабочей смены			137
	Столовая	26	13	0
	Медпункт	2	1	0
	Войсковые части МВД	99	0	21
	ВСЕГО	**310**	60	112

Table 10.3.2 – **CSFSF staff list in passive operation** (translation of this table see on p.208)

№ п/п	Наименование структурных подразделений, должностей	Кол. штатн. един.	Вахта, чел.	4 х 3
1	2	3		
1	**Руководство ЦХОЯТ**	**7**	**0**	**7**
2	**Бухгалтерия**	**3**	**0**	**3**
3	**Планово-экономический отдел**	**3**	**0**	**3**
4	**Отдел кадров**	**2**	**0**	**2**
5	**Режимно-секретный отдел**	**2**	**0**	**2**
6	**Административно-хозяйственный отдел**	**10**	**0**	**10**
	Итого по АУП	***27***	***0***	***27***
7	**Производственно-технический отдел**	**3**	**0**	**3**
8	**УКС**	**4**	**0**	**4**
9	**Отдел ЯБ, РБ и ООС**	**18**	**6**	**6**
10	**Отдел физической защиты**	**11**	**0**	**11**
11	**Цех транспортно-технологический**	**10**	**0**	**2**
11.2	*Бригада вагон-контейнерного эшелона*	*4*	*0*	*0*
12	**Цех вспомогательных систем**	**44**	**16**	**11**
12.1	*Участок вентиляции, тепловодоснабжения, водопровода и канализации*	*10*	*5*	*0*
12.2	*Участок КИПиА, связи и сигнализации*	*7*	*2*	*3*
12.3	*Участок электротехнических устройств*	*9*	*4*	*1*
12.4	*Ремонтно-механический участок*	*12*	*5*	*2*
16	*Участок автотранспорта*	*3*	*0*	*3*
	Итого производственного персонала	***90***	***22***	***37***
	ИТОГО обслуживающего персонала	**117**	**22**	**64**
	Явочный состав максимальной рабочей смены			86
	Столовая	16	8	0
	Медпункт	2	1	0
	Войсковые части МВД	99	0	21
	ВСЕГО	**234**	31	85

11 LABOR PROTECTION

Labor protection is a system of legislative acts, social-economic, administrative-technical and therapeutic-prophylactic measures and means assuring safety, protection of human health and ability for work in process of labor. Labor protection is implemented in accordance with the Law of Ukraine "Labor Protection" of 21 November 2002.

In order to ensure labor protection, the current document provides for, in accordance with RD, constructive and design decisions that allow assuring personnel safety without harm for his health and ability for work during the operation of buildings, equipment and process systems following, at the same time, the current Rules on safe operation.

An engineering process performed at the CSFSF is reduced, mainly, to handling and welding operations. The peculiarity lies in the fact that individual process operations are performed in rooms with increased radiation background (restricted access area).

CSFSF is designed; equipment for implementation of the selected technological process is chosen in accordance with the relevant regulatory documents (RD) regulating design of industrial enterprises, nuclear energy facilities and operation of the existing SNF storage facilities.

Technical decisions made according to the current RD ensure both guiding of the accepted engineering process in compliance with the given regulation and personnel labor (safety) protection.

Hazardous and harmful production factors that may occur at the CSFSF as a result of deviation from RD requirements (instructions) during maintenance, violation of the given maintenance periodicity and repair, deviation from regulatory requirements (instructions) during these or those operations etc. include, mainly, the following:

- hazard of electrical shock;
- drop hazard of loads transferred by hoisting devices;
- possibility of injuries in contacting with rotating parts of equipment, operating hoisting devices and transport means;
- impact of fire hazardous factors;
- increased radiation background, contamination of equipment surfaces with radioactive materials.

Issues related to negative impact of hazardous and harmful production factors on personnel and related, first of all, to the increased radiation background of rooms, radiation contamination of process systems and equipment and fire are described, correspondingly, in chapters… of the current document.

Measures to be accepted in the project and that envisage exclusion (decrease) of negative impact on the personnel of other possible hazardous and harmful factors mentioned above are given below in Subsection 11.1.

11.1 Industrial Safety

The personnel safety is ensured by implementation of a set of technical and organizational measures regulated by designing standards (different "Rules" and Construction Standards") and "Rules for Arrangement and Safe Operation..." the main of which, related to CSFSF, are given in Table 11.1.1.

Table 11.1.1 List of regulatory documents regulating CSFSF safe operation

Marking	Title
DNAOP 0.00-1.02.99	Rules for arrangement and safe operation of lifts
DNAOP 0.00-1.03-02	Rules for arrangement and safe operation of lifting cranes
PUE edition 6 with amend.1	Rules for arrangement of electrical facilities
DNAOP 0.00-1.32-01	Rules for arrangement of electrical facilities. Electrical equipment of special

	facilities
DNAOP 0.00-1.33-01	Rules on safe operation of heat-technical equipment of power plants and heat network
DNAOP 00.0-1.28-97	Rules of labor protection at motor transport
DNAOP 1.1.10-1.04-01	Rules of safe work with tools and devices
GKD 34.20.507-2003	Technical operation of power plants and networks. Rules
DNAOP 0.04-1.05-90	Rules for arrangement and safe operation of equipment and piping at nuclear plants
DNAOP 1.1.10-1.01-97	Rules of electrical facility safe operation
DNAOP 0.00-1.21-98	Rules for safe operation of consumers' electrical installations

The design documentation will provide for the following to protect personnel against the above mentioned hazardous and harmful factors:

- protective fence of rotating equipment parts;
- producing stairs for lifting with a certain slope;
- closure of gaps, fencing of sites;
- piping identification coloring;
- necessary ways of personnel evacuation;
- flange connectors at pipelines for caps during a repair period;
- devices for periodical static and dynamic tests of lifting devices.

Exclusion of traumatism, caused by electrical shock and lightning impact, simultaneously with arrangement measures (performed during the equipment operation process) is ensured in the project by acceptance of the following technical decisions in accordance with PUE:

- design, construction, a method of installation and isolation class of the applied devices, electrical equipment, cables and wires comply with the network parameters and conditions of the environment;
- grounding of electrical equipment and components of electric installation that can be under tension as a result of isolation damage;
- compliance with appropriate distances to current-carrying parts of their closure (fencing);
- construction of a protective grounding mat connecting it with all metal parts of equipment and constructions being usually not under tension;
- three-wire electrical network of 220 V with installation of outlet sockets with the third grounding wire;
- network of repair lighting with tension of 12 V;
- lightning protection of a building.

For this purpose, not only grounding of all conductive elements of electrical equipment (shells, casing etc) that can be under tension accidentally is performed but also it is obligatory the grounding of these components.

In addition, the grounding mat is performed in all rooms where electrical equipment is located, it is connected to general grounding mat of the facility (in compliance with PUE) with organization correspondingly of leveling metal bands near external entrances of buildings that is necessary to reduce "step voltage" and "contact voltage", it means that, finally, it serves to reduce risk of electric traumatism.

Protection from the lightning impact is ensured by a set of measures on lightning protection for buildings and constructions, particularly, by installation of lightning accepting networks connected to the external grounding mat edge at building roofs and by installation of a lightning protector standing separately.

The following should be implemented at first:

- persons having special education and trained within the scope of the requirements for the held position can be admitted to work;
- arrangement, operation and repair of equipment, buildings should meet the requirements of state regulatory documents on labor protection;
- protection means, devices and tools applied in equipment maintenance should be inspected and tested in compliance with the current state regulatory documents on labor protection.
-

11.2 Industrial Sanitation

Industrial sanitation measures could be subdivided into:

- medical service;
- meals;
- sanitary and accommodation service;
- provision with hygiene and sanitary conditions at personnel workplaces.

Medical service, including initial and routine medical examination is provided for at the transfer building changing room medical center (4,200m elevation).

CSFSF personnel meals are stipulated in the dinging room, which is included into the administrative building.

For CSFSF personnel sanitary and accommodation service there is stipulated:

- receiving building changing room at 4,200 m elevation;
- 0,000 m sanitary air lock for personnel who works in the transfer tube.

Changing room and sanitary air lock are stipulated for servicing of both the staff and involved repair personnel and persons on business trips.

The main objectives of the changing room designed in the receiving building are:

- work wear changing and storage;
- distribution of overall working clothes, footwear and other IPM;
- control of the CSFSF restricted access area personnel work wear and skin contamination ;
- personnel sanitization.

Sanitary air lock is purposed for:

- obtaining of additional IPMs for the personnel who works in the transfer tube and undertakes container emergency transfer;
- obtaining of additional work wear;
- contamination monitoring of additional IPM, work wear, footwear and hands;
- provision, if necessary, with additional airtight IPM;
- airtight IPM acceptance and transfer for decontamination.

Additional IPMs, which are stipulated to be obtained in the sanitary airlock during activities on container emergency transfer, include non-recoverable respirators, glasses that protect the eyes from dust, face shield, rubber apron, sleeve-protectors, welder's IPMs (for welding), etc.

Additional airtight IPMs, which are stipulated to be obtained in the sanitary air lock, include pressure face shield, pressure helmets, pressure suits, plastic IPMs.

To ensure hygiene and sanitary work conditions for the personnel of the CSFSF transfer building, there is stipulated forced combined extract-and-input ventilation, heating and air conditioning systems. The transfer building ventilation is designed separately for the "restricted" and "free" access area rooms.

The "restricted" access area ventilation system fulfills the following functions:

- prevents air contamination of rooms and atmospheric air (exceeding the permissible values) with radioactive substances;

- provides the maintenance staff with permissible meteorological conditions and air purity of rooms during main and repair works.

For heat removal, a combined extract and input ventilation with mechanical or natural impulses is provided for in the “free” access area rooms.

Air change in rooms and also air temperature in rooms are accepted according to the sanitary standards and process requirements.

Operable ventilation installations, pumps and compressor equipment are the vibration and noise source in rooms of the transfer building. Noise reduction measures ensure an operable equipment noise level that does not exceed 80 dBA.

Operating and repair personnel normal work, taking into account prevention of injury both under normal operation and during evacuation from buildings and structures, is ensured by selection of corresponding systems, types and dimensions of artificial lighting in all rooms and at all workplaces; specific lights with independent power supply source in the form of accumulator batteries designed for two hours of operation are used for evacuation lighting. Light in rooms shall correspond to the standards depending on the work process characteristics at specific work places, on environment conditions, etc. There is stipulated working, repair, emergency and evacuation lighting.

12 DECOMMISSIONING

12.1 Decommissioning General Work Plan

A decommissioning final conception and strategy should be developed by the Client prior to the CSFSF decommissioning depending on decommissioning final objectives and on specification of further activities on SFA management.

The main objectives of the current decommissioning plan are:

- to define decommissioning principles;
- to define decommissioning approaches;
- to define decommissioning strategy main approaches;
- to assess anticipated types and quantity of generated RAW;
- to define possible directions with regards to generated RAW management.

12.2 Main Principles

CSFSF decommissioning main principles are:

- to ensure low level of risk for personnel and the environment;
- to minimize radioactive waste generation during CSFSF decommissioning;
- to reduce economic costs.

During CSFSF design at the subsequent stages, these principles shall be paid proper attention, including:

- during selection of used materials for decontamination facilitation;
- during selection of decisions with regards to layout in order to ensure access to the equipment and radioactive material removal;
- during selection of design decisions for dismantling facilitation;
- during selection of SF storage technology in order to facilitate SF removal from the CSFSF site.

12.3 Decommissioning Strategy

CSFSF decommissioning strategy is an appropriate, according to the current legislation, decommissioning order that specifies priority, duration and principals of a facility decommissioning and a state of facility after completion of each stage.

According to the General Safety Regulations on Decommissioning, a decommissioning scenario (strategy) should be selected taking into account the following factors:

- nuclear facility radiation state after final shutdown and changing of this state within the time;
- nuclear facility physical state and changing of this state within the time, including integrity assessments of buildings and structures during long-term time period;
- safety requirements;
- all aspects of radioactive waste management, including collection, conditioning, temporary storage, transfer and disposal;
- availability of decontamination and dismantling method and technology;
- presence of trained and experienced personnel;
- presence of necessary financial resources;
- nuclear facility site intended use;
- results of personnel, population and environment impact assessment;
- social factors.

The most significant tractors that effect decommissioning strategy selection, are:

- legislative and regulatory requirements;
- expenses on decommissioning and funding;

- SF treatment strategy;
- RAW management infrastructure;
- criteria on material control removal;
- social and public aspects;
- nuclear facility status;
- owner's interests, including site intended use;
- availability of resources;
- radiological aspects.

Each factor, which effects decommissioning strategy selection should undergo analysis with regards to specific nuclear installation, what should result in satisfactory development of a decommissioning plan.

The Client's decision on SF subsequent treatment after long-term storage period (100 years) is a main condition with regards to the beginning of CSFSF decommissioning.

CSFSF decommissioning strategy is specified by the Client's decision on CSFSF decommissioning final objective. The following options are possible:

- extension of the existing CSFSF operation life-time;
- constriction of a SF storage facility with other storage method at CSFSF site;
- a free territory will be instead of the CSFSF site.
-

Prior to decommissioning, the following activities should be carried out for all options of CSFSF decommissioning:

- technical and radiation survey of CSFSF structures and elements;
- transfer of the existing SFA containers for disposal and/or processing;
- management of generated RAW;
- development of design documents which shall allow to proceed with a subsequent decommissioning stage. .

Terms of decommissioning stage are specified by terms of SFA container transfer that are determined, in their turn, by the terms of acceptance of these containers for disposal or processing.

- A final shutdown stage is the same for options 1 and 2 with regards to purpose and different with regards to the terms, because if is specified by work scopes In general case, the following activities should be carried out at the stage of final shutdown: analyze a possibility to use the existing structures and elements for a new facility;
- define measures and means for possible modernization and/or replacement of separate elements;
- develop design documents that shall allow to proceed with a subsequent decommissioning stage.

There is no final shutdown stage for the third strategy option.

A dismantling stage for options 2 and 3 is the same with regards to the purpose and different with regards to the terms, because it is determined by the dismantling scopes. In general case, CSFSF structures and elements should be dismantled at this stage, as well as management of generated RAW should be carried out.

Dismantling stage is absent for option 1.

12.4 Safety Ensuring Measures at Decommissioning

A cask storage area should be designed in a way to contribute to quick, safe and efficient decommissioning of the facility. The canister with spent nuclear fuel is leak-tight, what exclude contamination of other equipment and allow remove and store canisters without further sealing or performance of subsequent operations on FA handling.

A cask storage area should be designed in a way to minimize a quantity of radioactive materials generated and contaminated equipment. The MPC outer surfaces will not be contaminated

because prevention of radioactive contamination of these canisters is mandatory condition for loading. Therefore, contamination of storage overpacks seems to be improbable. It is expected that activation of storage overpacks and concrete foundations due to SNF long-term storage will be insignificant.

A cask storage area should be designed in a way to facilitate removal of radioactive waste and contaminated materials. When a storage period for individual containers is terminated, these containers should be installed in transport modules and removed from the site. Then, the storage containers will be inspected and any contamination will be removed for disposal as low-level waste.

Fences, power equipment and other devices of the storage area for the HI-STORM storage overpacks will not require special measures on decommissioning because their contamination is not expected.

A cask arrangement area should be designed in a way to ensure simple and efficient work performance on decommissioning properly. SNF dry storage system in containers ensures SNF confinement and the possibility for its subsequent removal from the site. SNF will be tightly housed in containers for storage in a way to exclude contamination of other equipment and allow to transport and store sealed containers with no necessity to unseal a container with SNF or transfer SFA.

Safety in the CSFSF decommissioning should be based on use of the following principles:

- justification, non-exceeding and optimization principles in accordance with NRBU-97;
- defense-in-depth principle based on use of a system of barriers against ionizing radiation spread and systems of technical and arrangement measures on barrier protection and reservation of their efficiency;
- principle of maximum possible use to ensure safety of the infrastructure created during operation;
- principle of maximum possible use of the operation personnel experience.

Safety in the CSFSF decommissioning should be ensured by implementation of a set of arrangement and technical measures covering radiation protection of the personnel, public and the environment, prevention of accidents and industrial safety.

In CSFSF design, the following measures, which facilitate the CSFSF decommissioning, will be taken into account:

- measures on activation minimization of systems and equipment;
- measures on minimizing RAW generation during operation;
- measures on minimizing contamination of equipment and structures;
- measures on facilitating decontamination of systems and equipment in decommissioning;
- measures on collection of the information on CSFSF systems, equipment and rooms;
- measures on arrangement of the required areas in decommissioning of systems.

12.5 RAW Management in Decommissioning

Management of radioactive waste generated in the CSFSF decommissioning supposes maximum use of the RAW management design scheme:

- liquid radioactive waste, as they are generated, will be removed by means of an oil tank to be treated at the NPP or other processing powers of the CSFSF exclusion are;
- according to the design scheme, low-level radioactive waste will be removed for treatment at the ChNPP or CDF by means of specialized rented transport;
- in case of intermediate solid radioactive waste generation, it is supposed to rent containers and specialized transport at the ChNPP or CDF and to remove for further treatment and disposal at the ChNPP or CDF .

Generation of high-level radioactive waste during the CSFSF decommissioning is not supposed.

List of Reference Regulations and Literature.

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2 NP 306.6.124-2006 Rules on Nuclear and Radiation Safety in Shipment of radioactive Materials (PBTRM-2006). SNRCU, 2006.

3 Law of Ukraine on Nuclear Energy Use and Radiation Safety.

4 NP 306.1.02/1.034-2000 General Provisions on Safety Assurance of Nuclear Power Plants (OPBU-2000). SNRCU, 2000.

5 NRBU-97 (GGN 6.6.1-6.5.001-98) Radiation Safety Standards of Ukraine (State sanitary standards). Ministry of Health of Ukraine, 1997.

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7 SP AS-88 Health and Safety Rules for Design and Operation of Nuclear Power Plants. Ministry of Health of USSR, 1988.

8 PNAE G-5-006-87 Standards for Seismic Designs of Nuclear Power Plants. GAEN USSR, 1988.

9 SPORO-85 Sanitary Rules for Radioactive Waste Management, Ministry of Health of USSR,1986.

10 SNiP 2.01.07-85 Construction Standards and Rules. Loads and Impacts.

11 SNiP 2.03.11-85 Construction Standards and Rules. Corrosion Protection of Structures.

12 DBN B 2.2.5-97 Civil Defense Safety Structures.

13 SNiP II-89-80 Construction Standards and Rules. General Layouts of Industrial Enterprises.

14 DBN 360-92 Town Planning. Planning and Building up of Town and Country Settlements.

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25 PNAE G-7-009-89 Equipment and Piping of Nuclear Power Facilities. Welding Joints and Depositions. General Provisions, Approved by GAEN USSR, 1989.

26 PNAE G-7-010-89 Equipment and Piping of Nuclear Power Facilities. Welding Joints and Depositions. Inspection Rules. Approved by GAEN USSR, 1989.

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28 SNiP 2.04.02-84 Water Supply. External Networks and Structures.

29 GOST 12.1.004-91 SSBT. Fire Safety. General Requirements.

30 DBN B.1.1-7-2002 Fire Protection. Fire Safety of Structures being constructed.

31 SNiP 2.09.02-85* Process Buildings.

32 NAPB B.07.005-86 (ONTP 24-86) Determination of a Category of Rooms and Buildings on Explosive and Fire Hazards.

33 NAPB 05.028-2004 Fire Protection of Power Enterprises, Separate Facilities and Units. Instruction on Design and Operation.

34 GOST 10704-91 Steel longitudinal welded tubes.

35 NAPB B.06.004-2005 List of Equitype Rooms that are Subjected to the Equipment by Automatic Fire Extinguishing and Fire Alarm Facilities.

36 GOST 27331-87 Fire Techniques. Classification of Fires.

37 NAPB 06.015-99 List of Rooms and Buildings of Energy enterprises of the Ministry of Energy of Ukraine Determining a Category and Classification of Explosive Fire Hazards.

38 DBN V.2.5-13-98 Fire Automatics of Buildings and Structures.

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42 SNiP 2.04.05-91 Heating, Ventilation and Conditioning.

43 NAPB V.05.023-2005/111 Instruction on Use of Fireproof Cable Coatings in Cable Structures.

44 VSN 47-85 Design Standards of Automatic Fire Extinguishing Facilities of Cable Structures.

45 SNiP 2.09.03-85 Structures of Industrial Enterprises.

46 SNiP 2.09.04-87 Administrative and Residential Buildings.

47 GOST 12.1.005-88 Air of the Working Area.

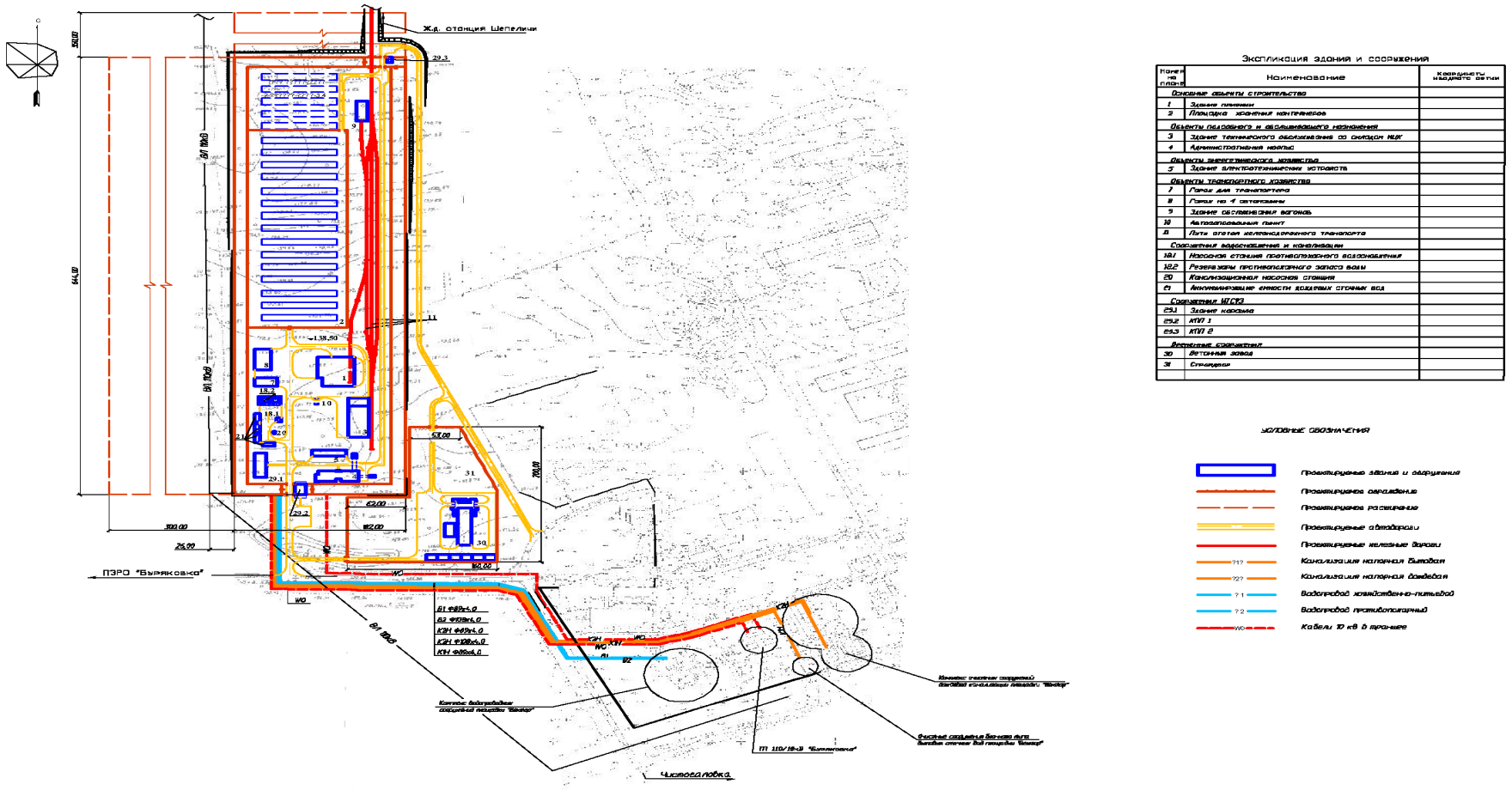
48 Regulatory Document on Decommissioning of Nuclear Power Plants and Pilot Reactors (OPB SE).

49 Seismic Zoning Plan of Ukraine, approved by the Order of the State Committee on Construction, Architecture and House Building No. 10 of 21 January 1998.

50 NP 306.4.07.016-98 Rules for Account and Control of Nuclear Materials at Facilities. MEB, Ukraine, Kyiv, 1999.

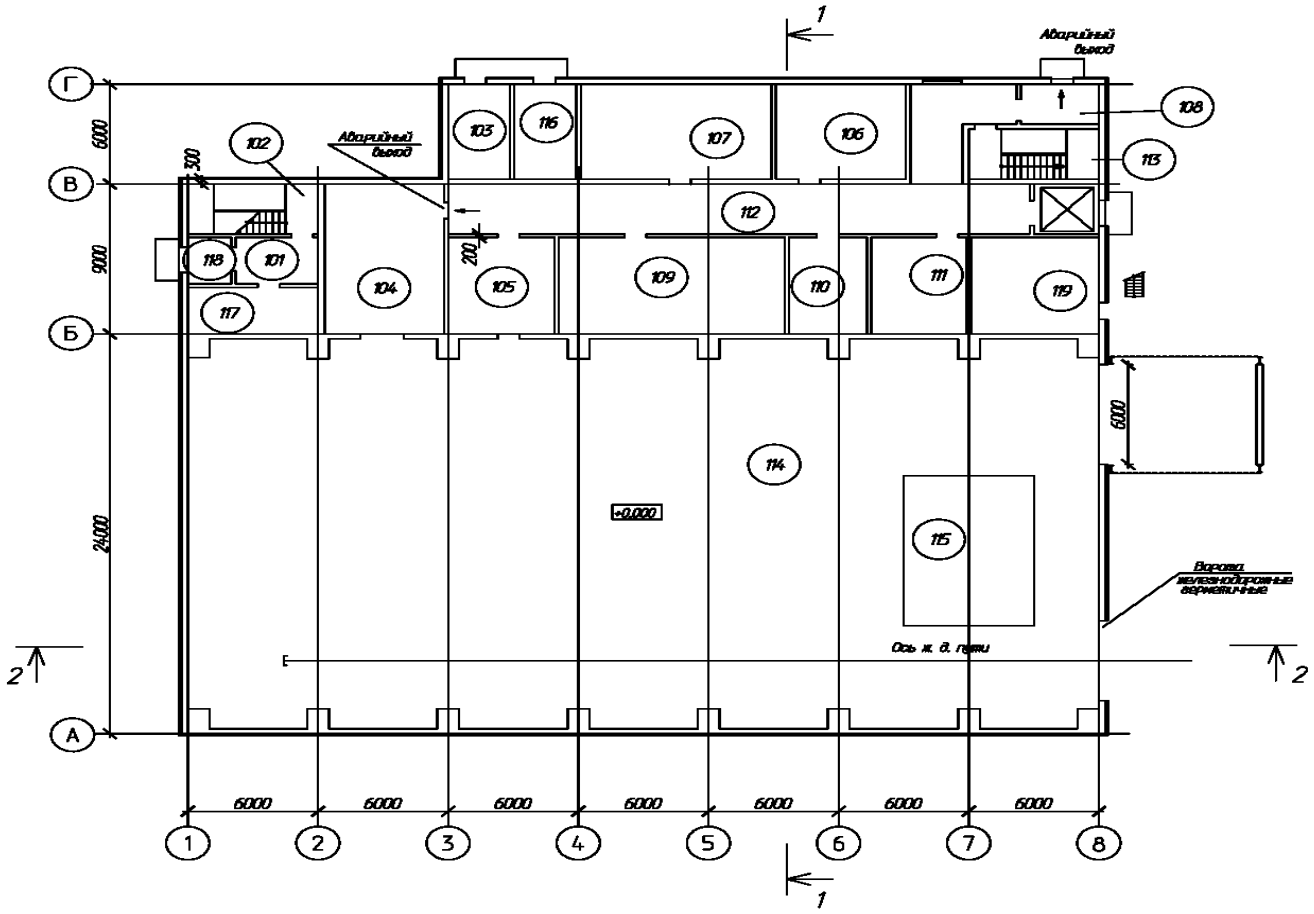
51 NP 306.2.105-2004 Main Provisions for Safety Assurance of Interim Dry Spent Nuclear Fuel Storage Facilities.

APPENDIX A

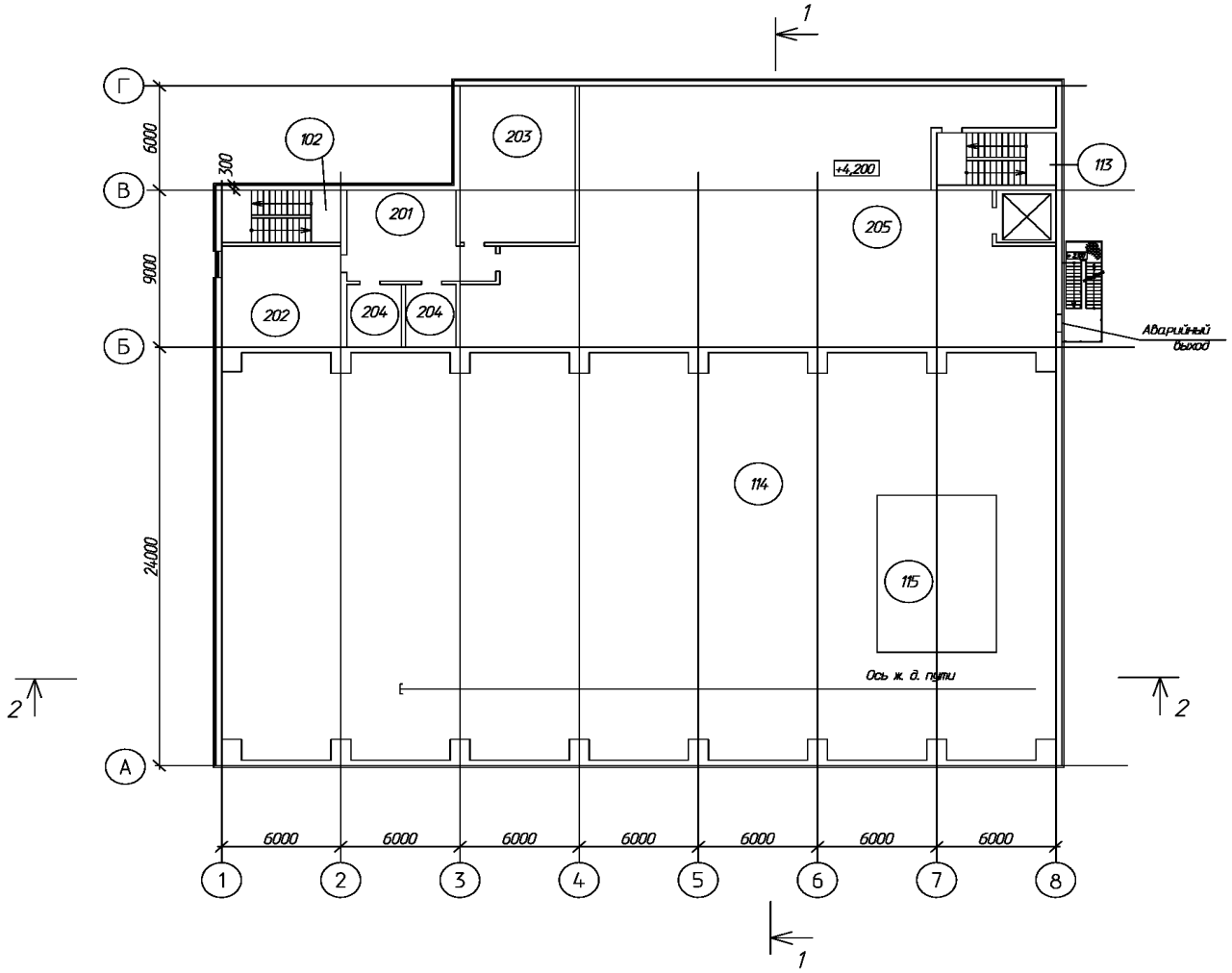


General layout diagram

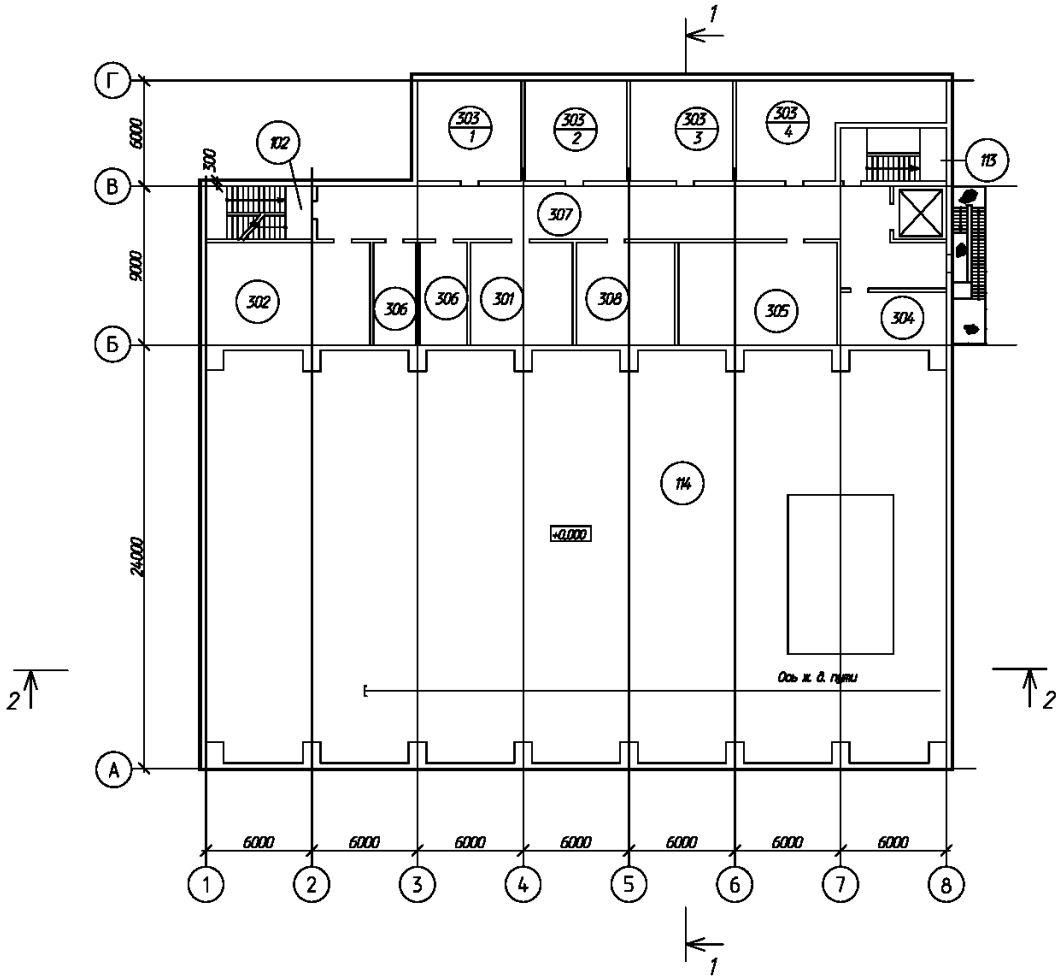
APPENDIX B



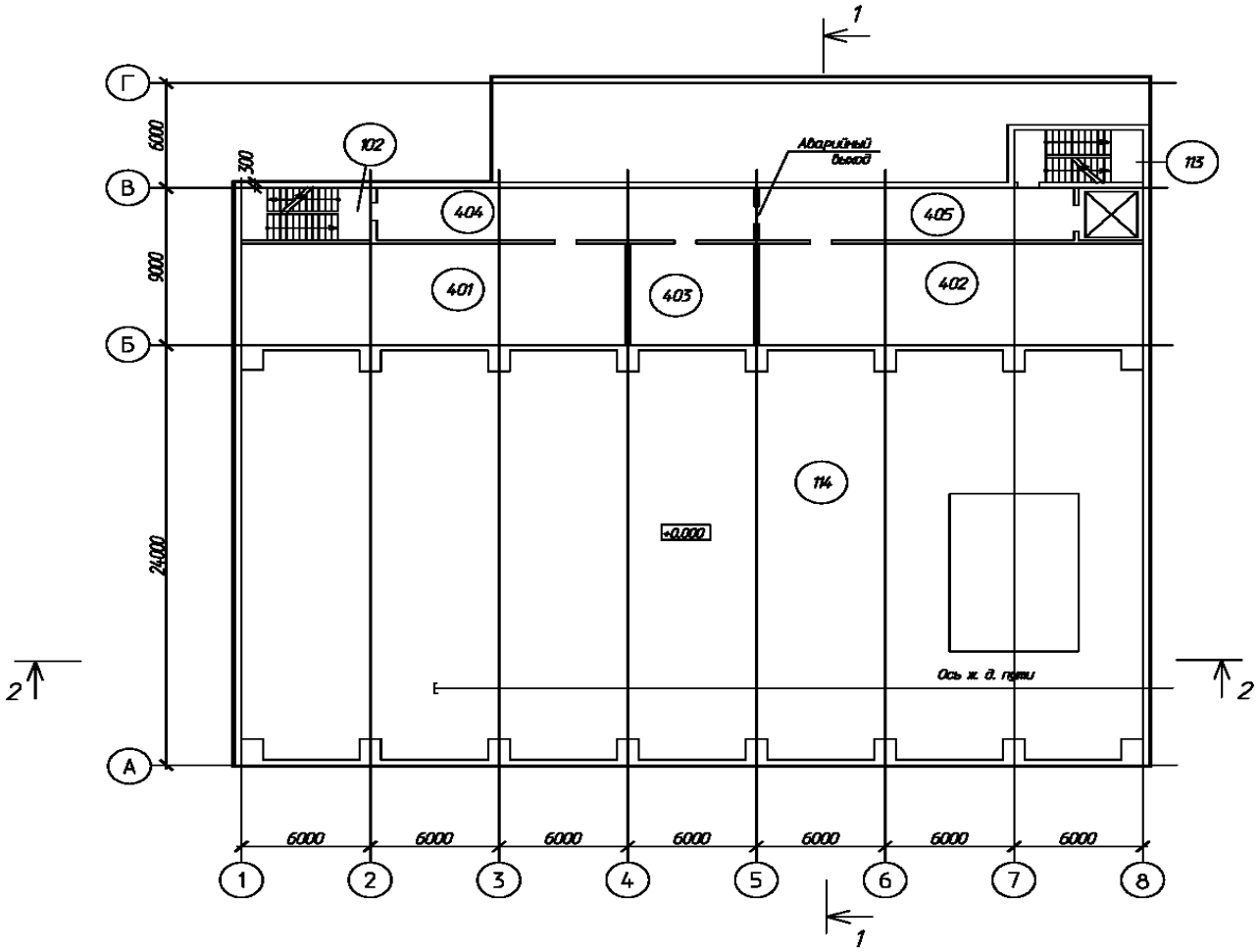
Drawing 12.5.1 –**Receiving building. Plan at 0,000 elevation**



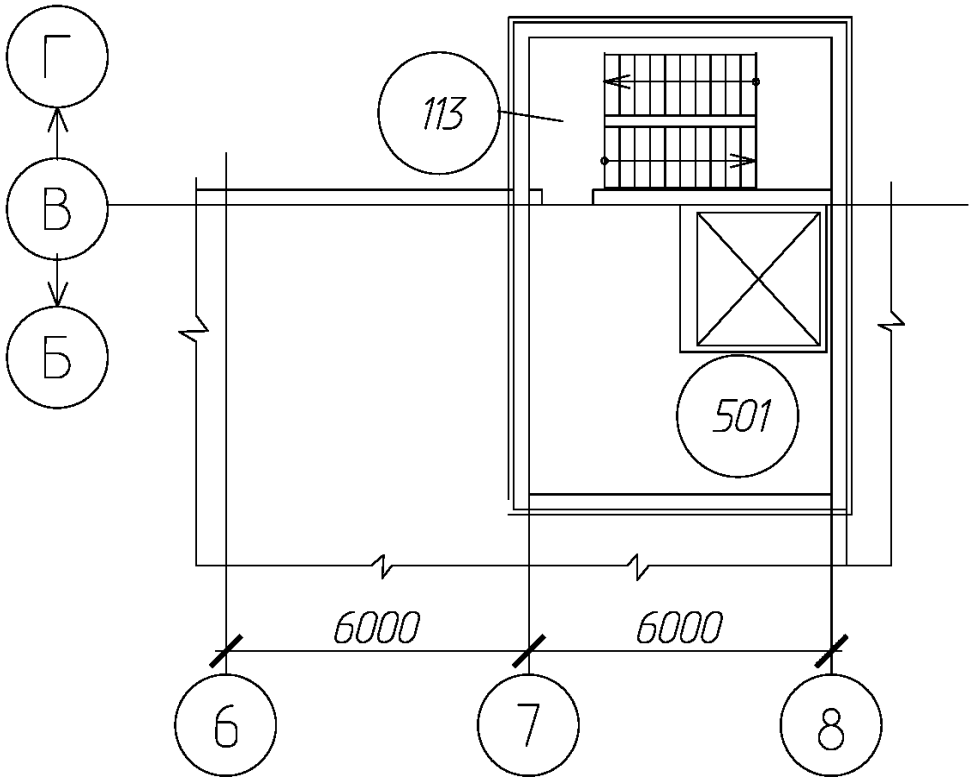
Drawing 12.5.2 – **Receiving building. Plan at 4,200 elevation**



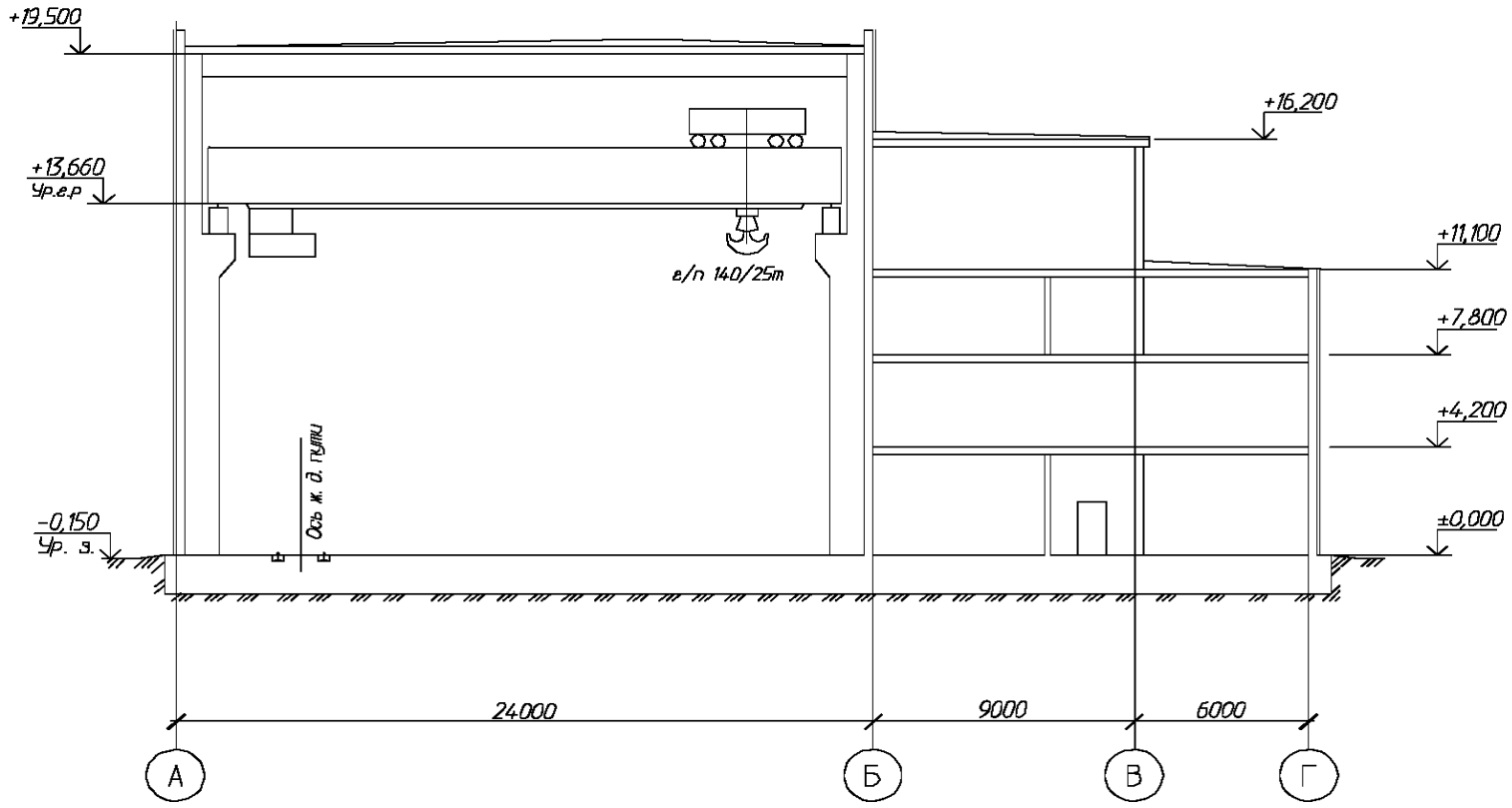
Drawing 12.5.3 – **Receiving building. Plan at 7,800 elevation**



Drawing 12.5.4 –**Receiving building. Plan at 11,100 elevation**



Drawing 12.5.5 – **Receiving building. Plan at 16,200 elevation**



Drawing 12.5.6 – **Receiving building. Cross section 1-1**

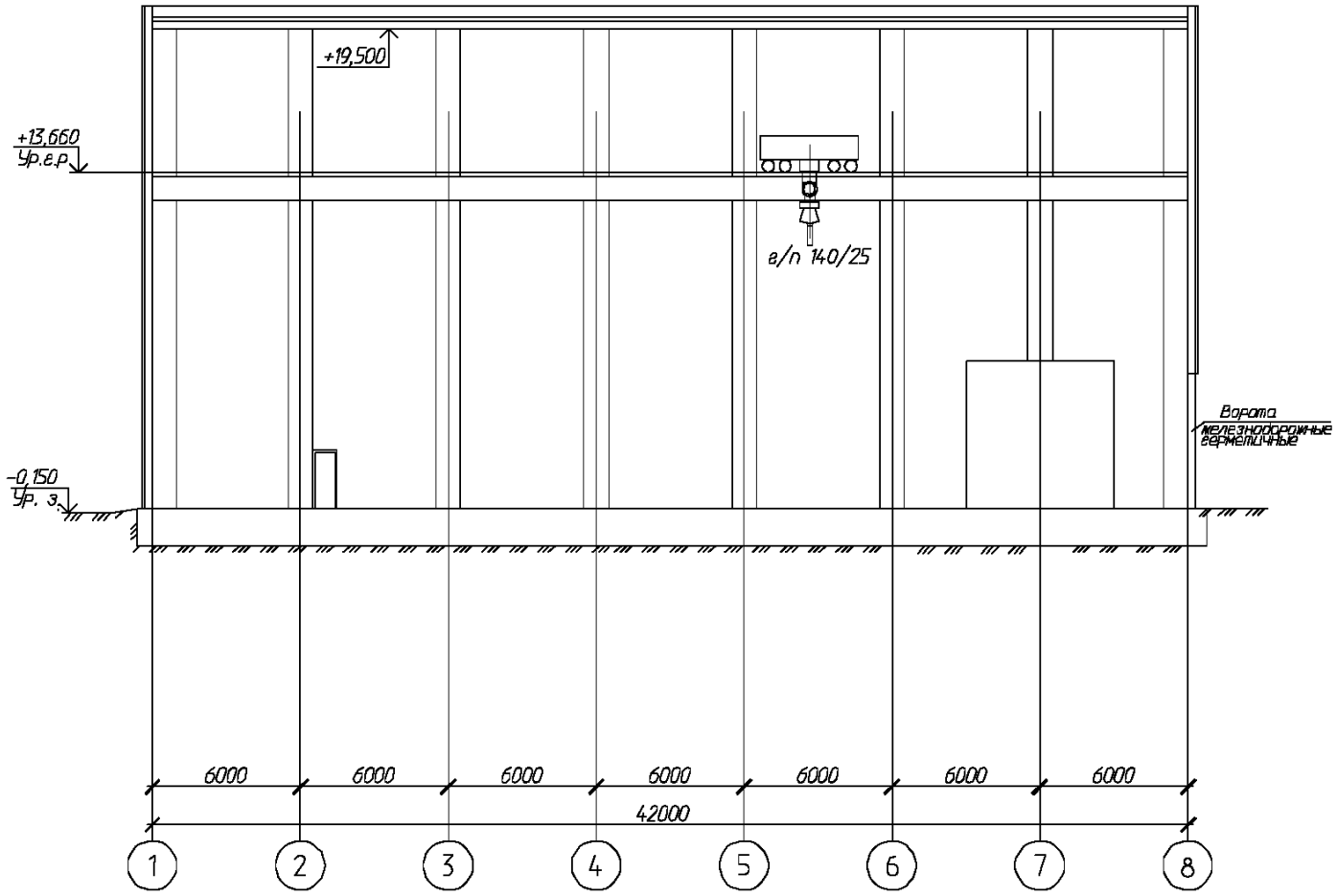
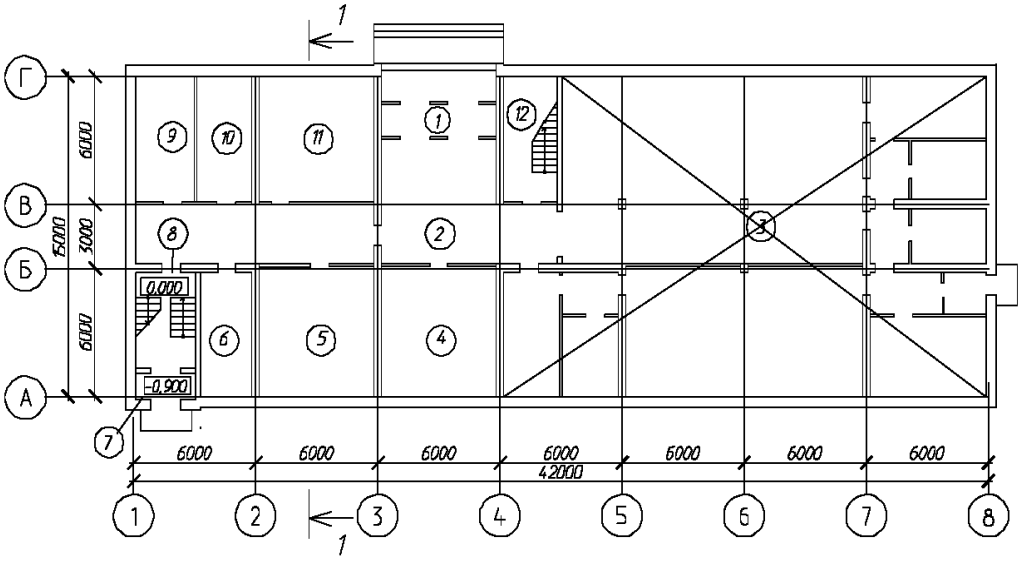


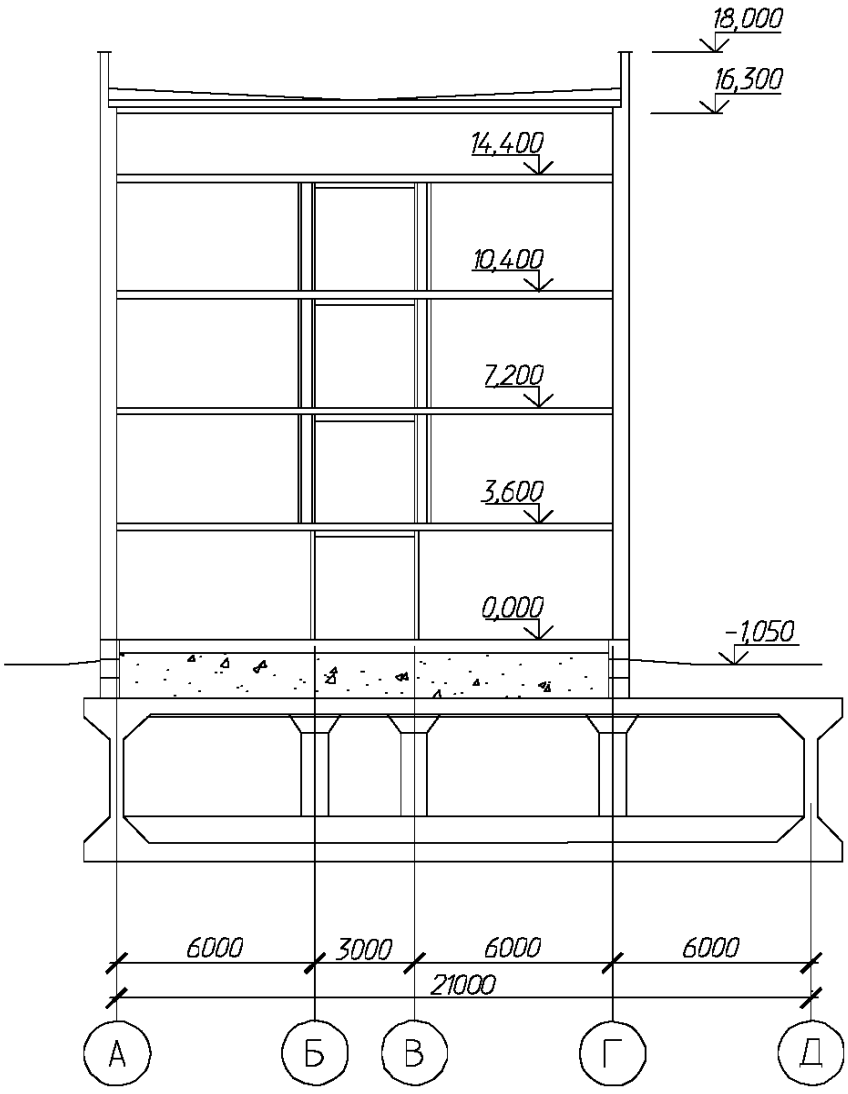
Figure 12.5.7 – **Receiving building. Cross section 2-2**

Table 12.5.1 – **Explacation of the receiving building rooms**

No. room	Title	Square, m^2	Room category
101	Corridor	10,66	-
102	Stairwell “clean”	18,0	-
103	Heat point	16,2	D
104	Workshops “dirty”	49,5	D
105	Units of changing rooms	28,4	V
106	Reserve room	34,2	D
107	Laboratory	50,1	D
108	Lobby	8,6	-
109	Room for shower reference tanks	60,3	D
110	RT pump station	20,8	D
111	Reserve room	25,5	D
112	Corridor	100,8	-
113	Stairwell “dirty”	18,0	-
114	Handling tube	953,5	D
115	Transfer chamber	54,0	D
116	Compressor house	16,2	D
117	Electrical unit	16,8	D
118	Lobby	5,6	-
119	Input ventilation	34,2	D
201	Corridor	32,6	-
202	Electric and technical room	34,7	D
203	Unit of amenity rooms for the free access area personnel	52,2	D
204	Water closet	8,9x2	-
205	Unit of changing rooms	378,0	D
301	Archive	33,6	D
302	IAEA instructor room	53,9	-
303/1,2,3,4	Office rooms	33,9x3; 47,0	D
304	CCR personnel room	18,0	-
305	CCR and ventilation panel	52,2	D
306	Water closets	13,9x2	-
307	Corridor	113,6	-
308	Reserve room	32,4	-
401	Inlet ventilation center	103,7	D
402	Unit of rooms for exhaust ventilation centers	103,7	D/V
403	Room for water reserve tanks	34,2	-
404	Corridor “clean”	52,7	-
405	Corridor “contaminated”	44,0	-
501	Engine room for a lift with carrying capacity of 2000 kg	34,2	D



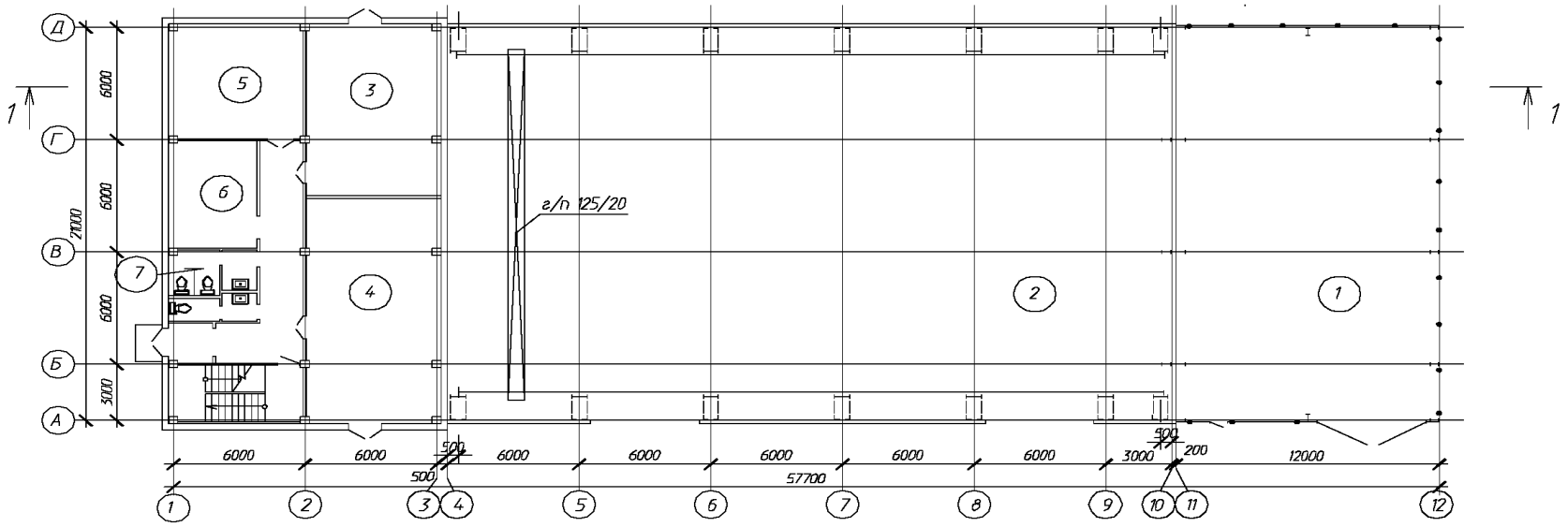
Drawing 12.5.8 –**Administrative building. Layout at 0,000 elevation**



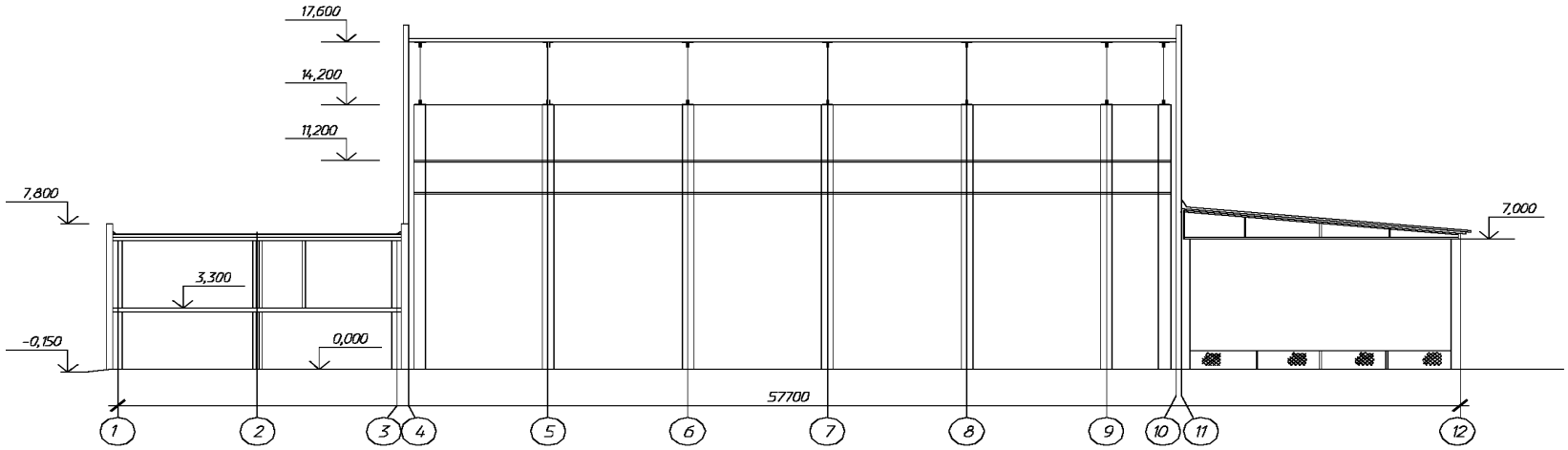
Drawing 12.5.9 – **Administrative building. Cross section 1-1**

Table 12.5.2– **Explication of rooms and the administrative building**

No. room	**Title**	**Square, m^2**	**Room category**
1	Lobby	8,4	-
2	Entrance	74,5	-
3	Complex of dining rooms	321,6	D
4	Communication room	34,1	D
5	First-aid post	33,7	-
6	Water closet	14,7	-
7	Lobby	3,5	-
8	Stairwell	13,1	-
9	Heat point	16,9	D
10	Electrical circuit unit	15,8	D
11	Ventilation chamber	33,0	D
12	Stairwell	15,3	-



Drawing 12.5.10 – **Maintenance building with MPC storage. Layout**



Drawing 12.5.11 – **Maintenance building with MPC storage. Cross section**

Table 12.5.3 – **Explication of the administrative building**

No. room	**Title**	**Square, m^2**	**Room category**
1	Area for concreting and storing the HI-STORM storage overpacks	252,0	D
2	Storehouse of new HI-STORM, MPC	690,0	D
3	Electrical workshop	55,5	D
4	Mechanical workshop	74,5	D
5	Concrete laboratory	37,9	D
6	Office	23,1	-
7	Water closets	15,0	-

Table 10.3.1 – CSFSF staff list in active operation

o.	Structural subdivisions, positions	Amount of regular units	Watch, persons	4 x 3
	2	**3**		
	CSFSF Administration	**8**	**0**	**8**
	Account Department	**3**	**0**	**3**
	Economic Planning Department	**4**	**0**	**4**
	Personnel Department	**2**	**0**	**2**
	Document Security Department	**2**	**0**	**2**
	Maintenance Department	**17**	**0**	**17**
	Total according to AUP (administrative personnel management)	***36***	***0***	***36***
	Production and Technical Department	**5**	**0**	**5**
	UKS	**9**	**0**	**9**
	NS, RS and EP (Environmental protection) Department	**19**	**0**	**19**
0	**Physical Protection Department**	**11**	**0**	**11**
1	**Transport-engineering shop**	**44**	**22**	
1.1	*HI-STORM grouting site*	*6*	*3*	*0*
1.2	*Team of railway container train*	*18*	*9*	*0*
2	**Backup systems shop**	**59**	**24**	**11**
2.1	*Section of ventilation, heat and water supply, water piping and sewerage*	*10*	*0*	*10*
2.2	*I&C, communication and alarm section*	*8*	*0*	*8*
2.3	*Electrical device shop*	*8*	*0*	*8*
2.4	*Repair shop*	*13*	*0*	*13*
2.5	*Concrete factory*	*12*	*6*	*0*
6	*Motor transport site*	*5*	*0*	*5*
	Total with regards to operating personnel	**147**	**46**	**55**
	TOTAL with regards to attending personnel	**183**	**46**	**91**
	Shift attending personnel maximal			13

	number			7
	Dining-room	26	13	0
	First-aid post	2	1	0
	Military units of the Ministry of Internal Affairs	99	0	21
	TOTAL	**310**	**60**	**112**

Table 10.3.2 – CSFSF staff list in passive operation

No.	Structural subdivisions, positions	Amount of regular units	Watch, persons	4 x 3
1	**2**	**3**		
1	**CSFSF Administration**	**7**	**0**	**7**
2	**Account Department**	**3**	**0**	**3**
3	**Economic Planning Department**	**3**	**0**	**3**
4	**Personnel Department**	**2**	**0**	**2**
5	**Document Security Department**	**2**	**0**	**2**
6	**Maintenance Department**	**10**	**0**	**10**
	Total according to AUP (administrative personnel management)	***27***	***0***	***27***
7	**Production and Technical Department**	**3**	**0**	**3**
8	**UKS**	**4**	**0**	**4**
9	**NS, RS and EP (Environmental protection) Department**	**18**	**6**	**6**
10	**Physical Protection Department**	**11**	**0**	**11**
11	**Transport-engineering shop**	**10**	**0**	**2**
11.2	*Team of railway container train*	*4*	*0*	*0*
12	**Backup systems shop**	**44**	**16**	**11**
12.1	*Section of ventilation, heat and water supply, water piping and sewerage*	*10*	*5*	*0*
12.2	*I&C, communication and alarm section*	*7*	*2*	*3*
12.3	*Electrical device shop*	*9*	*4*	*1*
12.4	*Repair shop*	*12*	*5*	*2*
16	*Motor transport site*	*3*	*0*	*3*
	Total with regards to operating personnel	**90**	**22**	**37**
	TOTAL with regards to attending personnel	**117**	**22**	**64**
	Shift attending personnel maximal number			86

	Dining-room	16	8	0
	First-aid post	2	1	0
	Military units of the Ministry of Internal Affairs	99	0	21
	TOTAL	**234**	**31**	**85**

CENTRALIZED SPENT FUEL STORAGE FACILITY FOR WWER REACTORS OF THE UKRAINIAN NUCLEAR POWER PLANTS

FEASIBILITY STUDY ON INVESTMENTS

VOLUME 1
PART 4

Nuclear and radiation safety

Contents

Introduction 3
Abbreviations 4
1 NRS REGULATORY DOCUMENTS 8
2 NUCLEAR SAFETY 9
2.1 General provisions 9
2.2 Main technical decisions for ensuring nuclear safety 10
2.2.1 MPC loading on NPP power unit 10
2.2.2 Transportation from NPP to CSFSF 15
2.2.3 Receiving building 16
2.2.4 Storage area 16
2.2.5 On-site transportation 17
2.2.6 Assessment of effective multiplication factor 18
3 RADIATION SAFETY 20
3.1 The main principles and criteria for ensuing radiation safety 20
3.2 General approach to ensuring radiation safety 21
3.3 Radiation safety in construction 25
3.3.1 Radiation situation and sources of radiation impact 25
3.3.2 Normal construction conditions 28
3.3.2.1 Dose estimation for the personnel 28
3.3.2.2 Measures for ensuring radiation safety 29
3.3.3 Accidents in construction 32
3.4 Radiation safety in CSFSF operation 34
3.4.1 Radiation situation and sources of radiation impact 34
3.4.1.1 Characteristics of ionizing radiation sources 34
3.4.2 Dose estimation in normal operation 39
3.4.2.1 Dose estimation in loading at NPP power unit 39
3.4.2.2 Dose estimation in MPC reloading in the CSFSF 40
3.4.2.3 Dose estimation in maintenance and beyond the cask storage area 41
3.4.2.4 Measures for ensuring radiation safety in normal operation conditions 44
3.5 Radiation safety in accidents 46
3.5.1 Violation of normal operation conditions 47
3.5.1.1 Abnormal weather conditions 47
3.5.1.2 Partial clogging of MPC basket holes 48
3.5.1.3 Partial clogging of HI-STORM vent ports 49

3.5.1.4 Violations in handling operations 49
3.5.2 Design basis accidents 50
3.5.2.1 Earthquake 50
3.5.2.2 Tornado 50
3.5.2.3 Lightning strokes 52
3.5.2.4 Strong winds, hurricane 52
3.5.2.5 Water flooding in floods and high waters 52
3.5.2.6 Heavy snowfall 52
3.5.2.7 Heavy rains 52
3.5.2.8 Landslides of any genesis, ground collapses 53
3.5.2.9 Washing out of shores, slopes, river-beds 53
3.5.2.10 Territory collapse and depression, including underground washout 53
3.5.2.11 Explosions, fires beyond the site 53
3.5.2.12 Acts of terrorism and nuclear material theft 54
3.5.2.13 Fire inside the CSFSF 54
3.5.2.14 Explosion inside CSFSF 56
3.5.2.15 Power failure 56
3.5.2.16 Emergency pressure in the MPC 57
3.5.2.17 Release of radioactive substances from the MPC external surface 57
3.5.3 Beyond design basis accidents 59
3.5.3.1 Hypothetical origin of criticality 59
3.5.3.2 Blockages 59
3.5.3.3 Complete clogging of HI-STORM vent port 60
3.5.3.4 Aircraft crash 60
3.5.3.5 Failure of all fuel elements with MPC enclosure failure 64
3.5.3.6 Fall of HI-TRAC with MPC from the altitude of 38 m in the NPP reactor department 65
3.5.3.7 Measures for beyond design basis accident risk reduction 65
3.6 Radiation safety in decommissioning 66
List of the reference regulations and literature 67
Appendix A – Minutes of inter-branch meeting 69

Introduction

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Taking into account that the FS does not cover regulatory requirements for the scope of covering the nuclear and radiation safety issues, tentative structure and content of the current part were agreed at the inter-departmental meeting. The Minutes of the inter-departmental meeting is presented in Appendix A.

Under volume 1, part 4 the following activities have been performed:

- the list of regulatory documents on the activity at CSFSF has been specified;
- the basic technical decisions for ensuring nuclear safety have been made;
- the basic technical decisions for ensuring radiation safety in construction have been made;
- the basic technical decisions for ensuring the radiation safety in CSFSF operation have been presented;
- personnel exposure doses in CSFSF operation have been estimated;
- the initial events have been qualitatively selected that may lead to the design basis and beyond design basis accidents; the accidents have been determined that participate in environmental impact assessment;
- the main measures for ensuring radiation safety in construction, operation and decommissioning have been determined.

In describing technical decisions for ensuring nuclear and radiation safety related to the main spent nuclear fuel management technology at CSFSF, the Holtec International (developer and supplier of the SNF storage technology).

Abbreviations

EAA	-	Exclusion Area Administration
NPP	-	Nuclear Power Plant
ASME	-	American Society of Mechanical Engineers, Pressure Vessel Code
BV	-	Fuel Cooling Pool
WWER	-	Water-moderated Water-cooled Energy Reactor
HL	-	High-voltage Line
BWR	-	Boiling Water Reactor
SNRCU	-	State Nuclear Regulatory Committee of Ukraine
SSE ChNPP	-	State Specialized Enterprise Chernobyl Nuclear Power Plant
PR	-	Permissible Release
PE	-	Permissible Effluent
PI		Permissible Inlet
LRW	-	Liquid Radioactive Waste
CA	-	Control Area
EA&MRA	-	Exclusion Area and Mandatory Resettlement Area
BDBA	-	Beyond Design Basis Accident
PA	-	Process Area
IDM	-	Individual Dose Monitoring
RS	-	Radiation Source
IRS	-	Ionizing Radiation Source
IE	-	Initial Event
ACP		Access Control Point
RL		Reference Level
Keff		Effective Multiplication Constant
IAEA		International Atomic Energy Agency
ICRP		International Commission on Radiological Protection
MDBA		Maximum Design Basis Accident
SSE		Safe Shutdown Earthquake
MPC		Multi-Purpose Canister
MEU		Ministry for Emergencies of Ukraine
EDR		Exposure Dose Rate
HI-STAR		Transport Overpack
HI-STORM		Storage Overpack
HI-TRAC		Transfer Cask
GC		Guide Channel (Tube)
NOC		Normal Operational Conditions
SAR		Safety Analysis Report
EIA		Environment Impact Assessment
SFA		Spent Fuel Assembly
SFA-A		Spent Fuel Assembly of Alternative Type
SNF		Spent Nuclear Fuel
DL		Doze Limit
OBE		Operating Basis Earthquake
PMP		Project Management Plan
RW		Radioactive Waste
RS		Radiation Safety

RDM	Radiation Dosimetric Monitoring
ERM	Environmental Radiation Monitoring
RPM	Radiation In-Process Measurements
RF	Russian Federation
PWR	Pressurized Water Reactor
CA	Control Area
IPM	Individual Protection Means
IBPE	Individual Birthing Protection Equipment
CAP	Construction and Assembling Personnel
FFDS	Fuel Failure Detection System
RMS	Radiation Monitoring System
USA	United States of America
FA	Fuel Assembly
FE	Fuel Element
SC	Shipping Cask
PR	Process Regulation
SRW	Solid Radioactive Waste
TUE	Transuranium Elements
FS	Feasibility Study
ChNPP	Chernobyl Nuclear Power Plant
PCE	Particular Critical Event
SFSF	Spent Fuel Storage Facility
CP	Central Pipe
CSFSF	Centralized Spent Fuel Storage Facility

List of Terms

Abnormal events or off-normal conditions	-	In this document the term means design basis event II on ANS scale – the event that may occur with moderate frequency or about once per storage operation year, although it is not regular.
Gas-aerosol release (release)	-	Releases of radioactive substances into the atmosphere from process circuits and ventilation systems of the facility.
Radioactive contamination	-	Presence or spread of radioactive substances over their natural concentrations in the environment and/or in a human body.
Beyond design basis accident	-	In this document the term means design event IV on ANS - the event that is postulated due to that its consequences may lead to the maximum possible impact on the environment.
Control area	-	A territory where impact of radioactive releases and effluents from a nuclear facility is possible, and where the monitoring (NRBU-97) is carried out.
Assess control area	-	A territory where the extended radiation monitoring (NRBU-97) is provided for.
Exclusion are	-	A territory from which the population was evacuated in 1986 (Law of Ukraine).
Mandatory resettlement area	-	A territory that underwent the intensive contamination by long-lived radionuclides with the density of soil contamination with cesium isotopes of 15,0 Cu/km^2 or more, or with strontium isotopes of 3,0 Cu/km^2 or more, or with plutonium isotopes of 0,1 Cu/km^2 and the territories with the soils that contribute to high radionuclide migration to plants, with contamination density by cesium isotopes which makes from 5,0 up to 15,0 Cu/km^2 or more, or by strontium isotopes - from 0,15 up to 3,0 Cu/km^2, or by plutonium isotopes - from 0,01 up to 0,1 Cu/km^2, where the effective equivalent exposure dose of a person could exceed 5,0 mSv (0,5 rem) per year over a doze which one could get during the period before the Chernobyl accident (Law of Ukraine).
Environment	-	A set of natural, man-caused and social conditions of human society existence (DBN A.2.2-1-2003).
Natural environment	-	A set of natural factors and the environment entities of natural origin or evolution (DBN A.2.2-1-2003).
Man-made environment	-	An artificially created part of the environment consisting of technical and natural elements (DBN A.2.2-1-2003).
Design basis accident	-	In this document the term means design event III on ANS – a low-frequent event that can be expected at least once during storage facility operation life.
Contaminated lands	-	Territories that require measures on radiation protection and other special actions intended to limit additional exposure caused by Chernobyl accident, to provide regular economical activities.
Sanitary area	-	A territory around a nuclear facility where the people exposure level under normal operation conditions can exceed the dose limit for population (category “C”). Within this area the dwelling is forbidden, productive economical activities that does not relate to the radiation-nuclear facility is restricted and radiation monitoring is carried out (NRBU-97).

1 NRS REGULATORY DOCUMENTS

The CSFSF should be deigned, constructed and operated in accordance with the Ukrainian Laws and other legislative acts that regulate relations in nuclear energy use and radioactive waste management.

The main requirements provided for by the appropriate standards and rules on nuclear and radiation safety in force in Ukraine have to be applied to any activity at the CSFSF (design, construction, operation, etc.).

The requirements of the following documents were taken into account in development of the CSFSF FS:

- International agreements ratified in Ukraine;
- Laws of Ukraine;
- Decrees of the President and the Orders of the Verkhovna Rada and the Cabinet of Ministers of Ukraine;
- Regulatory documents on nuclear and radiation safety of Ukraine;
- Health and sanitary standards current within the ChNPP exclusion area.

The IAEA and ICRP recommendations are used in those their parts that do not contradict the requirements of the above mentioned documents and directed to decrease of radiation impact on personnel, the public, and the environment.

2 NUCLEAR SAFETY

2.1 General provisions

The basic criteria of nuclear safety for CSFSF systems are:

- effective multiplication constant K_{eff} under normal operation conditions and at design basis accidents shall remain of no more than 0,95;
- at presence of nuclear fuel with various enrichment levels it is necessary to take into consideration the fuel with the maximum enrichment [2];
- presence of absorbing elements in fuel assemblies or designs of a basket for spent fuel assemblies should be neglected if they are not fixed or if their efficiency is reduced as a result of initial events [2];
- equipment for spent fuel storage shall be designed so that the effective neutron multiplication constant will not exceed 0,95 even at filling of the storage facility with water, and also at such water amount, distribution and density as the initial event result that leads to maximum K_{eff} [2];
- spent fuel must be regarded as fresh if the effective neutron multiplication constant at burnup decreases, except for the cases when burn-up depth is used as a nuclear safety parameter and its monitoring is carried out by special means [2].

Under this FS the CSFSF includes the following:

- areas for loading SFA in MPC and preparing HI-STAR overpacks for transportation at every power unit of WWER NPP;
- transportation of the HI-STAR packages with SFA from NPP to CSFSF;
- a receiving building at the CSFSF site;
- a site to store the HI-STORM overpacks with SFA;
- an on-site transport system.

Areas to load SFA in the MPC and to prepare the HI-STAR overpacks for transportation are located in reactor departments of Khmelnitsky, Rivne and South-Ukrainian NPPs power units. In the reactor hall the SFA (after being kept in the cooling pond not less than 5 years) are loaded into MPCs, dehydrated and dried, MPCs are pressurized and filled up with helium. MPC two confining barriers provide for non-release of SFA radioactive substances into the environment. The HI-TRAC transfer cask and HI-STAR transport overpack are used to ensure biological shielding of the personnel during reloading.

MPC with SFA are transported from NPP to CSFSF in the HI-STAR transport overpacks designed in accordance with the USA safety requirements. These casks will be certified in Ukraine as type B (U) packages in accordance with the PBTRM[1]-2006 [21] requirements.

A receiving building is designed for reloading MPC with SFA from the HI-STAR transport overpack into a HI-STORM long-term storage overpack. MPC with SFA are reloaded in the receiving box by means of the HI-TRAC transfer cask.

A storage site for SFA casks is a passive storage system for HI-STORM overpacks, at that, the HI-STORM provides biological shielding or a barrier against radiation safety. Nuclear safety of the storage site ensured by design solutions of MPC placed into HI-STORM and by the monitoring system of HI-STORM with MPC state available on the site.

In accordance with the requirements of the regulatory documents [1,2] the CSFSF nuclear safety is provided by:

[1] transliterated

- limitation of SA arrangement interval in the MPC;
- limitation of mass of nuclear fission materials in one MPC;
- use of heterogeneous absorbers by Metamic arrangement and fixation in MPC;
- monitoring of process parameters of a set of nuclear fuel storage and management systems.

The CSFSF design decisions ensuring solution of these tasks are described below. These safety-ensuring measures are considered independently for each of the main components of the CSFSF.

It is proposed to apply at CSFSF the storage technology licensed and certified in the US. The HI-STAR overpack, certificated in the US for transportation of PWR type spent fuel in MPC-32 (32 SF assemblies) is used for SF transportation from NPPs to CSFSF. The HI-STORM overpack certificated in the USA for storage of spent fuel from PWR NPP units in MPC-32 (32 spent fuel assemblies) is used for long-term SF storage in the CSFSF..

In accordance with the Minutes of the inter-departmental meeting (Appendix A) in description of technical decisions and nuclear safety assessments, the data for MPC-32 designed for SNF of pressurized reactors in the USA are presented at this design stage. At the subsequent design stages all substantiations required for licensing and certification of the technology and equipment in Ukraine must be performed in accordance with the current Ukrainian standards and safety rules for Ukrainian NPP SNF. To demonstrate similar characteristics of the USA SFA for which the Holtec International system was licensed in the USA and WWER-1000 SFA, their main characteristics are summarized in Table 2.1.1

Table 2.1.1 – The main characteristics of PWR and WWER-1000 SFA

Name	Unit	The MPC-32 with PWR SFA	MPC-31 with WWER-1000 SFA
Length of the fuel element active part	cm	365,76	355
Weight of uranium	kg	15855	13485
Fuel burn-up level	MW day/tU	55,000	45,000-50,000
NF initial enrichment degree	% ^{235}U	4,05 – 4,8	4,2 – 4,4

2.2 Main technical decisions for ensuring nuclear safety

2.2.1 MPC loading on NPP power unit

SFA are loaded into MPC at a power unit similarly to the existing SNF reloading system. Technical decisions for ensuring nuclear safety in SFA storage in CP and SFA reloading into a canister are described in the SAR for each power unit and, because the existing are used, they are not considered within this FS. At the subsequent design stages, with development of the Safety Analysis Report for the CSFSF, the existing decisions for ensuring nuclear safety will be described.

To ensure nuclear safety in SNF reloading, the constructive technical decisions are proposed that consider a specificity of the SNF storage technology in the CSFSF. The main element of the Holtec International storage technology is the multi-purpose canister (MPC) which design ensures nuclear safety in SNF storage.

The MPC consists of an enclosure vessel and a fuel basket. General view of the MPC is given in Figure 2.2.1. The vessel is a two-layer cylindrical canister of corrosion-resistant steel with a baseplate, a lid and a closure ring designed in accordance with ASME requirements, Section III, Subsection NB (class 1). The MPC cylindrical canister is made of two rolled sheets, at the same

time longitudinal welds of shells do not coincide (Figure 2.2.2). The inner layer of a cylindrical vessel and a lid form the first confinement barrier. The outer layer of a cylindrical vessel and a closure ring form the secondary confinement barrier. FE cladding was not considered to be confinement barrier in the MPC design. The MPC is a welded pressurized vessel that meets the requirements for transfer limits of ASME standards on caldrons and vessels under pressure, Section III, Subsection NB (class 1). Geometrical characteristics of confinement barriers are presented in Figure 2.2.3.

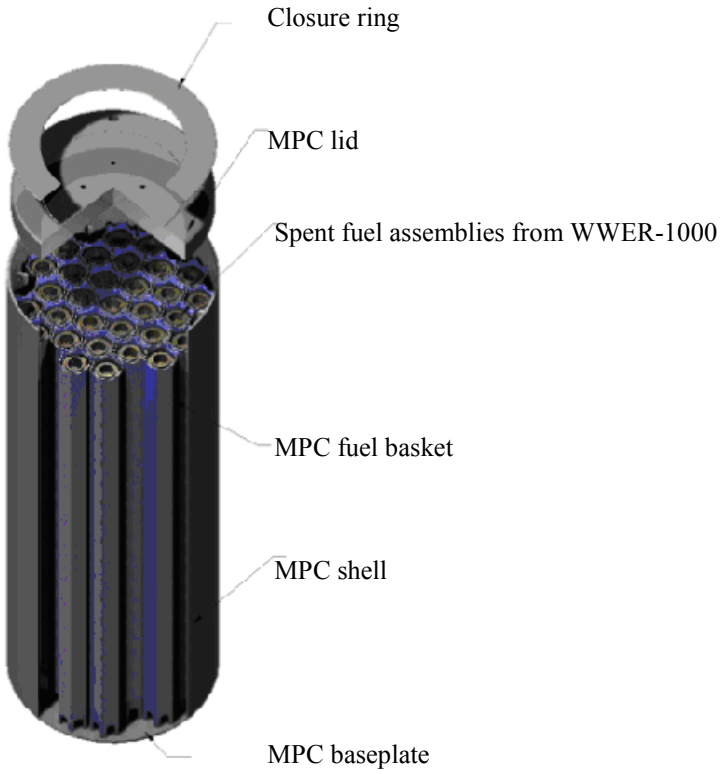


Figure 2.2.1 – MPC general view

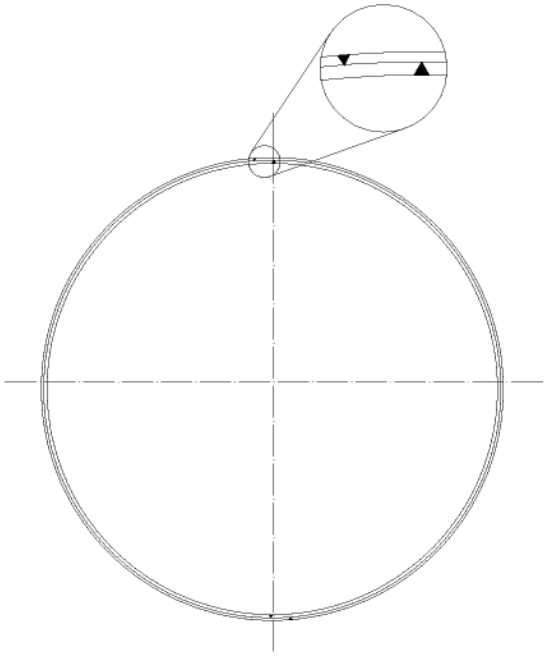


Figure 2.2.2. – **Arrangement of the MPC longitudinal welds**

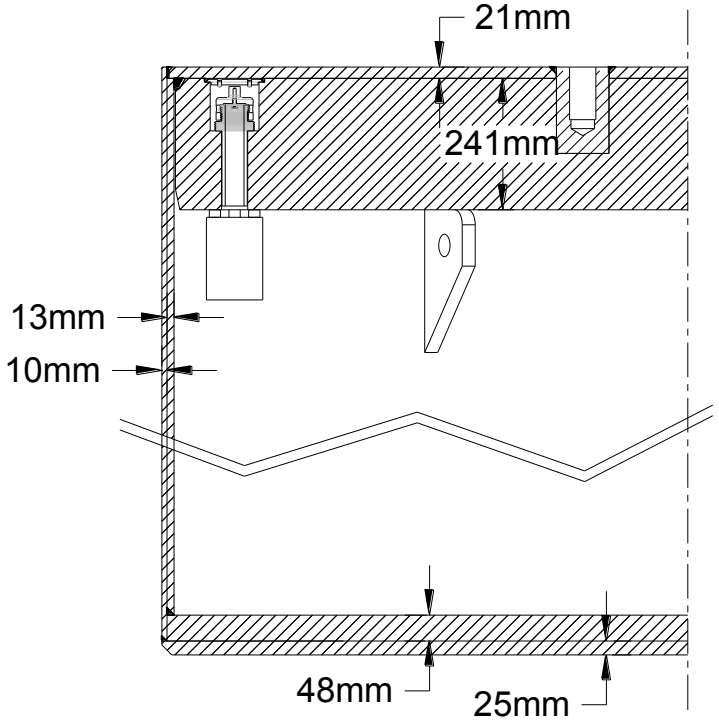


Figure 2.2.3 - Geometrical dimensions of the MPC confinement barriers

The fuel basket in the MPC has a honeycomb structure generating hexagon cells for fuel storage. Walls of all cells in the fuel basket are structurally connected with walls of the adjacent cells. MPC fuel baskets are designed and tested on compliance with requirements on reloading limit in accordance with Section III, Subsection NG of ASME standards.

A heterogeneous absorber is a specific design feature of MPC fuel baskets. Hexagon adjacent cells of the fuel basket are connected in a way that the following is located between two

SFA in the fuel basket: two sheets of heterogeneous absorber Metamic and two corrosion-resistant steel sheets.

The MPC fuel basket is designed in a way to use completely heat conductivity of the Metamic material (six times higher than in steel) and the convective heat removal performed by compressed inert gas by so-called thermosyphon effect (thermosyphon effect is not taken into account in safety substantiation) principle.

In addition to the MPC design features, in order to ensure nuclear safety in storage, the MPC after loading is dried and filled with inert gas (helium) under pressure of 4,2 kgf/cm^2. Under normal operation conditions, in thermal load in the MPC of 38 kW, the maximum pressure of 7 kgf/cm^2 is created in the MPC. After sealing of the lid and the closure ring during the MPC preparation for storage, the welded joints are tested for confinement by the helium detector. In accordance with the USA standards, the regulatory helium leakage 5×10^{-6} cm^3/s ensures that the possibility of the MPC confinement loss during storage will not exceed $3{,}71\times10^{-12}$ of leakages per welded joint.

In the MPC manufacture, all welded joints pass 100 % radiography. Each barrier is tested for leakages by means of the helium detector. The baseplate and longitudinal joints are welded in the MPC manufacture, welded joints of the MPC top lids are tested after SFA are installed in the MPC. Confinement barriers in the baseplate welding spots are submitted at Figure 2.2.4. Confinement barriers in the MPC lid welding spots are submitted at Figure 2.2.5.

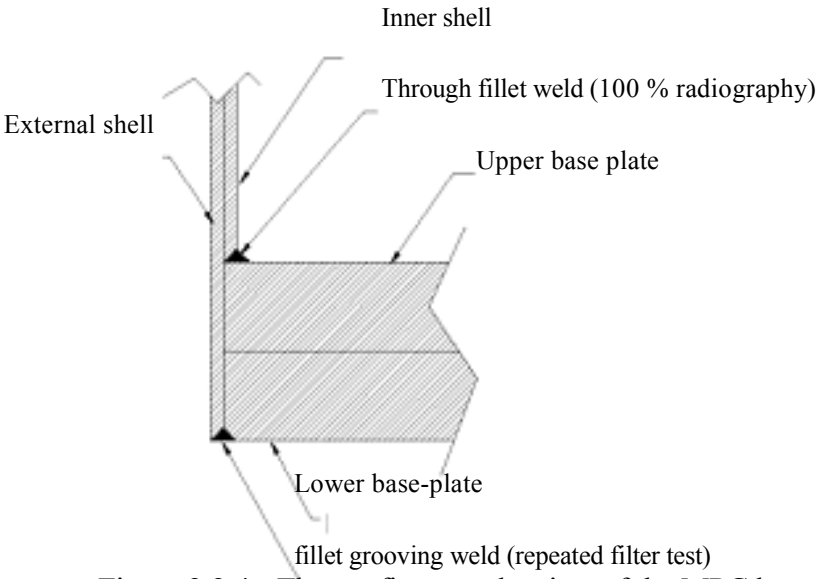


Figure 2.2.4 - The confinement barriers of the MPC baseplates

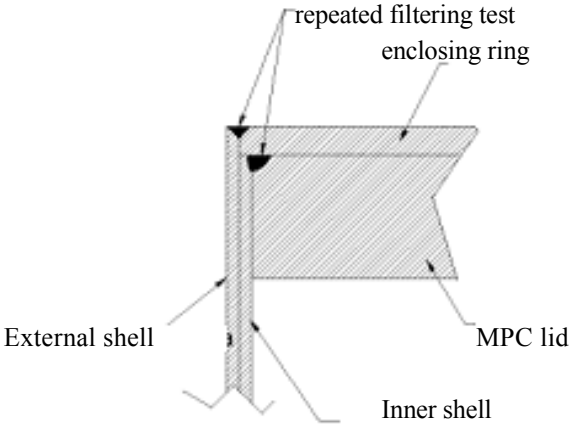


Figure 2.2.5 - The leak resistance barriers of the upper MPC lid

The MPC is intended both for sealed SFA and for damaged SFA.

Damaged SFA are identified prior to transfer and may be divided into two types: debris (that require special handling) and assemblies that mainly preserved their integrity (that can be handled using standard means).

SFA that preserved integrity can be handled according to the standard scheme but will be housed in one of the MPC cells equipped with a tube for damaged fuel.

The tube for damaged fuel is designed to house any components of fuel assemblies. It has thin stainless steel walls and a removable upper lid. Small sieves are installed at the tube ends that may retain any FA fragments without preventing water pump-down and helium circulation. The removable lid allows closing and raising the tube for damaged fuel. These tubes will be installed inside the MPC before the MPC installation in the cooling pond. After the tube filling, the tube lid for damaged fuel is installed at the tube after its filling by means of remote manipulators. It is possible to install up to 12 tubes for damaged fuel along the outer perimeter in MPC-31. Cells of the MPC fuel basket for tubes with damaged fuel have bigger sizes than cells for tight SFA, as a result, a total number of SFA installed in MPC-31 considering damaged SFA will reduce up to 24 pcs. Similarly, for MPC-85, a total number of SFA will reduce up to 78 pcs.

Figure 2.2.6 demonstrates the tube for damaged fuel housed in one of the peripheral MPC-31 cells designed especially for damage fuel. Technical characteristics of containers for damaged fuel are given in. The technical data for the canisters intended for damaged fuel assemblies are presented in Table 2.2.1.

Table 2.2.1 - MPC technical data for damaged fuel

Characteristic	Value
MPC-31 (WWER-1000)	
Internal size between hexahedron sides	241 mm
External size between hexahedron sides	244 mm
Cell height	4695 mm
Cells for tubes with damaged fuel (MPC-31)	
Number per MPC	Up to 12
Internal size between hexahedron sides	248 mm
Cell height	4699 mm
MPC-85 (WWER-440)	
Internal size between hexahedron sides	150 mm
External size between hexahedron sides	154 mm
Cell height	3356 mm
Cells for tubes with damaged fuel (MPC -85)	
Number per MPC	Up to 24
Internal size between hexahedron sides	158.75 mm
Cell height	3385 mm

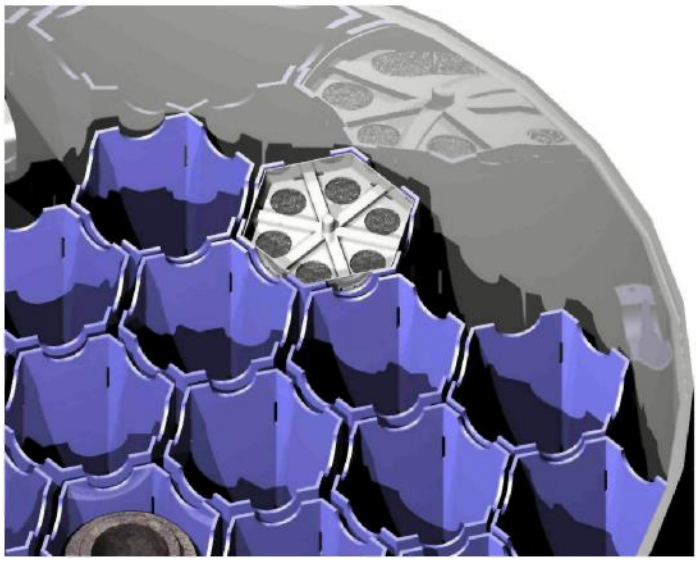


Figure 2.2.6 - The tube for damaged fuel assembly

2.2.2 Transportation from NPP to CSFSF

MPCs are transported from NPP to the CSFSF in the HI-STAR transport overpack. Nuclear safety in shipment is ensured by the technical decisions for the MPC. The HI-STAR overpack provides for the required conditions for the MPC protection in normal and emergency shipment conditions in accordance with safety requirements in the USA and it will be certified in accordance with the requirements of PBTRM-2006[2] at the subsequent stages.

During MPC transfer from NPPs to the CSFSF in a rail car, the HI-STAR with MPC is installed in the horizontal position, at that, special damping devices are installed on a lid and a bottom plate of the HI-STAR to protect in accidents.

Holtec International analyzed the heat removal efficiency in order to assess efficiency of the heat removal form SNF in the HI-STAR transport overpack to confirm a possibility for its transportation in the horizontal position and to ensure the FE wall temperature in accordance with the regulatory requirements. The HI-STAR system heat removal was assessed in the radial direction for a medium section. The temperature of the fuel element wall is obtained as a result of calculations. The classical heat transfer calculation approach has been taken into account that considers the following heat removal mechanisms:

- heat removal from the overpack outer surface due to natural turbulent convection;
- heat transfer due to heat conduction of solid and gaseous materials that the MPC, transport overpack consist of or that include the MPC or the overpack;
- heat transfer due to thermal radiation between steams of surface-surface and surface-the environment.

The following boundary conditions have been accepted in calculations:

- the HI-STAR section with heat generation section are reviewed in the input model;
- thermosiphon effect is not reviewed in the input model;
- the minimum values of heat conductivity coefficients for structural materials are used in calculations;
- axial heat removal (trough the MPC and HI-STAR upper and lower surface) is not taken into account in calculations;
- uniform heating of the HI-STAR overpack surface due to solar insolation is proposed in calculations;

- the input model supposes a circular gap to the diameter between cylindrical shells of the HI-STAR and the MPC (HI-STAR and MPC walls consist really of layers closely fitting each other);
- the calculation supposes maximum heat generation from SNF In the MPC - 30 kW, and the heat generation axial irregularity will constitute 1,1.

As a result of the analysis performed, the calculated temperature of the fuel element wall is 340°C, that is lower then the regulated temperature of the fuel element wall under normal operation conditions (350°C). This calculated value is obtained for SFA fuel elements located through the MPC center and have the worst temperature conditions relatively to periphery SFA. Thus, it is supposed that temperatures of SFA FE walls by periphery will be lower than 340 ^{o}C.

In HI-STAR transport overpack certification in Ukraine, in accordance with the requirements of PBTRM-2006[2], calculations will be made for WWER-440 SFA and WWER-1000 SFA.

2.2.3 Receiving building

Technical decisions related to nuclear safety ensuring in the receiving building are intended to reduce a probable mechanical damage of the MPC and exclude water ingress into SFA in the event of MPC emergency depressurization. This is related to the fact that nuclear safety shall be ensured firstly in the MPC.

In order to reduce MPC probable mechanical damages, it is proposed to use in the receiving building the equipment fitted for seismic conditions and with higher reliability indexes. In addition, the design decisions provide for MPC handling within the reloading box only, what excludes drop of MPC with damaged barriers, and besides, the receiving building is constructed in accordance with safety category I according to the Design Standards of Nuclear Plants with Different Type Reactors PiN AE-5.6 [26].

In order to exclude possible contact of water with SFA in the case of a hypothetical event involving failure of confinement barriers, there is no water supply in the handling tube and the reception box. Moreover, the design decisions exclude water ingress in the reloading box from the adjacent premises.

Water is not used in designing of fire protection in these premises.

During the whole process chain, at least two engineering barriers are provided for in the receiving building thus preventing water ingress to SFA: MPC enclosure shell, an enclosure vessel of the canister or of the HI-STAR, or HI-TRAC, or HI-STORM.

Remote observation is carried out for all the process operations, as well as neutron radiation in the transportation tube, where operations are performed on MPC reception and reloading.

2.2.4 Storage area

The MPC is a basic element ensuring nuclear safety during SNF storage at the storage area. The main technical decisions on nuclear safety ensuring at the storage area are intended for:

- ensuring the MPC protection against the environment external factors;
- ensuring the MPC protection against the environment external man-made factors, including diversion;
- isolation against the MPC neutron interaction with each other;
- ensuring sufficient heat removal from the MPC.

The following technical decisions are proposed to ensure nuclear safety during SNF storage:

- the HI-STORM protective overpack, which structure is designed for extreme impacts right up to aircraft crash, is used for the MPC storage. At the same time, the canister design and, correspondingly, the MPC remain undamaged;

- the HI-STORM overpacks are located at storage area with a step not less than 700 mm that excludes mutual neutron impact of two adjacent MPC;
- to exclude the storage area flooding, it is provided for a rainwater sewage system designed for water flow removal from the maximum daily precipitations within the CSFSF site;
- stationary continuous monitoring of temperature at the inlet and outlet of the HI-STORM vent ports reflecting the state of the MPC heat removal and, correspondingly, SNF;
- the CSFSF construction site (volume 1, Section 5) has been selected with low level and amplitude of subsoil water level oscillations that excludes accident initiators involving the site underflooding and, correspondingly, water ingress into the MPC through the HI-STORM vent ports;
- the site has been selected for CSFSF construction (volume 1, Section 5), located far from ponds and rivers, that excludes accident initiator involving the site underflooding and, correspondingly, water ingress into the MPC through the HI-STORM vent ports;
- in accordance with the design decisions, the storage site within the CSFSF protected perimeter is included into a specially important area, where personnel access without a permit is prohibited;
- CSFSF personnel makes rounds at regular intervals at the storage site to detect possible plugging of the HI-STORM vent ports and clean them timely;
- incombustible materials are used in storage site designing to exclude such an initial event as fire.

Stationary temperature monitoring at the inlet and outlet of vent ports allows monitoring possible helium leakage from the MPC. For MPC-32, in system licensing in the USA, performance evaluation of such monitoring has been done. The MPC was filled with helium under pressure of 4,2 kgf/cm^2, in the MPC thermal loading of 38 kW, inside gas pressure reached 7 kgf/cm^2 approximately. At the same time, the maximum temperature of fuel element cladding reached 358 °C. At helium leakage from the MPC, pressure drop for each 0,069 kgf/cm^2 caused raise of fuel maximum temperature approximately on two degrees. The nominal gas volume in the MPC was 10.5 m^3, i.e. helium leakage in the volume of 0.1 m^3 will correspond to an increase of the maximal temperature of the fuel element cladding in 2 C^0. Therefore, considering availability of the stationary temperature monitoring system, there is sufficient time to take measures on removal of emergency MPC up to the moment when the temperature of FE cladding reaches the maximum accident threshold (570°C). At the design stage there will be presented all necessary justifications that the accepted decisions will provide a fuel element cladding temperature no higher then 350 ^{o}C under normal operation conditions.

The air temperature at the inlet and outlet of the HI-STORM vent ports is monitored from the CCR in the receiving building with continuous attendance of the presence.

2.2.5 On-site transportation

On-site transfer of SNF is conducted by special crawler; the HI-STORM containing the MPC with SFA is transferred. The main element ensuring nuclear safety in SNF transfer by the crawler is the HI-STORM. The main technical decisions on nuclear safety ensuring in on-site transfer are intended to ensure the HI-STORM protection from mechanical damages in transfer.

The following technical decisions are proposed to ensure nuclear safety in on-site SNF transfer:

- the crawler transfers only one HI-STORM canister with MPC in one run, that is, the quantity of the transferred nuclear material is limited by a structure of the applied equipment;
- use of water is not provided for in the crawler structure and at its pathway, that excludes hypothetical possibility of water contact with SFA;

- the crawler design ensures canister lifting on a height not more then 28 cm, this excludes the HI-STORM damage in drop during transportation (HI-STORM is designed for drop from the height of 28 cm with no damages of canister and its content);
- the site general layout is designed to reduce the pathway of crawler with the HI-STORM from the receiving building to the storage site and to exclude pathway crossover by loaded crawler and other cargos at the CSFSF site, that reduces probable emergency situations in transportation;
- the crawler structure excludes high-speed movement, that excludes possible personnel errors in the crawler movement regulation and, correspondingly, the probability of cask drop during transportation is decreased.

2.2.6 Assessment of effective multiplication factor

Neutron effective multiplication factor (Keff) for WWER-1000 and WWER-440 SFA will be calculated during the SAR development at the design stage.

Keff preliminary assessments for WWER-1000 and WWER-440 SFA was made by the Holtec International in development of technical proposals for the CSFSF construction tender to confirm HI-STORM system appropriateness for WWER-440 and WWER-1000 fuel.

In calculating criticality for confirmation of HI-STORM system appropriateness for WWER-440 and WWER-1000 fuel, the computer code MCNP (4a) was used, because it is able to model a SFA triangular lattice. Holtec International verified this code in a large number of experiments, including SFA triangular lattices appropriate for WWER SFA.

The restrictions similar to the requirements of the Ukrainian regulatory documents were applied in MPC-32 calculations in licensing in the USA and in preliminary assessments for MPC-31 and MPC-85 for WWER SFA:

- neutron effective multiplication factor Keff shall not exceed 0,95 under normal operation conditions and at design basis accidents;
- fuel with maximum enrichment of 4,8%^{235} U (for WWER - 4,4%^{235} U) was used in calculations;
- SNF is regarded as fresh fuel, i.e. without taking into account its burn-up level;
- neutron effective multiplication factor shall not exceed 0,95 even in storage facility filling with water of optimal density.

According to requirements [2], availability absorbers in FA or structures should be neglected, if they are not fastened, or if their effectiveness becomes lower as a result of initial events. However, it is proposed to use in the HI-STORM system the heterogeneous absorber Metamic that is permanently fixed in the MPC fuel basket and whose characteristics are not degraded during storage. To confirm that Metamic does not lose its properties under various conditions, the Scientific Institute of the USA Department of Energy performed full-scale testing of the material and a special report was issues. After tests, the Metamic material started to be used at wet and dry type storage facilities instead of Boral material.

The calculations made in MPC-32 licensing in the USA confirmed that Keff would not exceed 0,95 under normal operation conditions, off-normal conditions and design basis accidents. It will be proved at the design stage that this statement is true for MPC-31 and MPC-85.

In researching properties of the neutron heterogeneous absorber Metamic in the USA impact of the following factors were assessed:

- gamma emission;
- neutron radiation;
- water of cooling ponds;
- temperature.

Gamma emission impact

No damages were observed in Metamic samples at gamma exposure with total dose of 3,8 $\cdot 10^{11}$ rad.

Neutron radiation impact

The potential effect of neutron radiation impact on metals (Metamic is a composite metal) is the decrease of their plasticity under high levels of neutron fluence. Usually, the reduction of plasticity starts at levels of 10^{20} - 10^{22} neutron/cm^2 as a result of fast neutron exposure. In Metamic sample testing, simultaneously with gamma exposure, the samples were exposed to neutron fluence of $1,5 \cdot 10^{20}$ neutron/cm^2. The maximum plasticity (tensile strain) loss was less than 7 %.

The Holtec International performed independent calculations for the accumulated fluence of fast neutrons in the container for the PWR SNF with computer code MCNP (2). At the same time, the calculation examined the fuel stored for five year, and radioactive decay was not taken into account in the conservative approach. These calculations show that the expected neutron fluence is less than 10^{16} neutron/cm^2 for 100 years of continuous irradiation, that is much lower than the neutron fluence ($1,5 \cdot 10^{20}$ neutron/cm^2) that can lead to loss of Metamic plasticity for 7 %.

Based on the tests and calculations results the conclusion was made that fast neutron irradiation in the typical MPC would not affect strength or functionality of the Metamic absorber during service life of 100 years.

Impact of cooling pond water

Water of PWR cooling ponds is a solution of boric acid of various concentrations. Thus, pH value of the basin medium is lower then 7. Metamic is a composite material consisting of aluminum and boron.

In testing Metamic samples, their behavior in water with boric acid concentration of 5-20 % was investigated. The test results show that material properties do not change. This can be explained by the fact that a thin layer of aluminum oxide is formed at contact with air on Metamic surface. Aluminum oxide is absolutely inert in the acid medium.

Temperature impact

In assessment of temperature impact on Metamic properties it was taken into account that Metamic constructive strength, as well as that of other metals, is a function of temperature. Besides strength impact, the impact on neutron absorbing properties of the material was estimated.

The test results proved, that Metamic neutron absorbing properties and strength properties remain satisfactory at the maximum temperature of fuel element cladding of 450°C and higher (up to 550°C).

3 RADIATION SAFETY

3.1 The main principles and criteria for ensuing radiation safety

According to [4] the radiation safety (RS) and radiation protection in relation to human activities are based on the following main principles:

- any activity accompanied with human exposure must not be carried out, if it does not bring the greater benefits to irradiated persons or the society as a whole in comparison with the harm which it causes (**justification principle**);
- exposure levels from any activity under regulation must not exceed the established limits (**not-exceeding principle**). Taking into account absence of radiation from radionuclides incoming with food, this principle is expressed by the following inequality [4]:

$$\frac{E_{ext}}{DL_E} + \sum_i \frac{I_i^{inhal}}{PI_i^{inhal}} \le 1 \qquad (3.1)$$

Where E_{ext} is effective dose of external exposure;

DL_E is the effective dose limit for the category under consideration;

I_i^{inhal} – is the annual inhalation of *i* radionuclide;

PI_i^{inhal} – is the permissible inhalation level for *i*- radionuclide and the category under consideration.

Individual dose levels and/or a number of irradiated persons for each radiation source must be as low as achievable, taking into account economic and social factors (the optimization principle).

At CSFSF construction and operation all necessary measures for minimization of additional radioactive contamination of the environment will be undertaken.

The radiation-hygienic regulations determined in the regulatory documents are used as the basic criteria for ensuring radiation safety standards.

Standards [4] determine the following categories of irradiated persons:

- Category A (personnel) - persons who are permanently or temporarily working directly with radioactive sources;
- Category B (personnel) - persons who do not work with radioactive sources directly, but can obtain additional exposure due to location of their working places in rooms or in industrial sites of facilities with radiation-nuclear technology;
- Category C – all members of the public.

Category A for CSFSF includes the builders, the personnel who works directly on the CSFSF site, and participates in loading of spent fuel assemblies, MPC preparation to storage and spent fuel transportation from nuclear power plants to CSFSF.

Category B for CSFSF includes the personnel of other facilities in within the exclusion are who can be beyond the CSFSF security perimeter, and also the personnel of the concrete plant located at the territory of the construction yard.

Category C of CSFSF includes the population living outside the ChNPP exclusion area and mandatory resettlement area.

Document [4] presents the values of effective and equivalent dose limits for the personnel of Categories A and B. Radiation dose distribution during a calendar year is not regulated.

Document [4] determines permissible levels of radionuclides obtained through inhalation and permissible radionuclide concentration of radionuclides in the working area air for the personnel

of Category A.

The permissible levels of beta exposure of skin, radioactive contamination of working area, skin (during a shift), working clothes, and individual protection means are determined in [4].

The design reference levels will be calculated at the design stage based on actual parameters of local radiation conditions.

In development of measures for ensuring radiation safety at the design stage it will be taken into account that according to the requirements of [20] the protection of personnel against external exposure, including protection of the premises attended by the personnel periodically or at repairing, shall be designed with safety factor 2 in accordance with the annual effective and equivalent doses of the current and potential exposure.

In CSFSF design the Sections related to radiation safety will define design estimations of critical event probability and the potential exposure doses caused by them substantiating and describing procedures of their provision, and also substantiation of measures decreasing these probabilities and doses to the regulated values.

According to [5], permissible risks of exposure are 2×10^{-4} year^{-1} for the personnel and 5×10^{-5} year^{-1} for the public. The "negligible risk" value is 5×10^{-7} year^{-1}.

The reference probabilities of critical events related to the sources of group I potential exposure are presented in [5].

The design will consider all possible initial events: failure of the construction, a system or a component; external events that lead to such failures; personnel errors. Possible scenarios of accident evolution will be developed and scenarios leading to the most severe consequences will be specified for each initial event selected according to the preliminary analysis results. Possible accident consequences for the personnel and the environment will be calculated for each scenario of accident evolution. Estimations of the expected radioactive substances and/or ionizing radiation releases beyond the CSFSF boundaries will be calculated, including emissions and releases into the environment.

Based on the analysis results a set of organizational and technical provisions for potential accident prevention and/or mitigation of their consequences will be determined.

The CSFSF will be constructed within the ChNPP exclusion area contaminated with radionuclides resulted from the accident on April 26, 1986. The reference levels at this territory are regulated by document GN 6.6.1.076-01 [22] that shall be taken into account at planning measures related to the CSFSF construction and operation.

At the stage of FS, the Holtec International data, the owner of the SNF storage technology in the CSFSF, are used in describing SFA management technology, radiation characteristics of containers to be used, initial events of design basis and beyond design basis accidents, the personnel exposure doses. The data given by the Holtec International are presented in the final SAR for the HI-STORM system, prepared by the Holtec International at the system licensing in the USA. The HI-STORM system is licensed in the USA for the fuel that is similar to WWER fuel by its properties. Sub-section 3.4.1.1 specifies the compliance analysis of the USA spent fuel and the WWER spent fuel.

3.2 General approach to ensuring radiation safety

The activities on ensuring radiation safety at all stages of CSFSF operation comes to ensuring radiation safety under normal operation and in accidents.

Observance of the radiation safety principles is achieved by selecting optimal technical decisions and by a set of radiation protection measures at all stages of the CSFSF life cycle (construction, commissioning, operation and decommissioning). All the measures can be conditionally divided into the following groups:

- organizational;
- radiation – hygienic;
- technical.

For each stage of the CSFSF life cycle the list of specific measures is developed and regulated by:

- the design documentation, including the construction management design, instructions and rules of the exclusion area – at the CSFSF construction stage;
- the commissioning program, by the programs of start-up activities, instructions and rules of the exclusion area – at the CSFSF commissioning stage;
- the CSFSF operation-engineering documentation and technological regulations, the instructions for radioactive waste management of the exclusion area – at the operation stage;
- the CSFSF decommissioning plan, instructions and rules of the exclusion area – at the CSFSF decommissioning stage.

It should be noted that application of some protective measures (for example, shielding, decontamination, dust suppression etc.) is not always justified. Application of these measures should be determined for each specific case and should be based on the optimization principle [4].

The schematic diagram of the radiation protection arrangement is presented at Figure 3.2.1.

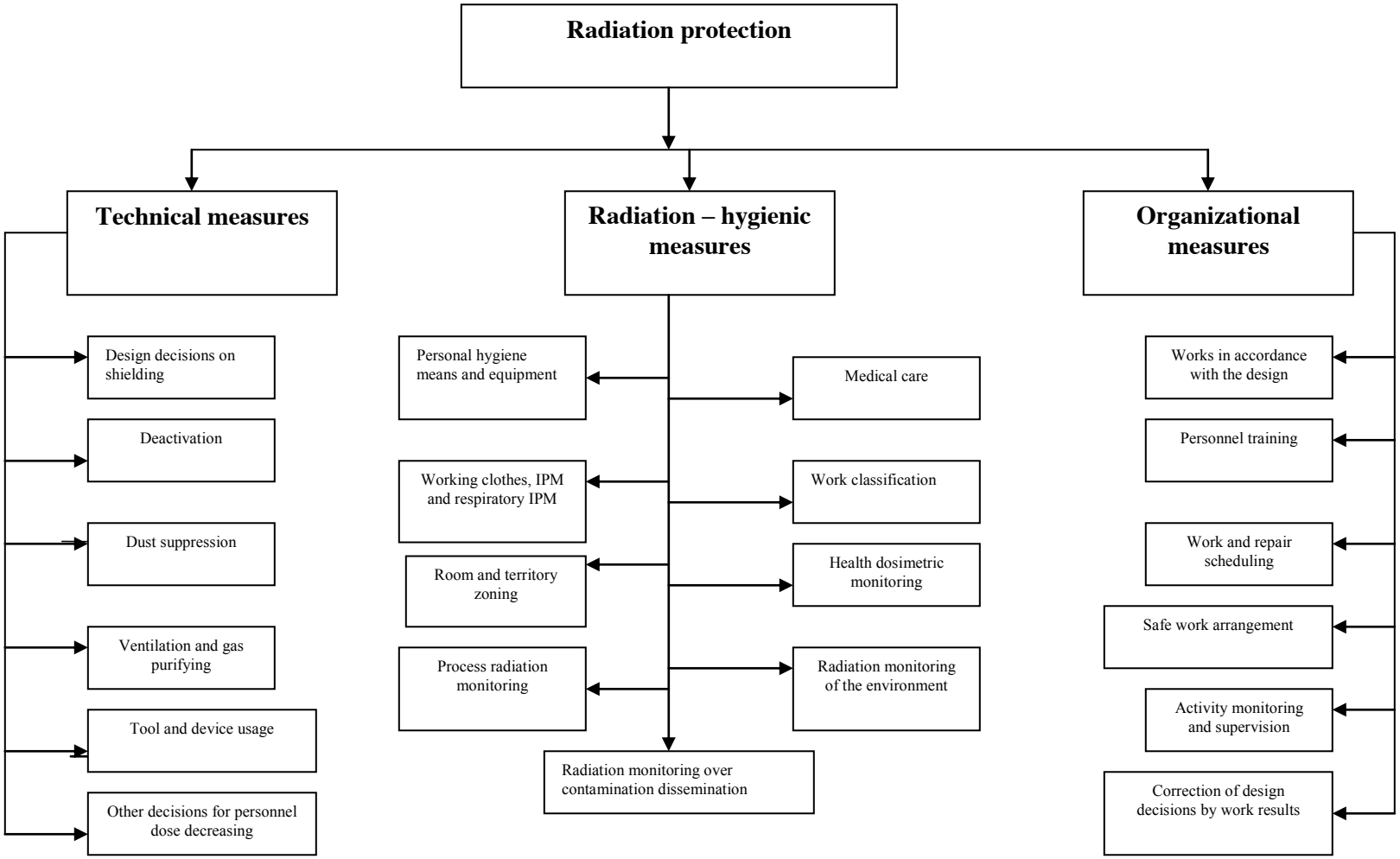


Figure 3.2.1 – The schematic diagram of CSFSF radiation protection

Potential exposure of the personnel (the public) is happened directly after a certain critical event (CE) unforeseen by the standards technological process, a particular critical event (PCE) which probability does not exceed 1×10^{-2} per year.

According to [5], the following events are considered as the initial events:

- failure of structures under operation, their systems or components, or failures of technical means applied at work;
- external events that lead to failures of the above structures, systems, components or equipment;
- errors of personnel who performs the work.

Therefore, the following initial events (failures) are considered:

- natural external events:

- earthquake (Safe Shutdown Earthquake (SSE));
- abnormal weather conditions (snow, wind, tornado, showers, etc.);
- lightning;
- flooding;
- flooding by subsoil waters;
- ground depression.

- man-made external events:

- fire;
- explosion;
- water flooding;
- loss of power supply;
- aircraft crash.

- internal events:

- failures of structural components of the system (units, assemblies or the system as a whole), breakage (destruction) of stationary structures;
- failures related to unplanned processes in materials;
- failures related to violations in the radiation protection system, including damages of passive and active elements of the barrier structures;
- failures, damages of passive and active elements of the information-warning systems;
- water flooding;
- fire;
- explosion.

- errors of the personnel.

The comprehensiveness of the list of initial events for design basis and beyond design basis accidents has been substantiated in drawing up the HI-STORM Final Safety Analysis Report, prepared for obtaining a license for the HI-STORM system in accordance with the requirements of the US Nuclear Regulatory Commission 10CFR72 and within the requirements of NUREG-1536. The safety analysis in accordance with the requirements NP 306.2.105-2004 [23] for CSFSF will be performed at the CSFSF design stage.

Taking into account that in describing emergencies and accidents in CSFSF operation the Holtec International data are used, the list of the applied terms determined the definitions of abnormal events, design basis accidents and beyond design basis accidents used in the SAR for the HI-STORM system in its licensing in the USA. Definitions of terms are presented in accordance with the American national standard (ANS) “Design Criteria for Separate Spent Fuel Storage Facility (Dry Type)” ANSI/ANS-57.9-1992.

3.3 Radiation safety in construction

3.3.1 Radiation situation and sources of radiation impact

In CSFSF construction the radiation impact on the personnel is connected, first of all, with preliminary preparation of a construction site which territory relates to the category of radioactively contaminated lands. The following activities are supposed in preparing a construction site:

- arrangement of fire-prevention strips along the perimeter of the construction site with forest;
- removal of forest vegetation including trees cutting and removal of underbrush, logging of the cut down wood and stubbing of stumps;
- removal of the top (vegetative) layer on the depth of 0,5 m and layout of the site territory surface;
- territory layout for construction of an access road to the construction site;
- construction of an access railway from the station "Shpelichi" to the construction site.

During these activities a short-term raise of radionuclide volumetric concentration in surface air is possible because of dust raising, which will lead to exposure of builders and additional surface contamination of the adjacent territories, including roads and facilities located near the CSFSF, first of all the Central Disposal Facility "Vector". Taking into account that the whole adjacent territory is radioactively contaminated at the same extent that the sectors of land activities, essential additional contamination of this territory would not take place. Because of the fact that the main scope of construction work will be carried out at the already decontaminated construction site, the further radiation impact during construction is not expected. Decontamination of the construction site before the basic scope of construction work means the whole set of activities for the site preparation including soil removal to create leveling mark plane for CSFSF site.

It is necessary to note, that the planed railway line from the railway station Shepelichi (to the east of the Buryakovka village) of 6,4 km length traverses the "western" trace of falls resulted from the accident at the ChNPP. Therefore, the maximum surface radionuclide concentrations in air were assessed based on contamination of these territories. The characteristic of surface contamination for this section with 137 Cs and 90 Sr is presented at Figures 3.3.1 and 3.3.2 correspondingly.

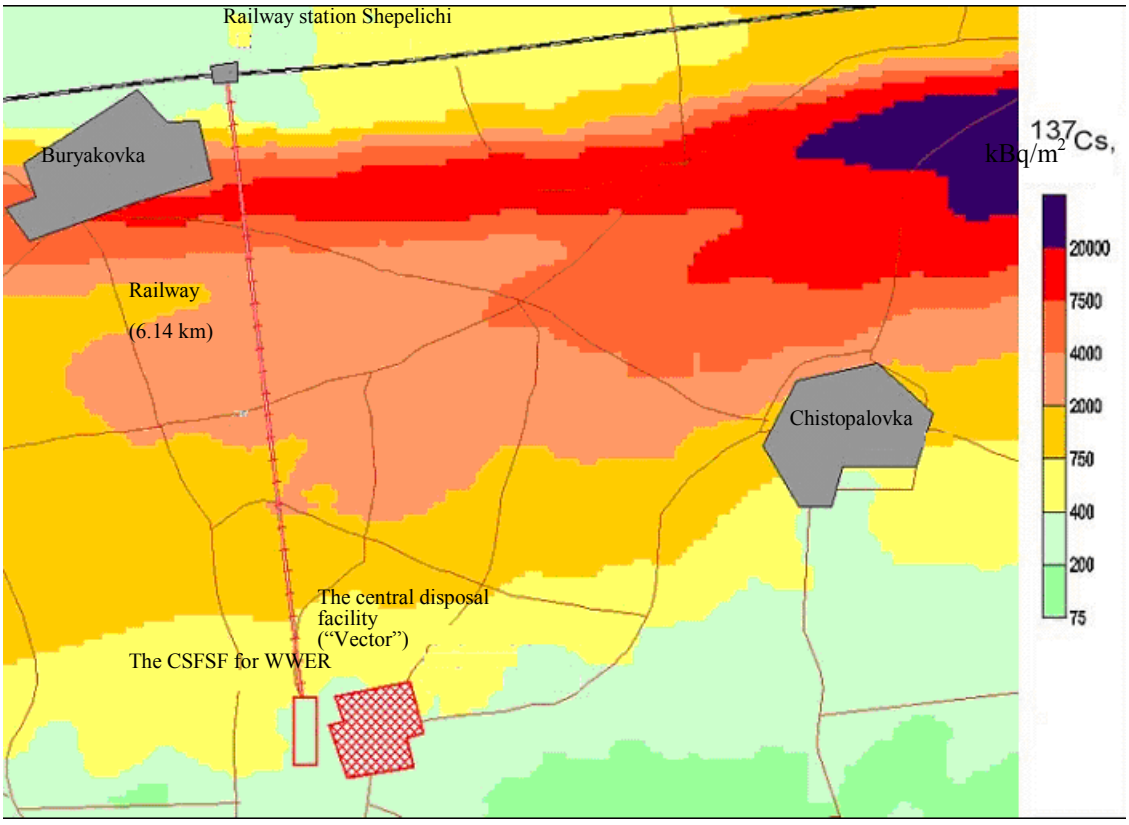


Figure 3.3.1 - The map-diagram of surface soil contamination density with ^{137}Cs on the railway section from the station "Shepelichi" to the CSFSF site

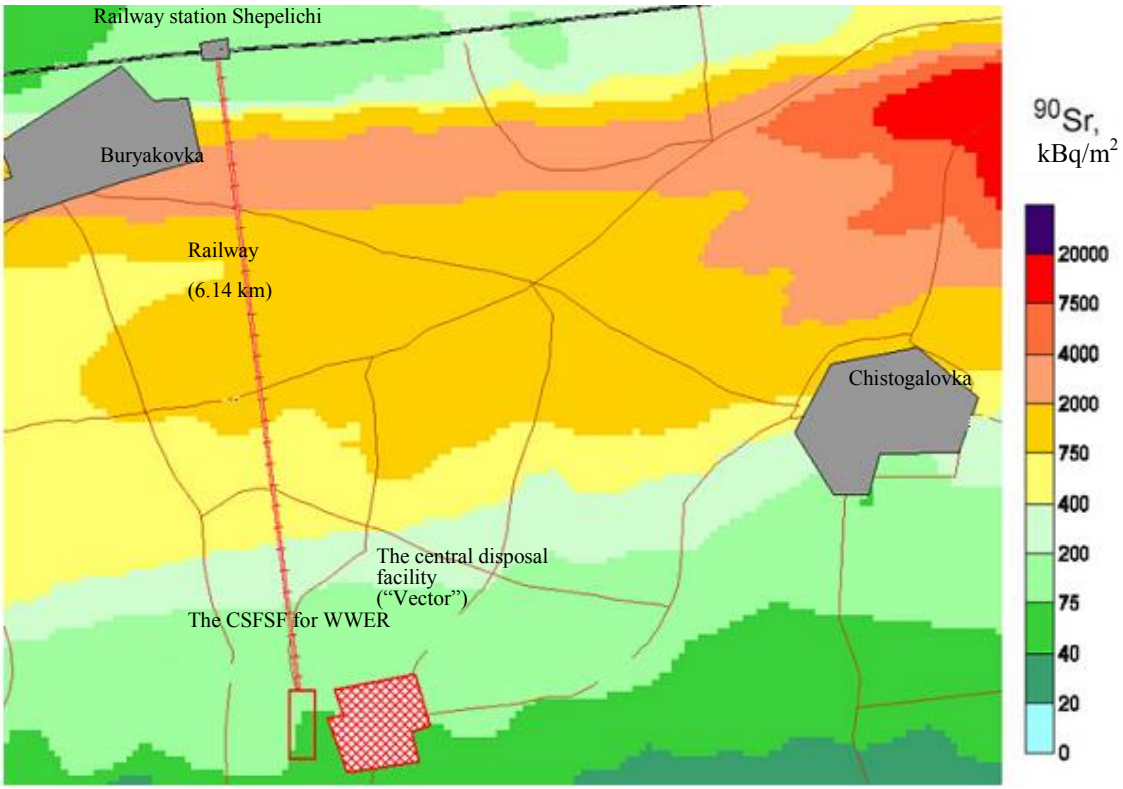


Figure 3.3.2 - The map-diagram of surface soil contamination density with ^{90}Sr on the railway section from the station "Shepelichi" to the CSFSF site

Earthwork within this section will be accompanied by radionuclide contamination of surface air. At that, the section with length of 0,3-0,6 km with surface contamination ~ $7{,}4 \cdot 10^9$ kBq/km^2 for ^{137}Cs and ~ $4{,}07 \cdot 10^9$ kBq/km^2 for ^{90}Sr will be of a special hazard for the personnel involved in railway construction.

To assess near-surface concentration of radioactive substances in air the following input data are used:

- maximum density of volumetric soil contamination (from the data presented at Figures 3.3.1 and 3.3.2):

- ^{137}Cs - 26,7 kBq /kg;
- ^{90}Sr - 5,33 kBq /kg;
- alpha emitting TUE - 0,28 kBq /kg.

- characteristics of the bulldozer:

- speed of movement- 1 km/c;
- bucket width - 2 m.

- weather conditions:

- normal (the class of atmosphere stability on Pascvil - D, wind speed - 3,3 km/c) - 95 % of time;
- extreme (the class of atmosphere stability on Pascvil - F, wind speed - 1 km/c) - 5 % of time;
- speed of aerosol falling - 0,8 cm/c;
- precipitation is absent;
- thickness of the soil layer contaminated with radionuclides - 10 cm.

At conservative approach, the ground is sand; gross dust release in sand loading, unloading and stocking is calculated by the formula:

$$M_c = \beta \cdot \Pi \cdot Q \cdot K_{1w} \cdot K_{2w} \cdot 10^{-2}$$

Where β is the coefficient that takes into account material loss as dust, proportion of units [β sand = 0.05]

Π - is material loss, % (in unloading 0.4 %, in loading 0.4 %, in stocking 0.5 %);

Q - is weight of construction material, t/year;

K_{1w} - is a coefficient that takes into account material moisture;

K_{2w} - is a coefficient that takes into account storage conditions;

Material moisture is not conservatively taken into account for construction site conditions.

Resulted from the assessment, the release speed is:

- ^{137}Cs - 200 Bq/sec;
- ^{90}Sr – 40 Bq / sec;
- alpha emitting TUE - 2,1 Bq / sec.

The air near-surface activity has been assessed in maximum of the near-surface concentration on average during earth works using the calculation methodology for release dissemination (Volume 3, part 2 Appendix B):

- ^{137}Cs - 4,7 Bq /m^3;
- ^{90}Sr - 0,9 Bq /m^3;
- alpha emitting TUE - 0,05 Bq /m^3.

3.3.2 Normal construction conditions

3.3.2.1 Dose estimation for the personnel

The dose calculation method is presented in Appendix B of Volume 3, part 2.

In dose calculation the following input data were used:

- the time for the access road construction is 6,4 months in 10-hour working day, a two-shift routine of work;
- a quantity of work with intensive dust generation is 2/3;
- work is conducted with equal speed at all way of construction;
- dose coefficient for surface soil radiation $2{,}91\times10^{-16}$ (Zv·m^2)/(s·Bq) (IAEA recommendations of 2001 (Publication No.19, Table 1.1, page 120);
- additional IPM have not been taken into account in calculation (conservative approach).

The calculation results show:

- the maximum individual effective dose from surface contamination is 1,14 mZv;
- the maximum individual effective dose of internal exposure is 2,2 mZv.

The maximal total individual effective dose will be 3,34 mZv.

Taking into account that all works within the ChNPP exclusion area, according to the existing rules, are carried out using IPM (shields practically totally the beta emission), it is possible to neglect beta exposure of feet and hands from the existing surface contamination of the territory.

Beta exposure from dust accumulated on open parts of skin can be neglected as well, because at observance of radiation hygienic standards and rules such exposure will be of short-term character, i.e. till the personnel come into the changing rooms provided in construction.

The equivalent dose from beta exposure of open parts of skin and of eye lens will be about 0,5 mkZv for all working time.

In comparing (Table 3.3.1) the calculated amount of radionuclides obtained by the construction staff with the regulated value according to NRBU-97 [4] for the personnel of category

A, the conclusion was made that the amount obtained from any radionuclide type will not be higher then the permissible one.

Table 3.3.1 - Comparison of values of radionuclides obtained in construction with the regulated values.

Radionuclide	**Incoming, Bq**		**Ratio calculated/permissible**
	Calculated	**Permissible, NRBU-97**	
^{137}Cs	$3{,}03 \cdot 10^{3}$	10^{5}	0,03
^{90}Sr	604	$3 \cdot 10^{4}$	0,02
alpha emitting TUE ($^{238\text{-}240}Pu$, ^{241}Am)	32	240	0,18

Thus, the construction staff exposure in construction within the most contaminated part of the construction site does not exceed the established limits. Hence, under normal conditions of CSFSF construction the established dose limits of the construction staff will not be exceeded. At that, the data resulting to the maximal individual effective dose are used in calculations.

3.3.2.2 Measures for ensuring radiation safety

The construction staff safety shall be provided by implementation of a set of measures. The basic measures on radiation safety in CSFSF construction are specified in Table 3.3.2

Table 3.3.2 – Measures for ensuring radiation safety in construction

Measures	Regulatory documents	Responsible
Personnel training Prior to work beginning the instructional advices (with records into the log) must be realized: - on radiation and general safety; - on fire safety studying the rules for using primary fire extinguishing means; - on actions in extreme situations; - on first medical aid to an injured person; - acquaintance with traffic routes.	The basic provisions on radiation, fire safety and on actions in extreme situations.	The Contractor on construction.
Arrangement of safe work Prior to work beginning it is necessary: - to assign persons responsible for safety at work; - to draw up necessary documents on work performance.	The instruction on work arrangement within the exclusion area.	The Contractor on construction, the Client.
Preparation of working places Prior to work beginning it is necessary to prepare working places: - to fence the working area; - to install temporary airlocks on the exit from the working area; - to mark traffic routes for the personnel and techniques; - to inspect working places by a fire prevention inspector with issuing of the work permission; - to provide with primary fire extinguishing means.	The basic provisions on radiation safety and work arrangement within the exclusion area.	The contractor on construction, the Department of fire prevention within the exclusion area.
Arrangement of medical aid: - permanent work of a first-aid post; - presence of means for the first medical aid on the working places.	The instruction on work organization within the exclusion area.	The Client, The Contractor on construction, the Ministry of Emergencies.
Admission to work Work is carried out according to the requirements of the documents regulating the safety at work: - daily coordination of work beginning and finishing; - the personnel entrance/exit into/from the working area on the established route.	The instruction on work organization within the exclusion area.	EAM, The Contractor on construction.
Monitoring and supervision The work must be accompanied by: - work safety monitoring; - technical quality monitoring of the construction and installation works; - designer's supervision.	WIP, SN and P III-4-80*, The design documentation.	The Contractor on construction, EAM, The design developer.

Measures	Regulatory documents	Responsible
Use of IPM and breathing IMP IPM and breathing IMP are selected depending on work types: - activities related to the increased dust accumulation (uprooting, earth work, etc.); - construction and assembling activities; - painting and other works performed by spraying; - welding work; - dust suppression, decontamination and RAW management activities.	Basic provisions on radiation safety.	The Contractor on construction, EAM (Ekocenter),
Use of collective and personal hygienic means The personnel must go out from the working area through temporary airlocks. During the work the personnel is provided with the necessary equipment and means: - for skin decontamination; - for personal protection means decontamination; - for personal hygiene.	Basic provisions on radiation safety.	The Contractor on construction, EAM (Ekocenter)
Radiation monitoring and control: - radiation observation of working areas (direct measurements, sampling, etc.); - individual radiation monitoring; - monitoring of air contamination with radioactive aerosols, contamination of working areas and personnel traffic routes; - monitoring of personnel contamination at the exit from the working areas; - monitoring of transport means and equipment contamination at the exit from the working areas; - process monitoring of radioactive waste management; - monitoring of decontamination of transport means, equipment and tools; - monitoring of individual protection equipment decontamination, and, if necessary, of personnel hygienic treatment; - recording of personnel dose loads.	The basic provisions on radiation safety, rules on individual dose monitoring of personnel exposure and radioactive waste treatment, work arrangement within the exclusion area.	EAM (Ekocenter), the Contractor on construction.
Decontamination and dust suppression: - decontamination of radioactively contaminated transport means, equipment and tools, etc.; - sanitary treatment of the personnel skin; - dust suppression on the sections with heavy traffic of the personnel and technical means.	Basic provisions on radiation safety and on work arrangement within the exclusion area.	The Contractor on construction, EAM.

3.3.3 Accidents in construction

All initial events in construction related to load fall or equipment failure do not lead to personnel exposure. The single critical event that can lead to significant radiation impact on CSFSF construction personnel from the external initial events possible at the construction site is a forest fire at the initial stage of preparatory work (before vegetation removal). It occurs because the basic volume of construction and erection work will be performed at the already cleaned territory; therefore, there is no significant radiation impact on the personnel at such an accident as falling of load, a crane, etc.

Fires are rather often within the Chernobyl exclusion area. According to the "ChernobylLes" data [6] about 60-100 fires are registered per year from which the overwhelming majority originates at the territories not covered with forests (fallow lands). Taking into account that the site preparation for CSFSF construction will include a set of forestry work for tree removal at the construction territory and at making access roads, the probability of ignition of laying and wood is high enough during such an activity.

The ground-type fire is usual for fire arisen in such conditions, when wood laying, grass-brush cover, underwood and underbrush are burning. During such a fire, radionuclides deposited in wood and laying and discharged into the atmosphere with smoke and flying ash will be disseminated in the atmosphere that lead to additional contamination of soil and radionuclide concentration raise in surface air. As a result of this process, radionuclides concentrate in wood laying ashes and radioactive aerosols of various dispersions are released into air.

Quantitative characteristics and dynamics of forest fires occurred in the exclusion area are presented in Table 3.3.1.

Table 3.3.1 – Quantitative parameters of fires at the E&MRA territory [9]

Year	**Number of fires**	**Square, hectares**	**Number of fires in accordance with fire site**		
			Villages	**Forests**	**Fallow lands**
1993	66	564,5	5	2	59
1994	100	130,9	8	3	89
1995	116	756,7	12	1	103
1996	79	296,3	36	6	37
1997	83	294,29	23	7	53

The available experimental data presented in Tables 3.3.2 and 3.3.3 were used in the input data for phytomass fractional composition and stocks in forests at the CSFSF construction site.

Table 3.3.2 - The phytomass fractional composition in forests at the CSFSF construction site

Phytocenosis component	**Trunk**		**Branches**	**Leaves, needles**	**A laying**	
	Wood	**Bark**			**AoL**	**AoF+AoH**
Phytomass stocks, t/he	111	22	23	4	7	11

Table 3.3.3 defines the phytomass fractional composition and stocks in 30-40 year-old forests growing within the CSFSF construction site (in tons of absolutely dry substance per 1 hectare) [7].

Values of ^{137}Cs specific activity for forest phytocenosis components were determined based on the transition coefficient presented in [8].

Table 3.3.4 determines content of ^{137}Cs in pine-tree phytomass components (Bq/kg) at soil contamination density (230 kBq /m^2) that is taken into account at estimation of CSFSF construction personnel impact.

Table 3.3.4 - Accumulation of ^{137}Cs in pine-tree phytomass components, Bq/kg

Trunk		Branches	Leaves, needles	Laying		
Wood	Bark			AoL	AoF	AoH
56	111	223	270	170	1700	21800

The calculations use the laying contamination density data presented in [12] based on the full-scale experiment results. It was revealed in [12] that the top (AoL) and fermentative (AoF) laying layers burn out in ground type fires in 30-40 year-old pine phytocenosis. The humus laying layer (AoH) (where the main radionuclide deposit is concentrated) in a ground fires does not burn down, and hence, the deposited radionuclides are not involved in the secondary transfer processes.

Numerous observations over the ground-type fire testify that a dynamic equilibrium appears when the area remains the same: instead of burned-up forest sections the new sections with equivalent square are occupied with a fire [13] after an initial stage during which the area swept by fire increases spontaneously.

The assessments performed show that a fire that may arise in construction of the railway line to the Shepelichi station is of the greatest danger. The railway passes through the radioactive trace (consequences of the accident in 1986) with the width about 300 m (where railway passes) and with the surface contamination level about 7500 kBq/m^2 for ^{137}Cs, 4000 kBq /m^2 for ^{90}Sr and 80 kBq /m^2 for alpha emitting TUE.

The ground fire front speed along the wind direction can be of 0,5 to 3 m/mines (in opposite direction the fire speed is 6-10 times less). At the region average wind speed (3,3 km/c at altitude of 10 m) the speed of ground fire can be, by estimations, about 0,7 m/minutes. It is accepted according conservatively that fire speed is 1 m/min, the wind direction – along the ChNPP lines and the fire origin point is on the trace axis.

In this case the forest will burn out of the total square about 72 thousand m^2 during 4 hours that will lead to summary release of about $5.4 \cdot 10^{10}$ Bq of ^{137}Cs, $2{,}9 \cdot 10^{10}$ Bq of ^{90}Sr and $5{,}8 \cdot 10^{8}$ Bq of alpha emitting TUE. At that, the time *t* during which the forest laying burns up to the dynamic equilibrium will be about 1000 sec [13], the intensive burning square is about 5 000 m^2, and release speed is about $3{,}8 \cdot 10^{6}$ Bq/sec for ^{137}Cs, $2{,}0 \cdot 10^{6}$ Bq/sec for ^{90}Sr and $4{,}0 \cdot 10^{4}$ Bq/sec for alpha emitting TUE.

The modified Gauss model was used for modeling of radionuclide transfer process in the ground fire. At that parameters of plume rise were calculated according to [15] taking into account the final fire square from [16] and the plume radius from [17].

The calculations shown that the greatest surface contamination will be observed at the distance of about 4000 meters from the fire spot and will be up to 200 Bq/m^2 for ^{137}Cs, to 90 Bq/m^2 for ^{90}Sr and 2 Bq/m^2 for alpha emitting TUE.

The maximum volumetric activity of ^{137}Cs in air will be observed at the distance of ~ 4-5 km from the fire origin and will be no more than 2 Bq/m^3. The maximal volumetric activity of ^{90}Sr in air will be no more than 0,8 Bq/m^3, and maximum values of volumetric activity for alpha emitting TUE will be no more than 0,2 Bq/m^3.

The individual effective exposure dose of the personnel at the distance of the maximum near-surface concentration (about 4000 m) will be of 0,1 to 0,7 mZv depending on weather conditions, that does not exceed the doses regulated in NRBU-97 [4].

It is necessary to note that additional surface contamination and individual effective equivalent exposure dose of the personnel calculated using such an approach are conservative. The forest fire warning system and fire-extinguishing systems existing currently within the ChNPP exclusion area allow reducing damages caused by forest fires.

Assessments show that the time of the considered forest fire localization (detection, fire

brigade departure, deployment, suppression beginning and fire localization at the burning territory) is about 30 minutes. Burnout of about 10 % of wood vegetation at the designed CSFSF construction site is possible during this time. Besides, the personnel involved in CSFSF construction are assumed in the given approach to be in the area of radioactive aerosol dissemination during the whole time of forest burning (about 4 hour). In development of the construction design the measures for construction personnel evacuation will be provided for at the design stage in the event of accidents during construction.

It is necessary to take into account as well that fires in the exclusion area cannot be related to CSFSF construction (the data on a number fires are presented in Table 3.3.1). The fire safety measures are provided for decrease of the probability or exclusion of fire origin.

3.4 Radiation safety in CSFSF operation

Radiation safety at CSFSF operation will be provided for if radiation impact on personnel, public, and the environment under normal CSFSF operation conditions, violation of operation conditions and in design basis accidents do not exceed the established dose limits of the personnel and the public exposure, specifications on emissions and releases, radionuclide contents in the environment, and also is limited during beyond design basis accidents.

3.4.1 Radiation situation and sources of radiation impact

Radiation situation within the CSFSF territory and in its premises is determined by factors that can be divided into two groups:

- factors not related to CSFSF activities;
- factors caused by CSFSF operation.

Ionizing radiation from the territory surface contamination resulted from the accident at ChNPP Unit 4 in 1986 is the main factor that is not related to CSFSF activities and that forms the radiation situation. The value of radiation background in CSFSF operation will depend on efficiency of decontamination activities (removal of surface soil) carried out at the construction stage. Contribution of this exposure to the summary dose after completion of construction and erection work is estimated to be considerably less than now.

The ionizing radiation sources that form radiation situation at the CSFSF territory and in its premises, and that are conditioned by CSFSF operation are:

- HI-STAR overpacks with the MPC;
- MPC with SFA placed into the HI-STAR;
- MPC with SFA placed into the HI-STORM;
- MPC with SFA placed into the HI-TRAC;
- equipment and filters of the exhaust ventilation system;
- containers with radioactive waste;
- radioactively contaminated surfaces of equipment and premises;
- radioactively contaminated IPM stored in the changing room;
- radioactively contaminated auxiliary IPM.

3.4.1.1 Characteristics of ionizing radiation sources

SFA come to the CSFSF in the enclosed multi-purpose canister. The main ionizing radiation source from the MCP is SFA. CSFSF supposes to store WWER-1000 SFA, alternative WWER-1000 SFA, and WWER-440 SFA. The main characteristics of SFA to be stored in the CSFSF are presented in Tables 3.4.1 and 3.4.2. The general view of WWER-1000 SF is specified at Figure 3.4.1. The WWER-440 SFA view is similar to the WWER-1000 SFA view.

Figure 3.4.1 –General view of WWER-1000 FA

Table 3.4.1 – The main characteristics of the WWER-1000 FA and the alternative WWER-1000 FA.

Name of characteristic	**Value**	
	Alternative FA (FA-A)	**FA**
FA “turn-key” dimensions	234mm	234 mm (the dimension between hexahedron planes)
SFA height	4570 mm	4570 mm
SFA weight	710 kg	670,5 kg
Number of fuel elements	312 pcs	312 pcs
Interval of fuel elements allocation in a FA	12,75 mm	12,75 mm
Fuel element length (fuel column height)	3530 mm	3530 mm
Fuel element diameter (inner/external)	9,1 mm /7,72 mm	9,13 mm /7,73 mm

Name of characteristic	Value	
	Alternative FA (FA-A)	**FA**
Fuel type	Uranium dioxide (UO_2)	Uranium dioxide tablets (UO_2)
Fuel weight (UO_2) in a SFA	491,4 kg ±4,5	455,52 кг±4,50
Fuel tablet diameter	7,57 mm	7,57 mm
Central hole diameter in a fuel tablet	1,5 mm	2,35 mm
Material of fuel element cladding	Zr+1%Nb alloy	Zirconium allow (Zr+1%Nb)
FA structural material (including guide channel and spacer grid)	Alloy E-635 Alloy E Э-110	Stainless steel
Guide channel diameter (inner/external)	12,6 mm /10,9 mm	11,2 mm / 9,6 mm
Central pipe material	Alloy E-110	Zirconium allow (Zr+1%Nb)
Central pipe diameter (inner/external)	13,0 mm /11,0 mm	12,6 mm / 11,0 mm
235U mass portion in uranium isotope mixture in fuel elements (fuel enrichment)	1,6% ÷ 4,4%	1,6% ÷ 4,4%
Permissible fuel element cladding temperature in storage: - in storage - in short-term transient modes (in total up to 8 hours)	 350 ^{0}C 450 ^{0}C	 350 ^{0}C 450 ^{0}C

Table 3.4.2 – Main characteristics of WWER-440 FA

Name of characteristic	Value
FA “turn-key” dimension	145 mm (dimensions between hexahedron planes)
FA height	3200 mm
FA weight	220 kg
Number of fuel elements in FA	126 pcs
Interval of fuel element allocation in a FA	12,2 mm
Fuel element length (fuel column height)	2320 mm
Fuel element diameter (inner/external)	9,1 mm / 7,73 mm
Fuel type	Sintered uranium dioxide tablets (UO_2)
Fuel weight (UO_2) in a FA, kg	131,2

Name of characteristic	Value
Fuel tablet diameter	7,57 mm
Central hole diameter in the fuel tablet	1,2 mm
Fuel element cladding material	Zirconium allow (Zr+1%Nb)
FA structural material	Stainless steel
235U mass portion in uranium isotope mixture in fuel elements (fuel enrichment)	1,6% ÷ 4,4%
Permissible fuel element cladding temperature in storage: - in storage - in short-term transient modes (in total up to 8 hours)	 350 ^{0}C 450 ^{0}C

It is supposed to store in the CSFSF SFA cooled in NPP cooling ponds not less than 5 years. Taking into account that ionizing radiation of WWER-1000 SFA is higher, alternative SFA with maximum enrichment of 4,4 % ^{235}U are considered in further calculations. The isotope composition and isotope activity of WWER-1000 SFA after five-year cooling in fuel cooling ponds are shown in Table 3.4.3. The data presented in the table were taken from the SAR performed for inter-unit transfers of the Khmelnitskiy NPP in the maximum fuel burn-up of 50 MW/t U.

Table 3.4.3 - Activity of the main isotopes of WWER-1000 SFA-A (Bq)

Nuclide	Activity	Nuclide	Activity
Pu-241	$2,27\bullet10^{15}$	Te-125m	$1,16\bullet10^{13}$
Cs-137	$2,14\bullet10^{15}$	Ni-63	$9,62\bullet10^{12}$
Ba-137m	$2,02\bullet10^{15}$	Pu-240	$9,31\bullet10^{12}$
Y-90	$1,49\bullet10^{15}$	Sm-151	$8,44\bullet10^{12}$
Sr-90	$1,49\bullet10^{15}$	H-3	$8,03\bullet10^{12}$
Pm-147	$8,17\bullet10^{14}$	Pu-239	$5,90\bullet10^{12}$
Cs-134	$7,36\bullet10^{14}$	Pr-144m	$3,49\bullet10^{12}$
Ru-106	$3,75\bullet10^{14}$	Nb-93m	$3,18\bullet10^{12}$
Rh-106	$3,75\bullet10^{14}$	Mn-54	$2,06\bullet10^{12}$
Pr-144	$2,49\bullet10^{14}$	Np-239	$7,18\bullet10^{11}$
Ce-144	$2,49\bullet10^{14}$	Am-243	$7,18\bullet10^{11}$
Fe-55	$1,42\bullet10^{14}$	Cm-242	$6,30\bullet10^{11}$
Kr-85	$1,41\bullet10^{14}$	Ag-110m	$5,98\bullet10^{11}$
Eu-154	$1,11\bullet10^{14}$	Cd-113m	$5,49\bullet10^{11}$
Cm-244	$9,25\bullet10^{13}$	Cm-243	$4,99\bullet10^{11}$
Pu-238	$8,46\bullet10^{13}$	Tc-99	$2,91\bullet10^{11}$
Sb-125	$4,73\bullet10^{13}$	Am-242m	$1,99\bullet10^{11}$
Co-60	$3,63\bullet10^{13}$	Am-242	$1,98\bullet10^{11}$
Eu-155	$3,15\bullet10^{13}$	Nb-94	$1,59\bullet10^{11}$
Am-241	$2,35\bullet10^{13}$	I-129	$7,08\bullet10^{8}$

After SFA are housed into the sealed MPC, the MPC with 31 WWER-100 SFA or 85

WWER-440 SFA become ionizing radiation sources. However, it is not provided for to manage directly with MPC. The HI-STAR (in transfer) or the HI-STORM (at long-term storage in the CSFSF), or HI-TRAC (at reloading at power units or in the receiving building) are used for biological protection of the personnel.

The HI-STAR overpack is designed to meet the US Nuclear Regulatory Commission and the IAEA transfer requirements. The maximum exposure dose rate (MED) on the overpack surface cannot exceed 2 mZv/hour at contact and 0,1mZv/hour at distance of 2 meters from the surface. In design of HI-STAR protection it is accepted that MED from HI-STAR loaded with the WWER -440 SFA or WWER–1000 SFA shall be less than the transportation limits established by the IAEA.

In calculating personnel dose loads in SNF management at the given design stage the data on the exposure dose rate on the surface and at the distance of 1 m from the surface of HI-TRAC and HI-STORM given by the Holtec International are used based on the data from the HI-STORM Safety Analysis Report during it licensing in the US. Tables 3.4.4 - 3.4.6 specify the MED from HI-STROM and HI-TRAC loaded with PWR SFA. MED directly for SF of Ukrainian NPPs will be calculated in detail at the CSFSF design development stage.

The use for calculations at the FS stage of the PWR SFA in MPC-32 (contains 32 SFA) is justified from the viewpoint of exposure dose rate estimation because of the following reasons:

- US PWR fuel element active part length is 365,76 cm; that is similar to the length of the WWER-1000 fuel element active part - 355 cm;
- uranium weight in MPC-32 is 15855 kg, and uranium weight in MPC-31 containing 31 SFA is 13485 kg;
- burn-up level of SF loaded into MPC-32 accepted at MPC licensing in the USA is 55,000 MW/tU, an average burn-up level of WWER-1000 SFA is 45,000-50,000 MW/tU;
- enrichment level of SF in MPC-32 considered at MPC licensing in the USA is 4,2 - 4,8 % ^{235}U, enrichment level of WWER-1000 SF is 4,2 - 4,4 % ^{235}U.

Therefore, the dimensions and weight characteristics specifying radiation sources are practically identical.

The use for calculations at the FS sage of the higher burn-up level is the conservative approach because dose rates will be lower in lower burn-up level.

The ^{235}U fuel enrichment level influences the contribution to the total MED of the dose from a neutron stream, at that, it is obvious from the presented data that MED neutron stream contribution to the total dose is insignificant.

Table 3.4.4- The MED from PC-32 (burn-up level: 55,000 MW/tU, enrichment level: 4,2 % ^{235}U, thermal load on the basket: 52,64 kW)

Location of a dose formation source	**Neutron flow MED, mrem/hour**	**Gamma MED mrem/hour**	**Total MED mrem/hour**
HI-STORM 100S Version B			
The middle of a side face	4	49	53
1 meter from the middle of a side face	2	25	27
HI-TRAC 125D			
The middle of a side face	142	189	331
1 meter from the middle of a side face	49	77	126

Table 3.4.5 – MED from MPC-32 (burn-up level: 55,000 MW/tU, enrichment level: 4,2 %

^{235}U, thermal load on the basket: 28,16 kW)

Location of a dose formation source	Neutron flow MED, mrem/hour	Gamma RER mrem/hour	Total MED mrem/hour
HI-STORM 100S Version B			
The middle of a side face	3	9	12
1 meter from the middle of a side face	1	5	6
HI-TRAC 125D			
The middle of a side face	90	74	164
1 meter from the middle of a side face	31	27	58

Table 3.4.6 - MED from MPC-32 (burn-up level: 55,000 MW/tU, enrichment level: 4,8 % ^{235}U, thermal load on the basket: 51,33 kW)

Location of a dose formation source	Neutron flow MED, mrem/hour	Gamma MED mrem/hour	Total MED mrem/hour
HI-STORM 100S Version B			
The middle of a side face	3	47	50
1 meter from the middle of a side face	1	25	26
HI-TRAC 125D			
The middle of a side face	105	173	278
1 meter from the middle of a side face	38	70	108

3.4.2 Dose estimation in normal operation

3.4.2.1 Dose estimation in loading at NPP power unit

Preliminary estimations of operation duration, number of personnel, and obtained doses in SFA loading at a power unit are presented in Table 3.4.7.

Table 3.4.7 - Dose estimation for the personnel at SFA loading at a power unit

Operation name	Personnel number	Duration (hours)	Average exposure dose rate mrem/h	Obtained dose, mrem
Preparatory activities	4	5	0	0
HI-TRAC and MCP preparation	4	5	1	20
Work with HI-TRAC in a cooling pond	5	5	3	75
Work for MPC closure	5	20	2	200
HI-STAR 100 overpack preparation	5	3	0	0
MPC transfer to HI-STAR 100	5	3	2	30
HI-STAR closure	5	4	3	60
HI-STAR emplacement into a transport platform	5	4	2	40
Final operations	5	1	0	0

The operations related to closure welding, MPC confinement verification are the most dose-consumption operations. Therefore, for these personnel, the personnel dose will be compared with the limit regulated by NRBU-97. The maximum expected number of MPC to be welded per year is 20 pcs. Hence, the maximum dose of one worker, if all these operations are performed by one person, is expected to be 200x20=4000 mrem that exceeds 20 mZv regulated by NRBU-97.

The operations for MPC sealing include:

1) installation of the automatic welding equipment;
2) MPC lid welding and verification on the welded seams quality;
3) MPC hydraulic tests;
4) inspection of welded joints after tests;
5) residual water removal from the MPC;
6) MPC drying;
7) MPC filling with inert gas;
8) cover plate welding on the vent and drain ports;
9) inspection of welded joints;
10) confinement check through the covered vent and drain ports;
11) enclosure ring installation;
12) enclosure ring welding and check of welded joints quality;
13) MPC lid confinement verification;
14) enclosure ring welding with spot welding, and quality control of the welded joints.

To reduce personnel dose during closing of one MPC, it is supposed, at least, participation of two welders, two specialists on drying and the job foreman who controls the process. Therefore, the dose for one person in loading of 20 MPC per year will be no higher than 800 mrem (4000/5) or 8 mZv that is lower than the regulated limits.

3.4.2.2 Dose estimation in MPC reloading in the CSFSF

Preliminary estimation of operations duration, number of the involved personnel and doses in MPC reloading in the CSFSF are presented in Table 3.4.8.

Table 3.4.8 - Estimation of personnel doses in MPC reloading in the CSFSF

Name of operation	**Number of personnel**	**Duration (hours)**	**Average exposure dose rate mrem/h**	**Obtained dose, mrem**
HI-STAR transport overpack receiving	5	2	2	20
HI-STAR preparation to MPC transfer	5	1	2	10
HI-STORM preparation	5	1	2	10
MPC transfer into the HI-STORM	5	2	0,5	5
Final operations	5	2	0	0

The most dose-consumption operations are those related to a HI-STAR transport overpack receiving. Therefore, for these personnel, the personnel dose will be compared with the limit regulated by NRBU-97. The maximum expected number of the MPC to be welded per year is 20 pcs.

Operations on HI-STAR receiving include:

1) inspection test;

2) shipping documentation analysis;
3) outer enclosure removal from the overpack;
4) closure plate bolts removal from the HI-STAR;
5) connection of the horizontal lifting cross-arm to the overpack;
6) HI-STAR overpack taking down from the railway platform;
7) HI-STAR installation on the temporal supports;
8) disconnection of the horizontal lifting cross-arm;
9) installation of the turner;
10) HI-STAR installation into the turner;
11) connection of the lifting cross-arm;
12) HI-STAR turn over into the vertical position;
13) removal of fastenings from the HI-STAR;
14) HI-STAR taking down from the turner;
15) HI-STAR installation on the floor of the transfer tube.

The main contribution to the dose is brought by operations 3), 4), 5), 8), 10), 11), 13. The maximum dose of one worker, if all these operations are carried out by one person, is expected of 20x20=400 mrem or 4 mZv that is lower than 20 mZv regulated by NPBU-97 [4].

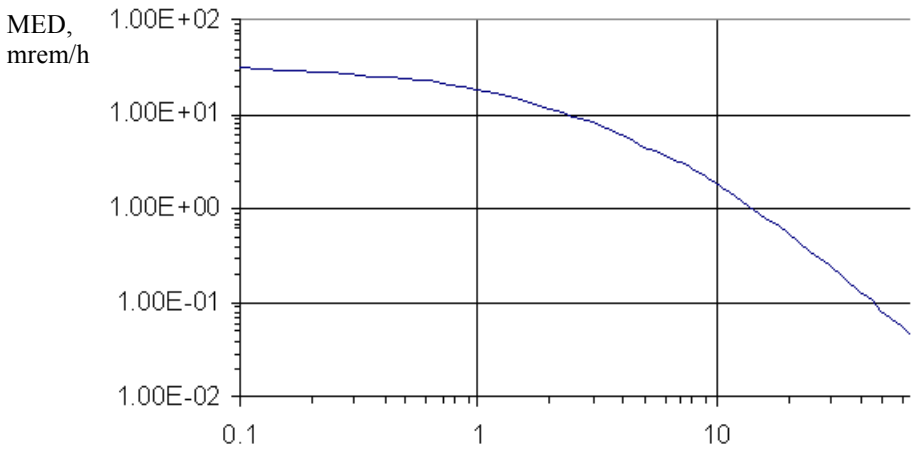
3.4.2.3 Dose estimation in maintenance and beyond the cask storage area

To assess individual effective exposure doses of the personnel at the CSFSF industrial site, dependence of dose rate from the individually located HI_STORM and from the storage area completely filled up with HI-STORM (design number is 458 pcs.) has been calculated.

Dose rate from a separate overpack will specify the radiation situation at the storage area in overpack maintenance during storage and at the in-service rounds of the site.

Dose rate from the storage area will specify the radiation situation at the CSFSF site outside the cask storage area. This is required to determine dimensions of the control area.

The data at the distance of 1 m from the HI-STORM overpack surface presented in Table 3.4.5 are taken as the input data on the radiation source. Resulted from the calculations, the MED dependence from the HI-STORM surface distance is determined taking into account the main gamma-emitting radionuclides of spent fuel (see Figure 3.4.2).



Distance, m

Figure 3.4.2 – MED dependence (mrem/h) from the distance (m) to a separate HI-STORM

Then, MED dependence was calculated from the CSFSF storage area distance taking into account real HI-STORM location at the storage area. At that, the MED on the storage area will vary from 30 to 60 mrem/h (average on the area is 45 mrem/h). The dependence of the maximum possible individual effective dose (mZv/year) (taking into account real HI-STORM location on the storage area) from the distance is presented at Figure 3.4.3.

Dose,
MZv/year

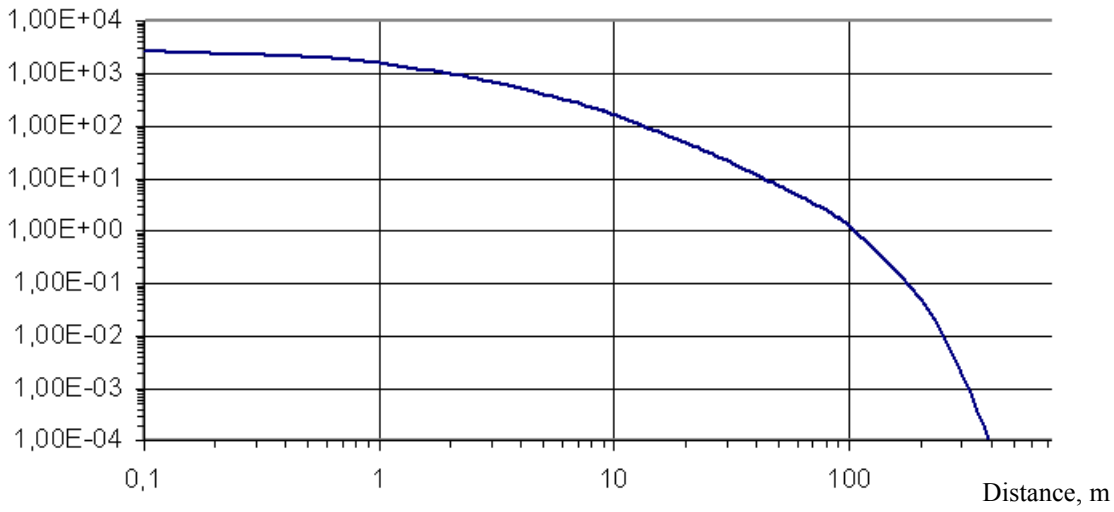


Figure 3.4.3 - Dependence of individual effective dose (mZv/year) from the distance (m)

The maintenance tasks for the cask storage area with the emplaced HI-STORM storage overpacks are:

- to control/ monitor the HI-STORM condition including:
  - cleaning of inlet vent ports of dust, snow, etc.;
  - cleaning of outlet vent ports;
  - maintenance of temperature transmitters (replacement for check and calibration);
- to monitor and maintain radiation monitoring equipment established on the storage area;
- to clean the area from restrictions (dust, snow, leaves).

The maintenance periodicity:

- external survey of the storage area is performed daily;

- radiation monitoring equipment inspection without its switching-off is carried out according to device certificates, but not less then once a week;
- radiation monitoring equipment inspection and calibration with its switching-off is carried out once a year;
- temperature measurement equipment is monitored according to device certificates, but not less then once a year;
- visual inspection of HI-STORM vent ports is carried out once a week;
- cleaning of snow, dust or other subjects (leaves) is carried out if necessary.

The following special machinery is used in maintenance:

- a mobile cradle for maintenance of outlet vent ports and monitoring devices located at altitude;
- a snow-removal machine.

A design number of personnel involved in maintenance at the CSFSF storage area constitutes:

- for daily monitoring and survey, cleaning of vent ports, area mechanical cleaning - two men-on-foot are required;
- for the scheduled maintenance:

- 1 mechanic;
- 1 electrician;
- 2 I&C technicians.

The service personnel expected doses are presented in Table 3.4.9. The estimation is made for design filling of the storage area, i.e. for 458 HI-STORM, 20 monitoring devices of dose rate sensors along the storage area perimeter and 916 temperature monitoring sensors.

Table 3.4.9 – Estimation of personnel doses in maintenance

	External survey of the storage area	Inspection of radiation monitoring means	Inspection and calibration of radiation monitoring equipment	Inspection of temperature measurement equipment	Visual inspection of HI-STORM vent ports state	Cleaning of snow, dust or other subjects (leaves)
Periodicity in a year	365	52	1	1	52	52
Number per year, times	365	1040	20	916	52	52
Operation duration, hours	1	0,1	0,5	0,08	2	3
Distance from the source, m	9	10	10	0,5	5	2
Dose rate in operations working, mrem/h	2,78	2,74	2,74	34,0	4,05	10,1
Obtained dose, mrem/h	1014,7	285	27,4	2491,5	421,2	1576
Personnel	man-on-foot	electrician, technician of I&C	electrician, technician of I&C	technician of I&C	man-on-foot	man-on-foot

Resulted from calculations presented in Table 3.4.9, the technicians of I&C are the most exposed ones, total individual annual exposure dose is 2491,5 mrem/year if one person works.

Taking into account that the staff list provides for 4 persons - two persons per shift, the individual annual dose of I&C technicians will be 6,2 mZv/year, that is lower than the requirements

of NPBU-97 [4].

3.4.2.4 Measures for ensuring radiation safety in normal operation conditions

Radiation safety of the operational and repair personnel must be provided by a set of measures.

Organizational measures

Prior to operation and periodically during operation the following organizational measures are provided for:

- personnel training;
- monitoring and supervision.

Personnel training is intended for obtaining knowledge in the field of radiation, general and fire safety rules during activities at the CSFSF, both in normal operational conditions and in possible accidents, and also knowledge and skills in processes for MPC handling in their transfer, preparation for storage and storage.

Training of personnel includes studying of regulatory and operation-engineering documentation of the facility, rules of behavior in the exclusion area, and also actions in emergencies and accidents within the scope required by personnel functions and responsibilities incumbent. After training, the personnel are examined and obtain standard certificates.

Personnel will be trained in accordance with the specially developed programs that include studying of the following materials:

1. The rules of behavior within the CSFSF territory, including:
   - rights and duties of the CSFSF personnel;
   - order of entrance and exit from the CSFSF territory;
   - order of obtaining and application of individual dosimeters;
   - order of passage trough radiation dosimetric racks.
2. Basis of dosimetry, CSFSF radiation-hazardous factors, protection methods against ionizing radiation, and parameters of the radiation situation at working places.
3. The rules of handling with individual protection means (IPM), including:
   - composition of the basic set of IPM and breathing IPM;
   - order of IPM application.
4. The order of actions in possible emergencies and accidents, including:
   - actions in case of emergencies;
   - evacuation routes in emergency;
   - first medical aid for injured people, etc.

The professional training is carried out in accordance with worker's specialization by theoretical studying of process regulations of the activity incumbent on him, and also by training the actions at simulators. After verification of knowledge obtained during theoretical preparation and training at simulators, the personnel are permitted to training with empty MPC to gain practical skills in process conditions. If positive results are obtained, the worker is allowed to separate process operations under control of the skilled expert-instructor with subsequent expansion of the operation nomenclature after operational experience achievement.

Additional target instructions of the personnel are provided for to improve the safety of work. The order of personnel instructions is determined in accordance with the requirements of the regulatory documents.

The monitoring and supervision is carried out to improve the safety of work safety and to exclude violations of regulations in process operations, what may lead to an emergency situation and unjustified personnel exposure higher than the established reference levels.

Technical measures

The following is provided for as the main technical measures ensuring radiation safety under normal operation conditions:

- shielding;
- use of remotely controlled mechanisms;
- decontamination;
- ventilation and gas purification;
- TV-monitoring.

The CSFSF radiation safety is based on the multi-barrier protection principle.

The MPC barriers are obstacles for mechanical release of radioactive substances into the environment, but they practically do not prevent ionizing radiation. The HI-TRAC in reloading, HI-STAR in transportation, HI-STORM in storage are the barriers with radiation protection functions.

One of the main measures of radiation protection is shielding that allows reducing of radiation impact taking into account the ALARA principle up to the level prescribed by the regulatory documents.

In design a differential approach will be used to shielding that takes into account:

- specificity of the process;
- necessity of personnel attendance in some operations;
- time for personnel attendance at various rooms.

Ventilation of rooms where overpacks are handled is an additional dynamic barrier on a way of radioactive substances release into the environment.

The ventilation system is designed in a way that air from more contaminated rooms do not get into the rooms with permanent personnel attendance. The air removed from the process rooms is cleaned by means of aerosol filters before it exhausts into the environment.

Radiation - hygienic measures

The sanitary-admission mode is introduced at the CSFSF.

The sanitary-admission mode is required to ensure physical protection, to exclude release of radioactive contamination beyond the CSFSF boundaries, to monitor IPM and skin contamination, to ensure changing of personnel clothes and sanitary treatment, to gather and send contaminated IPM for decontamination and disposal.

The CSFSF territory, buildings and rooms are divided into two areas:

- restricted access area where radiation impact on the personnel is possible;
- free assess area where radiation impact on the personnel is practically impossible in normal operation.

Depending on radiation impact extent the CSFSF rooms are divided into three categories:

- unattended rooms;
- periodically attended rooms;
- rooms of permanent personnel attendance.

At sanitary-admission mode introduction the personnel enter into the restricted access areas of the receiving building and leave the area boundaries only through the changing room (the stationary separating sanitary-hygienic facility).

The radiation monitoring system (RMS) is provided for monitoring of radiation impact on the personnel, the population and the environment under CSFSF normal operation conditions, violations of normal conditions and in design basis accidents at the CSFSF. The system operation will allow the personnel to keep contamination levels and radiation doses of the personnel and the

population at reasonably achievable low level and lower than the regulated limits.

The radiation monitoring system consists of the following subsystems:

- radiation process monitoring (RPM);
- radiation dosimetric monitoring (RDM);
- individual dosimetric monitoring (IDM);
- environment radiation monitoring (ERM);
- radiation monitoring for non-extending of radioactive contaminations.

Depending on the activity radiation monitoring includes:

- monitoring of ionizing radiation dose rate, beta and alpha-particle flux density at the working places, process rooms and the territory of the control area and the surveillance area;
- monitoring of radioactive gas and aerosol content in industrial and administrative rooms;
- monitoring of a contamination level of industrial rooms and equipment surfaces, personnel skin and clothes;
- monitoring of radioactive release into the atmosphere;
- monitoring of radioactive substances in drains;
- monitoring of gathering and transfer of solid and liquid radioactive waste;
- monitoring of a contamination level of transport means.

It is provided for to install a monitoring device equipped with automatic sound and light devices (e.g. in rooms where spent fuel is handled).

The CSFSF radiation monitoring system described in Volume 1, part 3 is the integral part of the monitoring and control system of the CSFSF set of systems.

3.5 Radiation safety in accidents

The list of initial events (IE) considered for this technology meets the requirements of PNAEG-14-029-91 [2] (items 4.2; 4.3; 4.4) and NP 306.2.105-2004 [23]. Some requirements [2] are not applicable to CSFSF in view of its specific technology, namely:

- item 4.2.11 [2] (leakage from a cooling pond or breaking of pipelines resulting in decrease of a water level);
- item 4.2.13 [2] (formation of explosive mixtures in a spent fuel storage facility);
- item 4.2.14 [2] (a reactor accident influencing safety of the storage systems and spent fuel management);
- item 4.2.14 [2] (accidents in the systems not related to fuel storage and management resulting in damage of spent fuel storage and transportation equipment);
- item 4.3.2 [2] (full dehydration of the SNF storage facility);
- item 4.3.3 [2] (drop of process equipment and structures on girder floors of storage compartments or the stored SNF);
- item 4.3.4 [2] (flooding of I class storage facilities with water).

The requirement of items 4.4.3 [2] and [23] on considering the impact of water boiling and generation of steam-and-water mixture on increase of the effective neutron multiplication factor (Keff) is fulfilled in nuclear safety analyses for NPP power units, because it is possible only in SFA loading at the power unit.

The requirement of items 4.4.5 [2] and [23] on considering possible water ingress into SNF "dry" storage facility - at the accepted SFA storage technology (the MPC with two confinement barriers), ingress of water or steam-and-water mixture inside the MPC is excluded.

Comprehensiveness of the list initial event regulated in [2] and [23] will be substantiated in

development of the CSFSF SAR at the design stage.

Below there is a brief analysis of initial events of accidents at the CSFSF based on the Holtec International data performed in the HI-STORM system licensing in the USA. The requirements to the list of the initial events in the USA are presented in 10CFR72, the format of information presentation in the SAR is according to the NUREG-1536 requirements.

Because of the fact that the USA terminology is used in the section, the section of the applied terms defines terms of *abnormal events*, *design basis and beyond design basis accidents* in accordance with the American national standard (ANS) "Design Criteria for Individual Spent Nuclear Fuel Storage (Dry Type) Facilities" ANSI/ANS-57.9-1992.

3.5.1 Violation of normal operation conditions

This subsection describes abnormal events or expected violations of normal operation conditions considered in the HI-STORM system licensing in the USA. The considered events can be both single (transfer operations) and repeated during the CSFSF design lifetime. At that, these events will not lead to violation of safety operation limits (for example, to exceeding of the maximum permissible fuel cladding temperature).

3.5.1.1 Abnormal weather conditions

In accordance with the 10CFR72 requirements, HI-STORM overpacks are designed for the ambient temperatures presented in Table 3.5.1. It is supposed that the lower and upper limits of abnormal temperatures will last no longer than 72 hours.

The MPC and HI-STORM calculation for abnormal temperatures at the CSFSF site will be carried out at the design stage.

For comparison, Table 3.5.1 defines the environment parameters at the CSFSF site.

Table 3.5.1 - Ambient temperature values

Condition	**HI-STORM designed temperature, °C**	**Ambient temperature within the CSFSF site, °C**
Normal air temperature (an average during a year)	27	6,7
Normal ground temperature (an average during a year)	25	-
Abnormal air temperature (an average 3 days)	From -40 to +38	From –35 to +39
Extreme emergency level of air temperature (an average 3 days)	52	40

The calculated temperatures of the HI-STORM components for the ambient air temperatures presented in Table 3.5.1 are shown in Table 3.5.2.

Table 3.5.2 Calculated temperatures of the HI-STORM components

HI-STORM 100 component	**Limit parameters of temperature in long-term storage conditions, normal operation (Long-term events), ° C**	**Limit parameters in not established and emergency conditions (Short-term events), ° C**
MPC shell	260	413

HI-STORM 100 component	Limit parameters of temperature in long-term storage conditions, normal operation (Long-term events), ^{o}C	Limit parameters in not established and emergency conditions (Short-term events), ^{o}C
MPC fuel basket	385	510
MPC neutron shield	427	510
MPC lid	288	413
MPC baseplate	204	413
Fuel cladding	400	400 or 570 (short-term operations)* 570 (not established and emergency conditions)
HI-STORM outer shell	177	316
HI-STORM bottom plate	149	177
HI-STORM inner shell	177	204
HI-STORM closure plate	232	288

* - short-term operations include MPC drying and on-site transportation, the limit temperature parameter of 570°C is applied to the MPC that contains all SFA with an average burn-up level. The limit temperature value of 400°C is for the MPC containing one or more SFA with a high burn-up level.

Thus, it will be required to confirm at the design stage that under normal ambient air temperatures the fuel cladding temperature will not exceed 350°C, and under abnormal ambient air temperatures during 72 hours the fuel cladding temperature will not exceed 450°C.

3.5.1.2 Partial clogging of MPC basket holes

The MPC basket design represents cells for SFA that are connected among themselves by oval ventilation holes at the baseplate level. General view of ventilation holes can be clearly seen at Figure 2.2.1. In accordance with the 10CFR72 requirements, the situation with ventilation holes clogging inside the MPC was considered.

Fuel spillages due to fuel element failure or corrosion deposits on fuel element surfaces are considered as the source of possible holes clogging. SFA in the MPC are stored in the inert medium with fuel element cladding temperature lower than the permissible values, hence, there is no evident mechanism that could cause significant degradation of fuel element cladding during storage time in MPC. Therefore only the possibility and amount of possible corrosion deposits and their impact on the heat removal capacity between cells with SFA inside the MPC are considered further.

The MPC is designed in a way that it is able to resist decreasing of air stream cross-section because of partial clogging of ventilation holes in the MPC basket. The analysis objective was to determine the maximum possible thickness of corrosion deposits at the MPC bottom and to compare thickness of deposits with the size of holes connecting the basket cells inside the MPC. It is conservatively accepted that the hole between cells is semicircular with a diameter equal to the smaller oval diameter, i.e. the real oval form of the hole was neglected.

The experimental data on possible surface contamination of PWR SFA in the USA was used to assess the maximum possible number of deposits. Resulted from the SFA surface contamination and the cell square for SFA, the maximum thickness of mud deposits at the MPC bottom is 9,1 mm. This value can be considered further as the boundary value for WWER SFA.

The obtained value of deposit thickness is less than the diameter of the oval hole in the MPC basket, hence, hole clogging does not occur and the heat removal is not damaged. The analysis performed allows stating that in partial clogging of MPC holes, MPC confinement barriers are not broken and, correspondingly, release of radioactive substances into the environment is not expected.

3.5.1.3 Partial clogging of HI-STORM vent ports

The HI-STORM vent ports are closed by the fine-mesh steel grid turned around under the angle of 90°; they are inspected regularly during operation in accordance with the overpack maintenance regulation, the stationary continuous air temperature monitoring is provided on the port inlet and outlet, hence, it is improbable, that vent ports will be clogged by wreckage, animal bodies, etc. in normal operation and in violations of normal operation conditions.

It is conservatively accepted for assessment of consequences that two of four vent ports will be completely clogged.

In analysis of this event the airflow models are used to calculate air temperature in the air radial gap. Clogging of two inlet ports reduces twice the total inlet square; that leads to increase of losses k/A^2 (k - is a hydraulic loss coefficient, A - is an open flow area square) for the inlet hole square in four times. However, the airflow system in the HI-STORM is designed in a way that inlet losses constitute rather smaller part of total pressure differential; therefore total increase of $\Sigma k/A_i^2$ is about 29 %. As a result, air consumption is reduced at 9 %.

Such a combination of factors (one of them increases pressure differential and another reduces it) leads to the total pressure decrease because of air consumption decrease at 8 %. Air consumption reduction leads to higher temperature difference between inlet and outlet points. As a result, temperature difference increases approximately at 10 % and the exhaust air temperature increases from 73 ^{o}C (164°F) to 78 ^{o}C (173 °F). As shown in the HI-STORM SAR, the temperature rise because of such an event is insignificant (in comparison with normal operation conditions).

In estimations of doses for the personnel involved in cleaning of vent ports it is accepted that one worker kneeling during 30 minutes (the actual time he kneeled) cleans by hands the inlet vent ports. Considering that the dose rate on the HI-STORM side face is 53 mrem/h (see Table 3.4.4), it is possible to make a conclusion that the worker's palms and forearm will receive the dose of 21 mrem for 30 minutes; the breast and trunk will receive a slightly smaller dose. Thus, taking into account the conservative approach, the received doses are considerably lower than the permissible ones.

3.5.1.4 Violations in handling operations

Violations in handling with HI-STORM and HI-STAR overpacks

The HI-STORM overpack is designed to withstand drop from 28-cm the altitude, at the same time, the MPC content remains undamaged.

It is supposed that the HI-STORM will be transferred within the CSFSF by means of the crawler whose design ensures non-exceeding of the HI-STORM regulated lift above land.

The HI-STAR used in CSFSF is a shipping cask that must be designed for drop from 9-m altitude without damage of its content. The maximum HI-STAR lift altitude in the receiving building is 7 m.

To exclude failures of the load-lifting equipment transferring the equipment containing SFA, it is proposed to use seismic resistance equipment with the increased reliability parameters.

The preliminary analysis allows affirming that violations in handling operations will not lead to additional dose loads of the personnel.

Violations in MPC lowering from HI-TRAC into HI-STAR

The reason of this initial event is the gross error of the personnel resulting in the following:

- either HI-TRAC and HI-STAR will not be placed along one vertical in lowering of the loaded MPC in the HI-STAR;

- or there is foreign matter in the HI-STAR or in the HI-TRAC interfering free MPC lowering into the HI-STAR during crane hook lowering.

This event can occur once only in HI-STAR loading and is of low probability. The event is revealed by strange sounds in slipping of the lowered MPC on the HI-TRAC or HI-STAR surface. In the worst case, easing of tension of cable slings connecting MPC with the crane hook will be noticeable. In any of these events the operation personnel must give immediately a command to the crane operator to stop MPC lowering, to lift it and to put it back to the HI-TRAC.

Taking into account, that during MPC lowering the gravity is the only force acting on it, the worst alternative will be load impact because of 1g acceleration on the MPC bottom or side face if MPC is stopped by a hindrance. In evaluating consequences it is taken into account that MPC is designed for greater loads than 1g, therefore this event will not lead to MPC destruction.

To assess personnel additional doses in accident liquidation it is supposed that two persons work at the distance of 1 meter from the HI-TRAC during additional 30 minutes. Taking radiation dose rate at 1-meter distance from the HI-TRAC side face to be 126 mrem/h (see Table 3.4.4), it is possible to make a conclusion that liquidation of this accident will lead to the total additional radiation dose of 126 human-mrem.

In this event the following measures must be taken:

- to stop immediately further MPC lowering;
- to lift the MPC and return it into the HI-TRAC;
- to check whether the HI-TRAC and HI-STAR centers coincide;
- to check whether the HI-TRAC and HI-STAR baseplates are in a horizontal plane;
- to check whether the HI-STAR has a restriction;
- to repeat MPC lowering.

3.5.2 Design basis accidents

3.5.2.1 Earthquake

The receiving building, the HI-STORM storage area as 1 category structures of nuclear and radiation safety according to PiN AE 5.6 and of 1 category of seismic resistance according to PNAEG 5-006-87 are designed in a way to withstand loads in earthquakes (SSE) (1 time per 10000 years), that corresponds to the earthquake of magnitude 6 for this site. At that, in accordance with the definition of 1 seismic resistance category structure in PNAE-G 5-006-87, it means that the building/structure after an earthquake of magnitude 6 keeps its protective and localizing functions. Thus, the earthquake is not an initial event for the design basis accident.

During HI-STORM 100 system licensing in the USA, the HI-STORM overpack stability has been analyzed in seismic impacts. The performed analysis of cask immobility in seismic loads has shown that in the HI-STORM horizontal acceleration of 0,1g (of magnitude 7) and corresponding vertical acceleration, it keeps its quiescent state in the friction coefficient to be not less than 0,1, i.e. the overpack immobility is ensured.

3.5.2.2 Tornado

The receiving building and the HI-STORM as the 1st category structures of nuclear and radiation safety according to PiN AE 5.6 must be designed taking into account special impacts caused by a tornado that corresponds to class 3 tornado for this site. As strength of walls of the receiving building will be designed taking into account load resistance originating in the design event - the tornado of class 3, the integrity of the building external walls will be preserved. Thus, the tornado is not an initial event of design basis accident.

The tornado design criteria for the HI-STORM (see Table 3.5.4) used in calculations for the

system licensing in the USA are more strict than the input data for the CSFSF site (see Table 3.5.3).

The possible types of HI-STORM damages to be analyzed as a result of tornados include breaking of the upper overpack part due to wind impact, loss of stability and damage of the external enclosure by missiles.

The system HI-STORM 100 must withstand pressure, wind and missiles resulted from tornados. The calculated wind and tornado parameters for the HI-STORM system are presented in Table 3.5.4. Pressure drop is limited by the calculated MPC external pressure for emergencies.

The list and characteristics of postulated missiles taken into account during the HI-STORM 100 system licensing are presented in Table 3.5.5.

Table 3.5.3 - Tornado characteristics for the CSFSF siting

Condition	Parameter
Maximum vortex rotation speed, V_p (m/sec.)	81
Speed of tornado forward movement, U_p (m/sec.)	20,3
Pressure drop between the center and periphery of the tornado vortex, ΔPp (GPa)	81

Table 3.5.4 - Tornado characteristics taken into account in the HI-STORM licensing in the USA

Condition	Parameter
Horizontal constituent of the tornado vortex rotary speed, m/sec.	130
Speed of objects transfer (m/sec.)	31
Maximum wind speed (m/sec.)	160
Pressure drop between the center and periphery of the tornado vortex (kPa)	20,7

Table 3.5.5 - Characteristics of missiles

Object characteristic	Weight (kg)	Speed (m/sec.)
An auto	1800	56,3
A strong steel cylinder (diameter of 20,3 cm)	125	56,3
A sphere (diameter of 2,54 cm)	0,22	56,3

The impact of hurricanes and missiles in tornados are considered separately and are combined according to NUREG - 0800. The tornado characteristics for design calculations were selected according to manual materials of Regulatory Guide 1.76.

The analysis shows that the tornado impact force is insufficient to overturn or move an overpack because the overturning moment is less than the restoring moment and the slipping friction coefficient (for steel or concrete) is higher than 0,11.

The calculations of overpack enclosure and cover plate resistance to armour-piercer penetration show that thickness of the concrete and steel layer is sufficient to prevent crushing,

cracking or cleaving of various overpack elements serving as shell-barriers. General overpack reaction to the shock impact caused by deformable "gear" possessing large energy was estimated. Such calculations show that the overpack remains in a vertical position after such an event and that loadings caused by impact will not affect the overpack integrity.

As postulated loadings in tornados are not able to turn down the overpack, they do not impact on the MPC as well.

Thus, the tornado is not an initial event of a design basis accident for the HI-STORM. The detailed calculations will be carried out for the HI-STORM overpack in licensing this technology in Ukraine.

3.5.2.3 Lightning strokes

The lightning protection system for all buildings and structures including the HI-STORM overpacks are provided for at the CSFSF. The system is designed to ensure protection against lightning strokes.

Lightning is not considered the initial event of the design basis accident for buildings and structures where the lightning protection system is provided for.

3.5.2.4 Strong winds, hurricane

Wind impact does not exceed tornado impact. Thus, if the tornado is not an initial event of the design basis accident, it may be assumed that strong wind is not an initial event of the design basis accident as well.

3.5.2.5 Water flooding in floods and high waters

The events related to possible CSFSF flooding were considered the initial events in floods and high waters at the rivers Uzh, Sakhan and Pripyat.

The maximum level of spring high water of +110,40 m of the Baltic System has been considered that cannot impact on the CSFSF buildings and the HI-STORM because the planning level of the site is not less than +138,50 m of the BS.

Thus, water flooding is not the initial event for the design basis accident.

3.5.2.6 Heavy snowfall

For CSFSF buildings and structures the maximum snow load is small in comparison with the impact of other considered loads.

The HI-STORM overpack is designed taking into account snow and glacial impacts. At that, in licensing the system in the USA, the data for the United States continental part and Alaska were used to calculate snow pressure on the HI-STORM. The calculated snow pressure values for warmed structures (heat from spent fuel), such as the HI-STORM system, vary within limits of 3,4-4,8 kgf/cm2. Taking into account that Ukraine is situated further south than Alaska and the maximum snow quantity within the CSFSF siting is 75 cm, it is considered that heavy snowfall is not the initial event of the DBA as for pressure on the HI-STORM.

Snowfall impact from the viewpoint of the HI-STORM vent port clogging is considered in analysis of vent ports complete clogging.

3.5.2.7 Heavy rains

The absolute daily precipitation maximum registered during the whole observation period within the CSFSF site fell in May 1983 and was 81 mm. With the frequency of 1 time per one hundred years the daily maximum can reach or exceed 100 mm.

The shower sewer system is provided for the CSFSF territory that is intended for drainage of water falling out in heavy rains, and, thus, water flooding of the CSFSF territory including the HI-

STORM storage area is prevented.

The HI-STORM vent ports are placed at ground level; hence, in abnormal heavy rains it is possible that the precipitation level will be higher than the vent port level. This event is considered because of complete clogging of vent ports. SFAs are housed in sealed MPC, therefore water ingress to them is excluded.

3.5.2.8 Landslides of any genesis, ground collapses

According to the CSFSF industrial site ground composition, there is no risk of landslides and collapses for the site.

3.5.2.9 Washing out of shores, slopes, river-beds

The site is situated at the significant distance from the river-beds, therefore the given initial events for the site are not considered.

3.5.2.10 Territory collapse and depression, including underground washout

The site conditions (ground water level is lower than 20 m from the ground level) and the decisions made in construction of the CSFSF buildings and structures (measures for considering of building settlements and lists) exclude the given initial event for the CSFSF.

3.5.2.11 Explosions, fires beyond the site

Taking into account that there is a road next to the CSFSF site, explosion of a car vehicle transporting acetylene balloons is considered as an initial event.

The receiving building and the HI-STORM as the structures of category 1of nuclear and radiation safety responsibility according to PiN AE 5.6 must be designed taking into account special impacts caused by an external explosion. Its structures must withstand impact of an air explosive wave with front pressure up to 30kPa with duration of a compression phase up to 1sec. at horizontal propagation.

An accident with a car transporting balloons with liquefied gas (acetylene, 40 kg) along the road to the Vector Complex is taken as the initial event. Resulted from the car accident, there is gas leakage; therefore the cloud of acetylene-air mix is formed in stoichiometric ratio. This cloud is approximately a hemisphere in the middle of which an explosion is initiated. The excess pressure at the blast wave front of 10 kPa is attained for 40 kg of acetylene at the distance of 73 m, i.e. the design criterion parameters for the receiving building design are not achieved, and hence, the building structures will not collapse.

The air wave parameters for which the HI-STORM system elements are designed are presented in Table 3.5.6. The table shows that external HI-STORM elements are designed for the maximal external pressure of 69 kPa that is higher than a possible shock wave due to acetylene balloon explosion. At the design stage the analysis of explosive danger to the CSFSF site will be carried out and the specific parameters of an explosive wave potentially possible for the site conditions will be determined.

Table 3.5.6 – Calculated pressure values

Pressure	Conditions	Pressure
External pressure on the HI-STORM	Normal	(0) External
	Not-established	(0) External

	Accident	69 kPa (pressure differential during 1 second at maximum) or 34 kPa (pressure differential in static conditions)

The analysis performed in the SAR for HI-STORM system licensing in the USA shows that pressure of an explosive wave from the accident with explosion near the HI-STORM storage area will not cause HI-STORM turning down or displacement. Therefore the radioactive release because of explosion will not take place.

The CSFSF site is located within the forest area. Fire-prevention strip creation outside the CSFSF industrial site is provided for according to the regulatory requirements for exclusion of forest fire impact on the CSFSF buildings and structures.

3.5.2.12 Acts of terrorism and nuclear material theft

The accepted technical decisions for SNF storage technology (sealed MPC and the metal-concrete protective HI-STORM) and decisions being accepted for the physical protection system allow excluding of ionizing radiation source theft, including nuclear material from initial events of design basis accidents.

Consequences of terrorist acts related to HI-STORM overpack damage are considered as consequences of the initial event related to external/internal explosion. At this design stage it is assumed that the shock explosive wave created during a terrorist act will not create pressure above 69kPa with duration of a compression phase up to 1sec. at which the HI-STORM integrity is provided. To reduce the probability of terrorist acts at the CSFSF it is provided for to create areas of special importance inside the guarded CSFSF perimeter to which the storage area refers as well. Hence, at this design stage taking into account the accepted physical protection measures it is accepted that the terrorist act is not initial event of the accident.

3.5.2.13 Fire inside CSFSF

Diesel fuel, car fuel and lubricants are combustible materials used in CSFSF.

The following events are considered as initial events of a fire inside CSFSF:

- fire indoors of the diesel generator room;
- fire of a gasoline tanker with fuel in fuel unloading into gasoline station capacities;
- fire in HI-STORM transit with the crawler from the receiving building to the storage area resulted from ignition of the transporter fuel tank.

A fire in one of the rooms is considered where diesel fuel is used for diesel equipment (the diesel generator room). The room is located in the detached building of electrical and technical equipment in the free-access area and has no contact with the rooms where containers with SFA and radioactive substances are stored. The building of electrical and technical equipment is designed in accordance with flame-resistance degree II. The fire alarm and fire protection system will provide with automatic gas fire extinguishing in the diesel generator room. Thus, the accepted fire protection measures allow excluding the current fire impact on structures of the cask storage area and on the receiving building storing containers with SFA and radioactive waste.

A fire of a gasoline tanker during the fuel discharge into gasoline station capacities can arise due to leakages in gasoline pumping and violation of fire safety rules. The gasoline station is situated at the distance not less than 70 m from the cask storage area, hence, if HI-STORM fire resistance on the crawler will be proved, it can be assumed that the given fire impact also will not lead to an accident with radioactive substance release into the environment.

During HI-STORM licensing in the USA the leak and ignition of 227,3 l of fuel from the crawler is considered as the fire initial event. The fire was regarded as an impact of incident radiation and of a specific thermal stream with forced convection on the HI-STORM surface. The fire temperature was assumed to be equal of 800°C (1475° F).

At the event analysis the following initial assumptions are taken:

- the HI-STORM overpack is completely enveloped in flames, the additional surface heat exchange area in the conservative approach is considered as the increase of the fire temperature;
- the minimally required value of average emissivity coefficient is not less than 0,9;
- it is accepted that the painted HI-STORM external surface will remain undamaged at the emissivity coefficient of 0,85;
- it was assumed conservatively that the emissivity coefficient of flame equal to 1,0 (the limiting maximum value) will lead to complete source blackening. If it is conservatively assumed that the emissivity coefficient of a flame is 1,0 and the emissivity coefficient for the painted surface is 0,85, the effective emissivity coefficient is 0,85. As the minimally required value of 0,9 is higher than the actual value 0,85, use of the average emissivity coefficient of 0,9 is conservative;
- the average flame temperature is not less than 800°C (1475°F); this is conservatively because the open flame, as a rule, captures great volume of the air that leads to the lower flame temperature. In addition, it was conservatively assumed that the same temperature values could be applied to the whole inflamed overpack surface. The given values are rather conservative and take into account the HI-STORM size.
- the fuel source impacts with the front width of 1 m (40 inches); this is conservatively because the stream actually can be more than the boundary lines of the HI-STORM external surface, i.e. more than 3 meters (10 foots). The conservative approach means that the fire impact time at equal amount of combustible substance increases in use of the front width of 1 m;
- based on the results of natural measurements of the HI-STORM surface temperature carried out at a large-scale fire, taking into account conditions a short-term fire the conservative forced convection coefficient of heat exchange being equal to 25,55 W/m^{2*o}C was applied.

Taking into account the conservative fire conditions and its accompanying thermal stream from the fire, the solar insulation effect is insignificant and was not taken into account. Moreover, the smoke screen resulted from the fire blocks the most part of solar insolation.

Taking into account the fuel volume in the tank (227,3 l), the HI-STORM outside diameter (3,492 m) and the accepted burning fuel front width (1 m), the burning fuel ring will occupy the area of 13,71m^2 and will have the depth of 1,37 cm. Proceeding from this depth and the linear fuel consumption of 3,8 mm/min, the estimated fire time will be 3,622 minutes (217 seconds). The linear fuel consumption of 3,8 mm/min. is the minimum calculated value presented in the Report of temperature tests for the modeled fire at the Sandia site large area. The minimal linear consumption use is the conservative approach because it increases the fire time.

Under the specified fire characteristics the fuel element cladding temperature did not exceed the permissible temperature according to the USA requirements. At the design stage the HI-STORM fire risk analysis of the CSFSF site will be executed.

Fire impact on the HI-STAR overpack was studied according to the safety requirements in the USA. The real fire accident occurred during spent fuel transportation in the tunnel of Howard Street in Baltimore was studied as a fire model. The NIST code for modeling the fire spreading dynamics was used; it was confirmed by the test program data on the fire arisen in the tunnel. The given code simulated characteristics of space temperature in the tunnel that did not have ventilation, and the fire source was a tripropylen puddle. The fire was not eased within seven hours. A transport

complex including HI-STAR overpack containing the MPC with the PWR spent fuel, a frame, and a railway platform was simulated. Two scenarios were analyzed:

Scenario 1: the HI-STAR center was at the distance of 20 meters (on the length of one platform) from the fire source (in accordance with 49CFR174.85).

Scenario 2: the HI-STAR was near the fire (the HI-STAR center was at the distance of 5 meters from the fire).

The estimated time for achieving the limiting temperature value of fuel element cladding (570°C (1058ºF)) by scenario 1 and scenario 2 is 100 hours and 30 hours, correspondingly. The overpack lifetime is 30 years at both scenarios. The results shown that the MPC ensures the SFA protective function even during ultimate event succession when HI-STAR 100 is enveloped in flame (temperature exceeds 816°C) within 7 hours. The fire analysis carried out by the US Nuclear Regulatory Commission shown that MPC is the important element which allows to weaken fire impact on SFA due to the stainless steel all-welded, enclosed and filled with inert gas structure that is a bad heat conductor and, hence, is a barrier against propagation of fire-generated heat into the stored fuel. A shipping cask not using the MPC (for example, a container with a bolted cover plate) will not be resistant to fire impact. The Nuclear Regulatory Commission has given recommendations to the US Department of Energy to use the MPC during SNF transportations as the important element of a shipping cask that ensures safety for life and health of the public.

3.5.2.14 Explosion inside CSFSF

Explosive gases are not used in CSFSF and explosive materials are not applied during the processes.

An explosion in the CSFSF can be caused only by ignition of fuel contained in fuel capacities in the gasoline station at the distance of 50-70 m from the HI-STORM storage area and at the distance of 70 m from the receiving building.

Explosion and fire impact on the gasoline station can be considered only from the viewpoint of impact on the receiving building structures and the HI-STORM overpacks.

The receiving building as the structure of category 1 of responsibility for nuclear and radiation safety according to PiN AE 5.6 must be designed taking into account special impacts caused by an external explosion. Its structures must withstand impact of an air explosion wave with front pressure up to 30kPa with compression phase duration up to 1 sec. at the horizontal propagation.

As it is shown in Table 3.5.6, the HI-STORM external surfaces are designed for pressure of 64 kPa.

The given design stage supposes that explosion in the gasoline station will not lead to creation of an air explosion wave with the front pressure above 30 kPa, hence, an internal explosion is not considered as the initial event of accidents for the receiving building and the HI-STORM overpacks.

3.5.2.15 Power failure

In failure of CSFSF external electric-power, it provided for the transfer to the reliable power supply system (diesel-generators) for systems influencing nuclear and radiation safety of the facility.

The uninterrupted supply sources are provided for the systems excluding disrupt of electric-power while diesel-generators are switched on.

For other safety-related systems the time of the complete power failure will not exceed 5 minutes. Two independent diesel-generator sections are provided for to exclude impact of diesel-generator failure on power supply of the safety-related systems under conditions of the complete CSFSF power failure. Thus, if one section fails, it is possible that the other section switches on.

Considering that the direct handling of spent fuel assemblies at the CSFSF is not provided

for, and spent fuel assemblies are in an inert atmosphere in the MPC, electric-power supply loss at handling operations with MPC is not the initial event of the design basis accident.

3.5.2.16 Emergency pressure in the MPC

In designing and licensing the HI-STORM system in the USA the calculated pressures inside the MPC (Table 3.5.7) are determined at which there is no release of radioactive substances beyond the MPC boundaries. The given calculations will be substantiated at the MPC certification stage of in Ukraine.

Table 3.5.7- Calculated pressure parameters in MPC

Pressure	Conditions	Pressure (MPa)
MPC inner pressure	Normal	0,7
	Off-normal	0,76
	Accident	1,4

Under normal operation conditions (NOC) the pressure in the MPC may rise higher than the established one during MPC sealing:

- due to raise of the average gas temperature in the fuel element cladding and MPC;
- due to permissible leakage of fuel element cladding.

Because of the first reason the maximal pressure in the MPC is possible only in extreme atmospheric air temperature. However the ambient air temperature analysis in section 3.5.1 has shown that the ambient air temperature at the CSFSF site cannot exceed the temperature for which the MPC is designed. Hence, the given reason is not real for the CSFSF site conditions.

Possible pressure raise in MPC in the second case is determined by the permissible number of fuel elements with gas-leaky claddings of 1 % (the safety operation limit for fuel assemblies during their operation in the reactor core according to item 1.2 of the appendix to PBYa RU AS - 89). All spent fuel assemblies unloaded from the core pass the leakage testing of fuel element cladding according to the burst can detection system ("KGO") acting at NPPs. As a result, gas enters from leaky fuel element cladding into the MPC space and accordingly builds up pressure in the MPC. The design stage the total geometrical volume of gas filling fuel element cladding and MPC free space will be determined in the CSFSF SAR, and, accordingly, the volume of the gases penetrating from "leaky" claddings (1 %) into the MPC helium space will be calculated. It will be reduced to atmospheric pressure and gas average temperature; generated excess pressure will be calculated as well. It is expected that generated pressure in the MPC will not be higher than the pressure for which the MPC is designed (Table 3.7.10). Hence, at permissible leakage of fuel element claddings, MPC seal failure is not expected as well as the additional personnel exposure.

If during the leakage test it is revealed that fuel elements are leaky, they are handled as defective spent fuel assemblies with special tubes for damaged fuel described in Section 2.2.1.

As to the emergency seal failure of all fuel element claddings the probability of this event belongs to the category of beyond design basis accidents. The unique cause of seal failure of all fuel element claddings housed in the MPC may be significant external dynamic impact on SFAs at their loading in MPC. Even if it is supposed that such an accident may occur, it will be detected at subsequent MPC filling with helium (before final sealing), and such MPC will be considered to be emergency one and will not be transferred at CSFSF. Thus, the accident with simultaneous seal failure of all fuel element claddings housed in the MPC can be presented only as a beyond design basis accident.

3.5.2.17 Release of radioactive substances from the MPC external surface

The proposed technical decisions using the HI-TRAC transfer cask during SFA loading in

the MPC in the NPP cooling pond reduce MPC surface contamination probability with fuel cooling pond water.

MPC surface contamination with the cooling pond water above the permissible levels is considered to be an initial event. MPC radioactive surface contamination with β-emitters will constitute conservatively $8{,}73\times10^{7}$ Bq/m^2 ($2{,}36\times10^{5}$ β-particles/ cm^2·min). At the same time this condition has not been defined in MPC loading in the HI-STAR in NPP.

If the excess of the superficial contamination limit was not detected in time prior to MPC transfer for storage from the NPP power unit, the radioactive particles can release into the environment due to the following two cases:

- during removal of MPC from the HI-STAR (short-term release from the receiving building stack);
- during MPC storage in the HI-STORM at the CSFSF storage area (continuous release from the storage module within 1 year).

Under the possible square of the MPC-31 surface contamination equal to 30,54 m^2, the release activity will be $2{,}67\times10^{9}$ Bq. The release is conservatively presented only by the radionuclide ^{60}Co.

This initial event is a design basis accident with the maximum consequences.

The worst values were conservatively chosen from the obtained results in analyzing radiation impacts of releases from the ventilation stack and from the HI-STORM.

The radionuclide dissemination in the atmosphere, in the case of the given event, was calculated with the modified Gauss method recommended by the IAEA (the method is presented in the appendix of Volume 3, part 2). The calculation results of the individual effective equivalent dose depending on distance from the release source are presented at Figure 3.5.1.

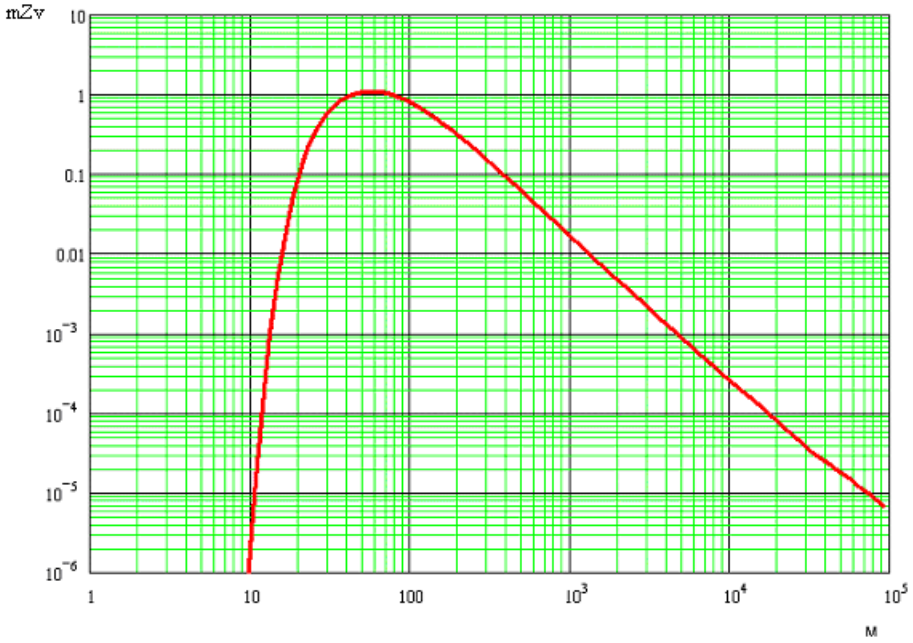


Figure 3.5.1-Dependence of effective radiation dose (mZv/year) due to all ^{60}Co impact routes from the distance (m) to the CSFSF at the release from HI-STORM within 1 year.

The above analysis shows that the additional personnel doses will not lead to excess of the permissible annual dose limits during radioactive contamination release from MPC surface.

3.5.3 Beyond design basis accidents

This section specifies initial events for beyond design basis accidents regulated by the requirements of PNAE-G-14-029-91, the IAEA and the US NRC.

The initial events leading to beyond design basis accidents according to the requirements of PNAE-G-14-029-91 are:

a) extreme natural phenomena with the impact parameters exceeding the design impacts considered in sections 3.5.1 and 3.5.2;

b) beyond design basis accidents at nuclear facilities adjacent to the SFSF site - not considered because there are no nuclear facilities in the neighborhood (the nearest ChNPP is situated at the distance of 12 km);

c) aircraft crash is considered based on probabilistic assessment or risk estimations for this event;

d) origination of self-sustaining chain fission reaction for SNF storage and management systems (it is not possible in the CSFSF because SFA handling is not supposed, at this case SFAs are housed in the sealed MPC in the inert medium).

Aircraft crash is the initial event leading to a beyond design basis accident for the SNF storage system according to the IAEA requirements.

The following events were considered to be initial events leading to a beyond design basis accidents for the HI-STORM storage system in the USA:

- hypothetical criticality;
- blockages;
- full clogging of HI-STORM vents;
- aircraft crash;
- HI-TRAC with MPC falling from the altitude of 38 m;

Taking into account that the Holtec International data are used at this design stage in describing the initial events, the beyond design basis accidents examined for the HI-STORM system during it licensing in the USA are presented below.

3.5.3.1 Hypothetical origin of criticality

It is assumed that the criticality may casually origin only during MPC loading at NPP. Taking into account that process of SFA loading into the MPC is similar to the existing process of SFA loading into the transport cask TK-13 (TK-6), this analysis is made in the SAR for the specific NPP power units. At the CSFSF design stage the beyond design basis accident will be considered in the SAR for MPC loading taking into account loading process particularities.

3.5.3.2 Blockages

Flooding, storm wind or mudflow can be initial events of blockages. Mudflows, missiles resulted from tornado or wreckages resulted from flooding can lead to clogging of ports. A blockage is an extremely rare event, however, it was analyzed in the SAR during HI-STORM licensing in the USA.

In the event analysis, wreckages were considered to be a material with maximum heat-insulated properties. At the same time, the MPC in the HI-STORM is exposed to short-term heating under adiabatic conditions. The minimum time required that fuel cladding reaches the short-term design temperature limit depends on the overpack thermal lag, environmental conditions where the overpack was stored, and convective heat exchange in SNF decay.

Between the maximum design temperature of fuel element cladding and the short-term temperature limit of fuel element cladding there is a difference about of 149°C (300°F). The conservative value of 66°C (150°F) is taken as the permissible fuel element cladding temperature

increase at HI-STORM blockage under wreckages, and then the dependence of thermal loading on the MPC from a time is calculated. The time during which the fuel element cladding temperature will reach the regulated limit was determined with the following formula:

$$\Delta t = \frac{m \times c_p \times \Delta T}{Q}$$

Where:

Δt = permissible term of HI-STORM stay under wreckage (in hours)

m = HI-STORM weight (in pounds)

c_p = specific heat (the British thermal unit/pound×°F)

ΔT = permissible fuel element cladding temperature increase (150°F)

Q = general thermal load from heat generation during decay (the British thermal unit/hour)

The analysis results shown that even the HI-STORM is buried under blockages, the permissible limit fuel element cladding temperature will not be achieved during the time necessary for overpack clearing from blockages. Moreover, wreckage will perform additional function of shielding and radiation level decrease at liquidation of such an accident. Hence, it is considered that the given accident will not result in release of radioactive substances into the environment.

3.5.3.3 Complete clogging of HI-STORM vent port

The consequence of complete HI-STORM vent port clogging is that normal air circulation required for MPC cooling will be ceased. A small heat amount will be nevertheless removed due to the local circuit of air circulation in the HI-STORM and its vent ports, and the MPC will continue to radiate heat into the colder HI-STORM. At temperature increase of the MPC the HI-STORM temperature will grow. Under such conditions the temperature of the HI-STORM, the MPC and the stored SFA will grow proportionally to the time.

Because of the significant weight and, accordingly, high heat capacity of the ferro-concrete HI-STORM (its weight exceeds 77 t), it is assumed that the temperature may significantly increase only in complete port clogging during several days. Taking into account that the stationary air temperature monitoring at the vent port inlet and exit, and also every day procedural overpacks rounds are provided for during storage, the given initial event can be excluded.

In estimating doses for the personnel involved in clearing of ventilating ports it is accepted that the worker kneeling within 30 minutes (the actual time spent on knees) cleans manually the inlet port. Considering that the dose rate at the Hi-STORM side surface is 53 mrem/h (see Table 3.4.4), it is possible to make a conclusion that worker palms and forearm will receive the dose of 21 mrem during 30 minutes, the breast and the trunk will receive a slightly smaller dose. Thus, the received doses taking into account the conservative approach are significantly lower than the permissible doses.

3.5.3.4 Aircraft crash

The initial event with aircraft crash was considered during the HI-STORM system licensing in the USA. The main results of the analysis performed in the SAR are presented below.

The HI-STORM is a steel welded structure with homogeneous concrete bulk (without armature or other sources which can cause cracks). Total radial thickness on which the flying object impacts and that it shall penetrate to reach the MPC is approximately 76 cm of steel and concrete. Design characteristics of the HI-STORM vessel are chosen in a way that it will be not exposed to brittle fracture under very low temperatures in winters in the northern part of the United States. Thus, the HI-STORM design is resistant to shock and impulse loads even at the coldest weather. The HI-STORM top part is made as a heavy steel welded closure plate that is fastened to the

cylindrical vessel with four big bolts, with the permissible combined axial load above 1361 t (see Figure 3.5.2).

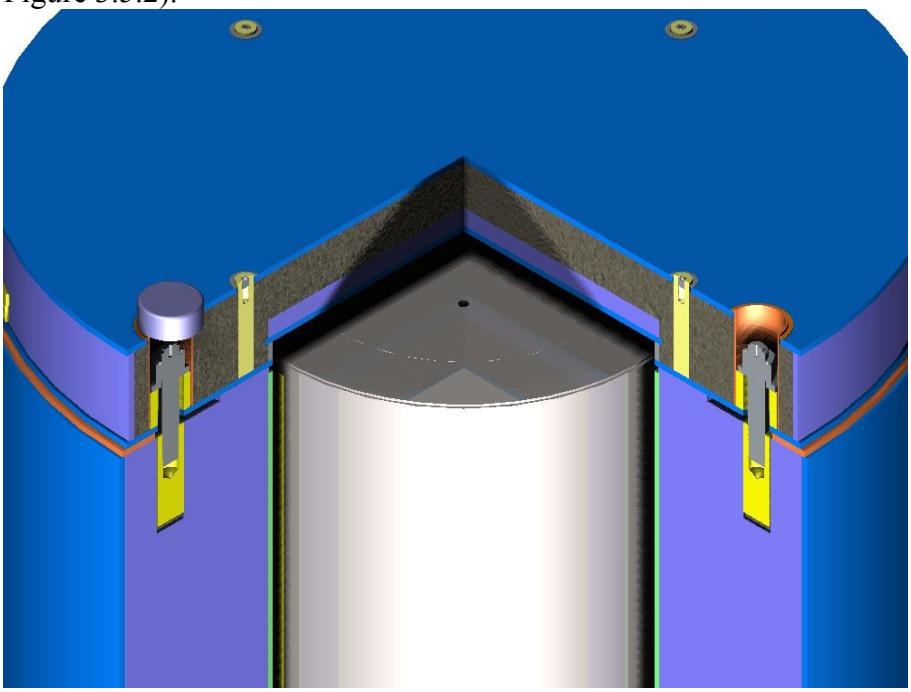


Figure 3.5.2-General view of a bolt joint of the HI-STORM closure plate

The HI-STORM is a cylinder that reacts a load several orders more than the bearing strength of the structures with plane faces. The ring-shaped cylindrical vessel is capable to resist considerably larger loads than structures with plane faces, basically due to distribution of tensile and/or compressing load at width, in contrast to bending moment distribution.

The HI-STORM system in its physical form is a free standing heavy cylinder (about 150 t in the loaded condition) with low relative elongation factor (as for altitude-diameter ratio). The following airplanes were considered to be the input data for the beyond design basis accident with aircraft crash:

- a non-rigid small private or service airplane flying with small or average speed, and containing firm elements of small weight;
- a non-rigid big multi-engine airplane flying with average speed, and containing the big fuel weight and heavy propellers;
- a non-rigid small high-speed airplane carrying multi-purpose firm elements, such as the engine and artillery equipment;

Figures 3.5.3 and 3.5.4 illustrate possible scenarios of airplane collision with the overpack. At figure 3.5.3 a sizable airplane collides with an overpack row, in this case the heavy “firm” aircraft engine (approximately 5 t per one engine and a cabin) will collide most likely with one overpack, and the rest part of the airplane will collide with other overpacks.

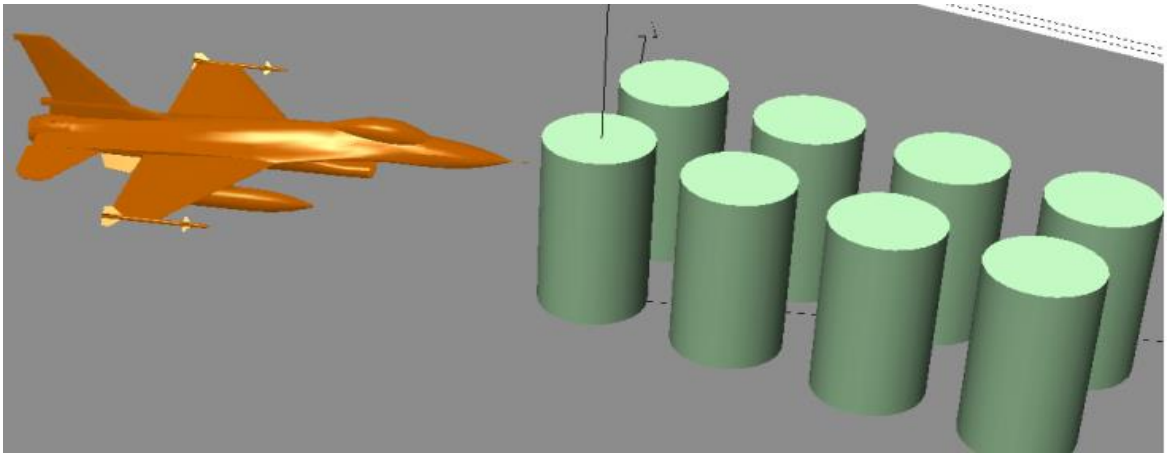


Figure 3.5.3. – Simulation of F-16 fighter collision of with a corner overpack

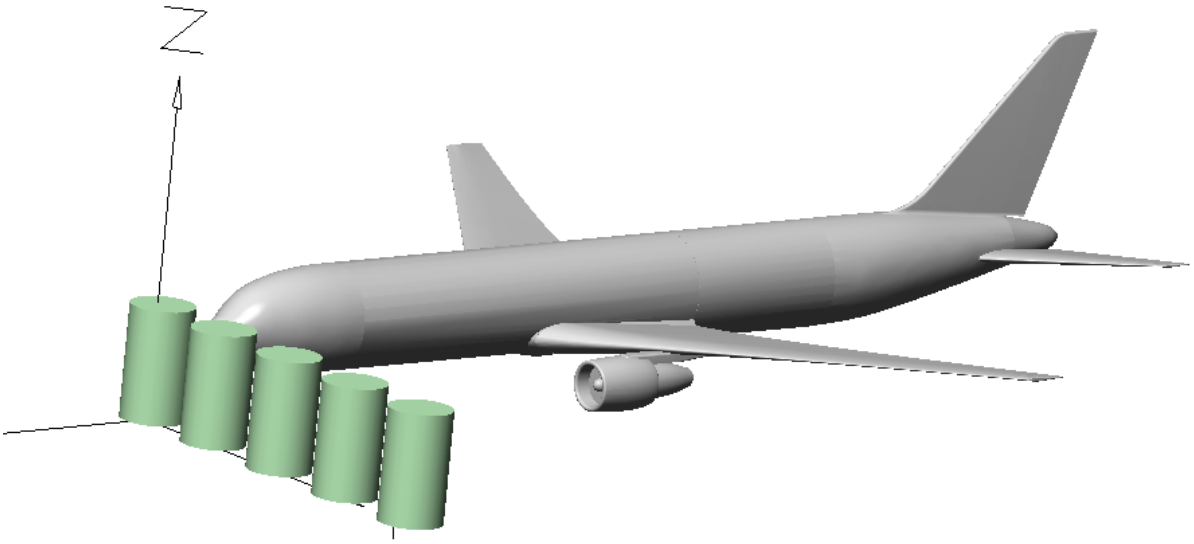


Figure 3.5.4. –Collision of a civil airplane with an overpack row

The explosion calculated by the Holtec International shows that a non-rigid small private airplane will distribute the bulk of its energy through an internal plastic deformation that renders small effect on the overpack. If a big airplane or one of its heavy engines with an average speed collides, or a small airplane flying with a high speed and carrying several firm elements collides, the collision can lead to overpack turning down. In this case if the overpack overturns, thus it will disseminate the energy given by a flying object to the metal and concrete HI-STORM shells and to the MPC confinement shell. The given statement is not true if the falling object (an airplane cargo) is intended for armor breaching due to a powerful heat release and metal cutting (with an acute protruding edge).

The Holtec International with the LS-DYNA code has developed the collision model of an airplane with the weight of 17t, having one jet engine of 2 t installed in the back part of the fuselage with the HI-STORM system located in a free order. The calculation has shown that the HI-STORM cylindrical shell is not breached under impact of objects with different speeds and different angles. Besides, the calculation has shown that:

- the overpack on a tangent reflects impact that can get on the nearest overpack at an average collision speed into the middle HI-STORM part. The impacted section remains non-

breached;

- the dent depth and square increases if collision speed increases; the altitude of the collision increases as well. In this case, the impacted HI-STORM rotates, shifts from it place and can collides with neighboring overpacks. Depending on linear and angular moments obtained at the collision one or both containers can turn and overturn;
- under airplane falling scenarios the HI-STORM close plates were not separated from the HI-STORM vessel, and MPC confinement remained safe;
- the vertical impact of a loaded airplane flying with an above-average speed to the closure plate did not breach the HI-STORM closure plate.

Besides of shock impact from an airplane collision, impact of fire arisen as a result of an aviation fuel ignition after collision was considered. According to the performed estimations, the MPC placed inside the HI-STORM will remain leak-tight during about an hour even if it is embraced with flames from the inflamed aviation fuel. Because the CSFSF storage area is a smooth surface, fire from the inflamed aviation fuel will be distributed along the surface area on the large square, thus the burning time will be short.

In the conclusion it is possible to add that the total effect of airplane or airborne engine collision with the HI-STORM overpack cannot cause an event with significant radiological impact on the CSFSF where HI-STORM are situated.

In order to estimate HI-STAR ability to preserve its properties during the accident with aircraft crash, the collision scenario of the HI-STAR with an airplane with the jet engine Boeing 767 (Figure 3.5.5) was developed. It was supposed, that the HI-STAR is in a transport position on the flat railway platform with impact limiters, and it contains a completely loaded MPC. The HI-STAR integrity estimation was comprised of a series of experiments analyzing HI-STAR damage rate at various speeds of the Boeing 767 engine under different attack angles. The calculation performed in accordance with the conservative modeling has shown that the MPC outer shell remains undamaged with large safety margins at all collision scenarios.

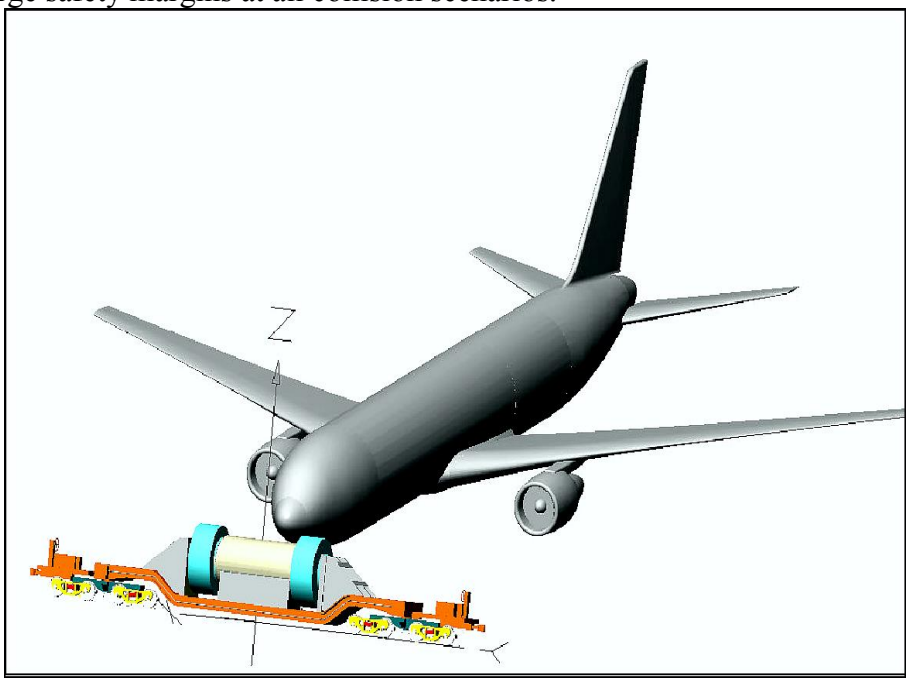


Figure 3.5.5 - Simulation of collision of the Boeing 767 airplane with the HI-STAR during transportation

3.5.3.5 Failure of all fuel elements with MPC enclosure failure

Radionuclide release from MPC confinement failure was considered during the HI-STORM storage system licensing in the USA in accordance with NUREG/CR-6487. To estimate accident consequences the US PWR SNF was considered with the maximum burn-up level of 70,000 MW day/kg U cooled in a fuel cooling pond within 5 years and initially enriched to 4,8 % ^{235}U. Within the accident estimation the impact of pressure raise inside the MPC due to decay heat generated by spent fuel stored in the MPC on the MPC leakage value was estimated according to the ASME requirements, section III, sub-item NB taking into account that welded joints were done according to the rules.

In accident estimation the internal pressure raise in the MPC up to 1,4 MPa and a leak from the MPC connected to such a pressure was considered and the personnel doses at the distance of 100 m from the damaged MPC were determined. The leak of $5x10^{-6}$ atm-cm^3/sec. in normal operation in the internal pressure of 0,69 MPa is assumed as a leak criterion that met the requirements of the Technical storage specification in the USA. Further rise of the internal pressure up to 1,6 MPA was examined and the greatest possible leak of $3,3x10^{-4}$ cm^3/sec was estimated. Possible release into the environment considering the MPC contents and release proportion is specified in NUREG-6487 [24] as follows:

- ^{85}Kr - 0,3;
- ^{60}Co - 1;
- ^{90}Sr, 134Cs, ^{137}Cs, ^{106}Ru - 2,0x10-4;
- ^{241}Pu, ^{144}Ce and other transuranium elements - 3,0x10-5.

The ^{60}Co amount is conditioned by the maximum surface activity of SFA. For the spent fuel assemblies from the PWR reactors in the US according to NUREG-6487 [24] the spent fuel assembly superficial contamination with ^{60}Co is $5,18x10^6$ Bq/cm^2.

According to NUREG-1536 [25] the release within 720 hours (30 days) was examined. In this case it was assumed that a person within 24 hours during 30 days is at the distance of 100 m from the damaged MPC. Moreover, all fuel elements in the MPC are breached and leakage into the environment is $3,3x10^{-4}$ cm^3/c. The following radiation doses of the personnel at the distance of 100 m from the damaged MPC are calculated:

- the total effective doze is 0,291 mZv;
- the effective doze the whole body is 0,0276 mkZv;
- the effective doze from inhalation is 0,291 mZv.

Such an accident is an absolutely hypothetical case of failure of all fuel elements in the MPC with subsequent release of gaseous fission products. It is impossible to determine any real initial event which direct consequences would entail simultaneous damage of MPC and all fuel elements housed in it. The unique impact on the HI-STORM storage module that can lead to simultaneous damage of MPC and all fuel elements is the significant external dynamic impact (for example, as a result of special missiles, etc.). This accident is considered to demonstrate relatively insignificant radiation aftereffects of an accident in the CSFSF even taking into account hypothetical initial events.

From the point of view of the radiological aftereffects the given accident is regarded as the beyond design basis accident with the maximal impact.

During a beyond design basis accident in the CSFSF the peak value of an individual effective dose will not exceed of 20 mZv. Thus, the individual doze at a beyond design basis accident will not exceed the permissible limit for normal operation.

3.5.3.6 Fall of HI-TRAC with MPC from the altitude of 38 m in the NPP reactor department

The probability of crane failure that leads to the weight falling was estimated based on results of earlier accidents specified in the NUREG-0612 report. NUREG-0612 estimates the crane falling probability with single redundancy within one year in the interval from $1 \cdot 10^{-4}$ to $4 \cdot 10^{-7}$ at an average number of rising operations from 4 to 10 times per year. At log-normal distribution of crane falling probability per year it gives the median value of $6{,}3 \cdot 10^{-6}$, that is equivalent to a conditional crane falling probability per each rise of $1 \cdot 10^{-6}$.

The presented probability values correspond to the probability of heavy weight falling from any altitude. The falling probability from altitude of 38 m will be essentially lower because of the following reasons:

- a rather short period during which the transfer cask with MPC are lifted at the altitude of 38 m;
- falling due to mechanical breakages according to the NUREG-0612 data occurs in most cases on a small lift heights as defective units fall out soon after loading;
- mechanical breakages according to the NUREG-0612 data cause approximately 30 % of all registered cases of falling, while the crane with high reliability parameters is used at NPP which belongs to safety class 1, that leads to the increased requirements to the maintenance service order;
- availability of two independent rising (lowering) systems - the basic and safety one on the crane.

Thus, in accordance with the accepted design decisions, the probability of the given accident is lower then 10^{-6}, and, according to 10CFR72, it is not regarded as a design basis accident.

Taking into account that the container is transferred in the reactor department from the altitude exceeding of 9 m / at the altitude of 37 m as a maximum/, the design provides for measures intended to exclude container fall from the altitude higher than 9 m.

If the container falls from the altitude higher than 9 meters, a self-sustaining chain reaction is excluded; there is damage of fuel element claddings and activity release from the fuel matrix. As MPC leak-tightness is failed, radioactive substances released into air of a room (a handling tube), and then are removed through the special ventilation systems into the ventilation stack of the NPP power unit. The Feasibility Study does not cover this accident because it does not influence the design decisions made for buildings and structures at the CSFSF site. Taking into account differences in design decisions of reactor departments of different NPP power units, this accident must be examined as a beyond design basis accident for each type of power units at the design stage.

3.5.3.7 Measures for beyond design basis accident risk reduction

To decrease and liquidate BDBA consequences, the emergency CSFSF plan is put into operation, which shall comply with the requirements of NPBU-97 [4]. The emergency plan, at least, should contain measures for creation of necessary emergency supply stocks that includes:

- the dosimeters and radiometric equipment;
- emergency sets of IPM, and respiratory IPM;
- emergency supply of direct reading dosimeters;
- transport facilities and reserved combustive-lubricating materials;
- means of pharmacological radiation protection;
- communication and management means;
- decontamination means.

To decrease the BDBA probability the measures are taken related to nuclear facility physical protection provision including a set of organizational, legal, search and engineering measures.

3.6 Radiation safety in decommissioning

Radiation safety in CSFSF decommissioning will be ensured by the following design decisions.

The dry type storage facility excludes generation of a large number of liquid radioactive waste and, accordingly, the possibility of premise contamination is not assumed.

SFA will be stored in the leak-tight MPC, therefore HI-STORM contamination and, correspondingly, dose loads of the personnel in their possible dismantling will be minimal. The use of overpack storage restricts the possibility of contamination of large areas even in case of loss of MPC tightness.

The rooms' surfaces in the MPC handling areas will be covered with easily decontaminated materials, therefore at periodic decontamination of these rooms dose loads of the personnel in decommissioning will be insignificant as well.

The effective special ventilation system will prevent radioactive substance dissemination in the rooms of the receiving building under normal operation and during possible accidents.

The technological process does not assume to use some toxic and other potentially hazardous radioactive substances.

Because the basic impact on the personnel in CSFSF operation will be conditioned by external gamma radiation, the dose loads on the personnel in decommissioning (after spent fuel assemblies removal) will be essentially lower than dose loads in operation. The main exposure doses can be obtained in decontamination of rooms of the restricted access area and equipment located in these rooms.

After decontamination of contaminated equipment and rooms the dose loads on the personnel will be considerably reduced.

At subsequent design stage a CSFSF decommissioning concept will be developed. The decommissioning concept must be included as a separate section into the SAR at the design stage where the sufficiency of the design and organizational-technical solutions of CSFSF decommissioning with minimally possible radiation exposure on the personnel, the public, and the environment will be proved. In the concept the general aspects of decommissioning determined in NP.306.1.02/1.004-98 [23] will be examined with possible detailed elaboration at the design stage.

At that planning of rooms and installation of systems and elements will be optimized taking into consideration the necessity to remove HI-STORM large fragments, to have free disconnection and remote moving of the MPC, to allocate the equipment for decommissioning.

The main equipment necessary for ensuring radiation protection in decommissioning will include:

- equipment preventing contamination of rooms (including local ventilation and filtering systems);
- radiation monitoring equipment;
- equipment for monitoring dose rate and superficial contamination on working places, contamination of components and materials in dismantling;
- equipment for monitoring aerosol volumetric activity on working places.

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Appendix A – Minutes of inter-branch meeting

Approved

Deputy Minister of Fuel and
Energy of Ukraine

____ Shteinberg M.O.

“ __ “ _____ 2006

DECISION
on scope and content of the information
presented in the Feasibility Study for siting and constructing
the Centralized Spent Fuel Storage Facility for WWER spent nuclear fuel of Ukrainian NPPs on issues of nuclear and radiation safety and the environmental impacts

AGREED:

Deputy Head of the
State Nuclear Regulatory Committee
of Ukraine

_____ Bozhko S.G.

12.04. 2006

AGREED:

Deputy Minister of
Environmental
Protection of Ukraine

_____ Grischenko A.V.

“ __ “ _____ 2006

First Vice-President – Technical
Director of SE NNEGC "Energoatom"

____ Kovrizhkin J.L.

14.04 2006

Deputy Main
Sanitary Doctor of Ukraine

____ _____ Burlak G.F.

“ __ ” __ 2006

BACKGROUND

The necessity to construct the centralized spent fuel storage facility (CSFSF) in Ukraine is determined by:

- National Energy Program of Ukraine up to 2010 approved by the Order of the Supreme Council of Ukraine No. 191/96-VR of 15.05.1996;
- Decree of the President of Ukraine No. 1863/2005 of 27.12.05 "On the Decision of the Council of National Security and Defense of Ukraine of 09 December 2005 "On Energy Security Conditions in Ukraine and Basic Concepts of State Policy for its Provision";
- Energy Strategy of Ukraine up to 2030 (the Order of the Cabinet of Ministers of Ukraine No. 145-r of 15 March 2006).

According to the existing Ukrainian legislation, one of the most important documents to justify approval of the decision on allocation, design and construction of a nuclear installation is a feasibility (FS).

Currently, the State enterprise NNEGC "Energoatom" develops the feasibility study for construction of the nuclear facility – the centralized spent fuel storage facility for WWER reactors (the WWER CSFSF). The proposed WWER CSFSF is intended for interim (up to 100 years) spent fuel storage from Ukrainian NPP.

The FS is developed in accordance with the requirements of DBN A 2.2-3-2004 "Composition, Order of Development, Agreement and Approval of Design Documents for Construction".

At that, it is taken into account that:

- FS composition presented in DBP A 2.2-3-2004 (Appendix F) has a character of recommendation;
- WWER CSFSF design has three stages: the FS, the design, the working documentation;
- current regulatory documents have no statements as for the scope of information at the FS stage, in particular, as regards radiation and nuclear safety issues, and the environmental impact assessment. The scope of such requirements is clearly determined for the design stage;

and also, taking into account the standards of the Law of Ukraine "On the Order of Decision Making on Allocation, Designing, Construction of Nuclear Facilities and Installations Designed for Radioactive Waste Management that Have General-State Importance",

DECIDED:

1. To develop a report on compliance with the sanitary standards of NPBU-97, NPBU-97/D-2000 and OSPZRBU-2005 at the Design stage.
2. To present the basic decisions as for nuclear and radiation safety provision within the framework of the feasibility study in the scope specified in Appendix 1.

3. In development of the Environmental Impact Assessment (EIA):

only additional CSFSF impact on the environment shall be assessed during comparison of different sites for CSFSF construction in accordance with the ecological criteria taking into account the existing environmental background parameters in the region of the site location;

- to present the public opinion at the FS stage in that part of the activity which can be taken into account before FS completion. It is required to provide for at the subsequent design stage the Environmental Impact Assessment specification taking into account results of the public consultations and the local referendum, and also technological and technical parameters influencing on the Environmental Impact Assessment.
- to take into account the statements presented in Appendix 2 is considering the environmental impacts.

Appendix 1

Main decisions on ensuring nuclear and radiation safety
(structure and content)

1 Regulatory documents on nuclear and radiation safety

The documents are indicated that constitute the basis for developing the current issues in the FS (the Ukrainian regulatory documents, the IAEA recommendations, regulatory documents of the countries-suppliers of the spent nuclear fuel management technology).

2 Nuclear safety

2.1. General provisions:

- The main nuclear safety criteria and principles shall be identified for the CSFSF system taking into account the principle of supremacy of the Ukrainian regulatory documents (if Ukrainian regulatory documents have more strict criteria compared to those of the countries-suppliers of the spent nuclear fuel management technology);
- General decisions related to nuclear safety directly at the CSFSF and during SNF loading at the NPP power units shall be presented.

2.2 Basis technical decisions ensuring nuclear safety:

2.2.1 Basic technical decisions for the facilities and operations at the WWER CSFSF site are:

- Technical decisions should be presented for all stages of spent fuel management at the CSFSF site;
- The results of nuclear safety estimation should be presented (effective multiplication factor estimation) in accordance with the technology developer's data (the Holtec International) referencing to the existing documents with substantiations made for the similar spent fuel (with not less as prescribed in the WWER CSFSF design values of initial enrichment and burn-up levels) confirmed by the American regulatory body;
- Basic decisions shall be presented for heat removal from the canisters with spent fuel of the Holtec International technology referencing to the existing ones with substantiation for the similar spent fuel (with the values of initial enrichment and burn-up levels not less than the prescribed in the WWER CSFSF design) confirmed by the American regulatory body;

2.2.2 Basic technical decisions for spent fuel management at the operating NPP power units:

- Basic operations with SNF that are differ (or are additional) compared to the standard NPP operations should be described;
- Basic technical decisions for nuclear safety provision during these operations should be described.

3 Radiation safety

3.1 Basic principles and criteria of radiation safety:

• the principles and criteria should be presented on the basis of the regulatory documents in force.

3.2 General approach to ensuring radiation safety:

• Set of measures and a general regulation for their application should be described; the

functional diagram of the radiation protection should be presented;

- Approach to radiation exposure estimation including initial event analysis should be presented.

3.3 Radiation safety in WWER CSFSF construction:

- Describe radiation conditions of the site and radiation sources on the base of the existing data (there is no special additional research);
- Describe radiation safety under normal operation, including estimation of dose loads on the personnel and measures for radiation safety ensuring;
- Consider radiation safety in accidents with qualitative assessment of possible initial events, determine key initial events and qualitative or quantitative assessment of consequences.

3.4 Radiation safety under WWER CSFSF normal operation (at the CSFSF site and at NPP power units):

- Describe radiation state and radiation sources;
- Assess exposure doses for normal operation (for different operation areas of the CSFSF site);
- Specify measures on radiation safety provision under normal operation;
- Determine additional radiation exposure doses during loading of canisters at power units.

3.5 Radiation safety in accidents at the WWER CSFSF site:

- Specify qualitative assessment of initial events and their consequences;
- Define the maximum design basis accident (DBA) and assess radiation impact (dose);
- Determine qualitative assessment of beyond design basis accidents, select the key beyond design basis accidents and assess radiation impact (dose);
- Describe measures for decreasing beyond design basis accident probability;
- Describe measures for liquidation of accidents related to loss of tightness of the multi-purpose canister.

3.6 Radiation safety in accidents during loading of canisters at the NPP power unit:

- Provide with qualitative assessment of initial events (additional to the normal operation mode) and their consequences;
- Assess additional radiation impact (dose) on the personnel for key design basis and beyond design basis accidents.

3.7 Radiation safety in decommissioning:

- Provide with qualitative assessment.

Note. As for items 3.5 and 3.6 the consequences are considered for one design basis accident and one beyond design basis accident which were selected at the qualitative level. The detailed substantiation will be provided at the design stage.

The issues to be taken into account in development of the environmental impact assessment

1 *In considering the environmental impact during loading of canisters at the NPP power unit:*

- only the radiation impact on the public during these operations is considered and compared with the estimations made in the existing NPP EIA;
- the detailed assessment of he environmental impact during SFA loading at the power unit with the Holtec International technology will be described at the CSFSF design;
- in such estimation it is taken into account that under normal operation use of the Holtec International technology as for the environmental impact does not differ from the normal SFA reloading technology at NPP;
- in assessing the environment radiation impact under accidents release of radioactive substance, dose loads at the NPP site and the control area boundary are estimated for the design basis accident with maximum consequences and for the key beyond design basis accident. Accidents-representatives are selected at the qualitative level. Choice of accidents will be substantiated in the EIA at the design stage.
- the estimation is made only for one NPP site. The other sites are considered if any special measures are required.

2 In considering the environmental impact assessment during the spent fuel assembly storage at the WWER CSFSF site:

- the impact of the environmental components under normal operation, design basis accidents with maximum consequences and key beyond design basis accidents is considered. The accident selection is made at the qualitative level taking into account the Holtec International data. Choice of accidents will be substantiated in the EIA at the design stage;
- the environmental impact is considered in CSFSF construction;
- the underground water impact is performed from the point of view of the surface radioactive contamination. Competence of this approach shall be justified.

3 The issue on environmental impact during spent fuel assembly transportation from the NPP to the CSFSF are not considered.

It is provided for that safety substantiation for spent fuel transportation will be considered in licensing of the Holtec International transport overpack (HI-STAR).

CENTRALIZED SPENT FUEL STORAGE FACILITY OF UKRAINIAN WWER NPP

FEASIBILITY STUDY

VOLUME 3

Environment Impact Assessment

PART 1

Description of the CSFSF Site and Adjacent Area.
General Description of the CSFSF

Table of Content

Introduction 4
List of Abbreviations 5
List of Terms and Definitions 8

1 Basis for development of EIA 10

1.1 Data Regarding the Terms of Reference, Preliminary Performed Work, Available Reviews and Decisions 10
1.2 Data Regarding the Need of the CSFSF Construction 10
1.2.1 Current Status of Spent Fuel Management in Ukraine 10
1.2.2 State Policy of Ukraine with respect to Spent Fuel Management 10
1.3 Agreed List of Limitations 10
1.4 Data from the Client, Contractor, Input Data Including Survey Data and Information Provided by the other Companies and their Status 14
1.4.1 Client's Data 14
1.4.2 EIA Contractor's Data 14
1.4.3 Input Data Including Survey Data and Data Provided by the Other Companies 15

2 Physical-geographical and climatic description of the area and site 16

2.1 Physical and Geographic Description 16
2.1.1 Geographical Location 16
2.1.2 Geology and Tectonics 18
2.1.3 Seismic 21
2.1.4 Geomorphology and Relief 21
2.1.5 Hydrological Conditions 23
2.1.6 Soil Cover 30
2.1.7 Preserve Area Objects 33
2.1.8 Unfavorable Environmental and Technogenic Processes and Phenomena 35
2.2 Climatic Description of Region and Site 36
2.2.1 Climatic Description 36
2.2.2 Air Temperature 37
2.2.3 Wind 37
2.2.4 Air Humidity 38
2.2.5 Evaporation 39
2.2.6 Fogs 39
2.2.7 Precipitation 39
2.2.8 Thunderstorms 40
2.2.9 Hail 40
2.2.10 Snow Cover 40
2.2.11 Glaze 41
2.2.12 Soil Freezing 41
2.2.13 Snow Falls 41
2.2.14 Atmospheric Stability 41
2.2.15 Gusts 42
2.2.16 Tornado 42
2.3 Description of Flora and Fauna 43
2.3.1 Vegetation Growth 43
2.3.2 Faina Complexes 45

3 General description of facility and economical activity in the affected area 48

3.1 Economical Activity in the Affected Area 48
3.1.1 Transportation Facilities 48

3.1.2 Industrial Facilities 48
3.1.3 ChNPP Fuel Cooling Pool 54
3.1.4 Other Companies Involved in Accident Mitigation 54
3.1.5 RAW Management Facilities 54
3.2 Positive Aspects of the CSFSF Realization for the Region 55
3.3 Alternative Options of the CSFSF Location 56
3.3.1 Sequence of Site Selection in the Feasibility Study 56
3.3.2 CSFSF Alternative Sites 57
3.3.3 Comparison of Sites Based on Ecological Criteria 57
3.3.4 Recommended Site 57
3.4 Alternative Technologies Variants 58
3.4.1 Bunker Storage Facilities 58
3.4.2 Module Storage Facilities 58
3.4.3 Metallic Containers 58
3.4.4 Metallic and Concrete Containers 58
3.4.5 EIA Technology 58
3.5 CSFSF Normal Operation 59
3.5.1 Basic Functionality 59
3.5.2 Composition of Buildings and Structures in the CSFSF Area 61
3.5.3 Description of the Main Technology 63
3.5.4 Architectural and Civil Engineering Solutions 69
3.5.5 Monitoring and Control System 74
3.5.6 Communication System 77
3.5.7 Electric Power Supply System 78
3.5.8 Water Supply and Sewage System 79
3.5.9 Heating and Ventilation 80
3.5.10 Fire Safety 86
3.5.11 RAW Management System 89
3.5.12 Physical Protection System 91
3.5.13 Data on Consumed Resources 91
3.5.14 Data on Discharges and Releases 92
3.5.15 Data on Levels of Non-Radiation Influence 95
3.6 Arrangement of CSFSF Construction 95
3.6.1 Brief Characteristic of Construction Conditions 96
3.6.2 The Scope of Main Construction-Assembly Works 97
3.6.3 Construction Need for Main Structures, Articles and Materials 98
3.6.4 Decisions on Organisation of Construction for Preparatory Period 99
3.6.5 Decisions on Organisation of Start up Complex Construction 101
3.6.6 Decisions on Organisation of Construction on Subsequent Stages 102
3.6.7 Duration of Construction. Need for Construction-Assembly Staff 102
3.6.8 Method of Construction and Assembly Works Performance 103
3.6.9 Power Resources and Water Provision for Construction Demand 104
3.6.10 Occupational Health Safety Measures 106
3.7 Normal Operation Failures and Accidents at CSFSF 107
3.7.1 Emergency Conditions During Construction 107
3.7.2 Input Data for CSFSF Operation 109
3.7.3 Discharges and Releases under Abnormal Operational Conditions and Accidents 123
List of references 124
Attachment A Terms of Reference for Development of Feasibility Studies 128
Attachment B Environmental Conditions of the CSFSF site 129
Attachment C Diagram of Plot Plant and General Layout for the CSFSF 130

Introduction

This document is a part of the Environment Impact Assessment (EIA) for the Centralized Spent Fuel Storage Facility (CSFSF). In accordance with the Law of Ukraine about Use of Nuclear Energy [1] the CSFSF is considered as a nuclear facility. The EIA is an integral part (Volume 3) of Feasibility Studies and was developed based on the effective DBN A.2.2.1-2003.

The EIA making an integral part of the Feasibility Studies was developed for a preferable site selected for construction of the CSFSF described in Volume 1, Part 5 of the FS.

The Terms of Reference including the Addendum for development of the FS and the EIA is given in Appendix A to this document.

Part 1 includes the following:

- Main data regarding the EIA developers, work performed and data used;
- Data describing on-site environmental and technogenic conditions, which are considered through Part 2 for assessment of the CSFSF impact on environment;
- Description of processes to be used for management of spent nuclear fuel at the CSFSF including auxiliary and supporting systems described in Part 2 for assessment of possible conditions and barriers preventing from the CSFSF impact on the environment;
- Qualitatively selected initial events, which may lead to the design basis or beyond the design basis accidents as well as accidents defined and considered in Part 2 for assessment of impact on the environment;
- Assessment of releases and discharges under normal operation, abnormal operation and probable accidents with the most severe consequences used for subsequent analysis of the CSFSF impact on the environment.

In assessing the releases and possible consequences of design basis and beyond the design basis accidents, the data provided by Holtec International, designer and supplier of the SNF storage technologies, were considered.

List of Abbreviations

AB	-	Administration Building
GS	-	Gasoline station
ARMS	-	Automated radiation monitoring system
TC	-	Transportation Company
NPP	-	Nuclear Power Plant
BHS	-	Baltic system of heights
BPS	-	Bank pump station
WWER	-	Water moderated reactor
WIS	-	Water intake station
HVL	-	High-voltage (transmission) line
HVDS-750	-	High-voltage distribution substation
STS	-	On-site transportation system
SNRC	-	State Nuclear Regulatory Committee
SFA	-	State Forestry Administration (gosleskhoz)
CD	-	Civil Defense
CLM	-	Combustive-lubricating materials
SSE ChNPP	-	State Specialized Enterprise “Chernobyl NPP”
PR	-	Permissible release
DGS	-	Diesel-generator station
DDA	-	Dnipro-Donetsk avlakogen
PD	-	Permissible discharge
RCPP	-	Reinforced concrete production plant
SSPP	-	Steel structures production plant
MA	-	Monitored area
EZ and MRZ	-	Exclusion and mandatory resettlement zone;
LRTF	-	Liquid Radwaste Treatment Facility
SRTF	-	Solid Radwaste Treatment Facility
LRAW	-	Liquid radioactive waste
UPS	-	Uninterrupted power supply
EGE	-	Engineering-geological element
IDC	-	Individual dosimetry control
EB	-	Engineering barriers
OSV	-	Overpressure safety valve
SPS	-	Sewage pump station
ACP	-	Access Control Point
CL	-	Control level
ERMS	-	External Radiation Monitoring Laboratory
AM	-	Accident mitigation
M.D.A	-	Minimum detectable activity
MIA	-	Ministry of Internal Affairs
MH	-	Ministry of Health
MP	-	Meteorological potential
MDA	-	Maximum design basis accident
MDE	-	Maximum design earthquake
GRER	-	Gamma radiation exposure rate
MEU	-	Ministry of Emergencies of Ukraine
LCR	-	Local control room
MPC	-	Multi-purpose canister
NAS	-	National Academy of Sciences

NSC	-	New Safe Confinement
ND	-	Normative documentation
HI-STAR	-	Transportation overpack
HI-STORM	-	Storage overpack
HI-TRAC	-	Transfer cask
NERC	-	National Energy Regulatory Commission of Ukraine
NCA	-	Normal confined aquifer
NRBU	-	Radiation Safety Standards of Ukraine
LMLW-SL	-	Low and medium radioactive short living waste
NTD	-	Normative and Technical Documentation
SAR	-	Safety Analysis Report
EIA	-	Environment Impact Assessment
SCF	-	State Control Facility
OS	-	Outdoor switchgear
SFA	-	Spent fuel assembly
OS	-	Object “Shelter”
SNF	-	Spent nuclear fuel
IRWSF	-	Interim radioactive waste storage facility
DL	-	Dose limit
DE	-	Design earthquake
RWDF	-	Radioactive waste disposal facility
PA	-	Preserve area
IC	-	Industrial Complex
ICSRM	-	Industrial Complex for Solid Radwaste Management;
RAW	-	Radioactive waste
HCCR	-	High capacity channel reactor
RR	-	Radiation release
RM	-	Radiation monitoring
ERM	-	Environmental radiation monitoring
RN	-	Radionuclides;
RPM	-	Radiation in-process measurements
SG	-	Switchgear
RF	-	Russian Federation
SCA	-	Sanitary -control area
IPE	-	Individual protection equipment
HBC	-	Human body counter
MCS	-	Monitoring and control system
CAP	-	Construction and assembly personnel
FFDS	-	Fuel failure detection system
CP	-	Construction personnel
RMS	-	Radiation monitoring system
DSFSF	-	Dry spent fuel storage facility
FR	-	Fuel rod
TO	-	Transportation overpack
SRAW	-	Solid radioactive waste
TU		Transuranium element
WT	-	Water table
CCA	-	Capital Construction Administration
SFPF	-	Spent fuel preparation facility
PP	-	Physical protection
KhNPP	-	Khmelnitsky Nuclear Power Plant
SFSF	-	Spent Fuel Storage Facility

CSFSF	-	Centralized Spent Fuel Storage Facility
CDE	-	Central Disposal Enterprise
CWTF	-	Centralized Waste Treatment Facility
CCR	-	Central Control Room
NF	-	Nuclear fuel

List of Terms and Definitions

Abnormal events or off-normal conditions	-	Design event II as per ANS assumes an event, which, though not regularly, but may occur rather frequently or once per operational year at a storage facility
Biocenose	-	Historically generated collection of flora and fauna species residing the area with more or less similar living conditions
Gaseous aerosol release (release)	-	Release of radioactive matters into the atmosphere outside the process loops and ventilation systems of an enterprise
Damp area	-	An area characterized with humid and warm climate with the precipitation rate exceeding evaporation
Long-term storage	-	Hereinafter assumes interim storage of spent nuclear fuel with the design storage time exceeding 30 years
Permissible release (PR)	-	Regulated maximum cumulative level of gaseous aerosol release. A permissible release is a release under which a total annual effective dose per an individual out of a critical public group (outside the control area) accumulated due to all radionuclides released is equal to a dose limit quote (NRBU - 97)
Permissible discharge (PD)	-	Regulated maximum cumulative level of water discharge. Permissible discharge is a discharge under which a total annual effective dose per an individual out of a critical public group (outside the control area) accumulated due to all radionuclides contained by the release is equal to a dose limit quote (NRBU -97)
Radioactive contamination	-	Presence or dissemination of radioactive matters beyond their natural content in the environment and/or human body
Beyond-the-design-basis accident	-	Hereinafter assumes event IV as per ANS, as an event, which is postulated due to its consequences which may lead to maximum possible impact on the environment
Monitored area	-	An area, which can be affected due to radioactive releases and discharges from a radiation-nuclear facility and which is subject to monitoring (NRBU -97)
Radiation monitoring area	-	An area, which requires stringent dosimetry monitoring (NRBU -97)
Exclusion zone	-	An area from which the population were evacuated in 1986 (Law of Ukraine)
Mandatory resettlement zone	-	An area which was intensively contaminated by long-living radionuclides with the soil being contaminated by cesium isotopes ranging from 15,0 Ci/km^2 and higher or strontium from 3,0 Ci/km^2 and higher, or plutonium from 0,1 Ci/km^2 and higher, as well as an area characterized with soil allowing for easy travel of radionuclides into the plants with contamination density being from 5,0 to 15,0 Ci/km^2 due to cesium isotopes or 0,15 to 3,0 Ci/km^2 due to strontium, or 0,01 to 0,1 Ci/km^2 due to plutonium, where an effective equivalent dose of an individual can exceed 5,0 mSv (0,5 rem) per year beyond the dose taken in the pre-accident period (Law of Ukraine)
Environment	-	Collection of environmental, technogenic and social conditions allowing for existence of human society (DBN A.2.2-1-2003)
Natural environment	-	Collection of environmental factors and objects of natural origin or development (DBN A.2.2-1-2003)
Technogenic environment	-	Artificially created part of environment consisting of technical and natural elements (DBN A.2.2-1-2003)
Design accident	-	Hereinafter assumes design event III as per ANS, as a rare event,

		which can be expected, at least, once per lifetime of a storage facility
Radioactively contaminated lands	-	Areas requiring performance of radiation protection measures and other specific actions aimed at limiting additional exposure due to Chernobyl accident in order to ensure routine economical activities
Sanitary control area	-	An area surrounding a radiation-nuclear facility, where the rate of human exposure under normal operational conditions can exceed the dose limit quote assigned for category B. It is prohibited for people to settle within a sanitary control area. Conduction of industrial activities not related to a radiation-nuclear facility requiring radiation monitoring is limited (NRBU-97)
Ecotone	-	Vegetation of transient nature between neighboring communities
Phytocenosis	-	Historically generated collection of vegetation species existing within the area with more or less similar climatic, soil and other conditions
Fauna complex (zoocenosis)	-	Collection of fauna species included in biocenose

1 BASIS FOR DEVELOPMENT OF EIA

1.1 Data Regarding the Terms of Reference, Preliminary Performed Work, Available Reviews and Decisions

In accordance with requirements of DBN A.2.2-3-2004 the Feasibility Studies included assessment of the CSFSF impact on the environment. The assessment was performed in accordance with requirements of DBN A.2.2.-1-2003 "The Content and structure of environment impact assessment (EIA) documents during design and construction of enterprises, buildings and facilities"[3].

1.2 Data Regarding the Need of the CSFSF Construction

These data are given in Volume 1, Book 1.

1.2.1 Current Status of Spent Fuel Management in Ukraine

1.2.2 State Policy of Ukraine with respect to Spent Fuel Management

1.3 Agreed List of Limitations

Design and construction of the CSFSF will be conducted in accordance with effective normative documents.

The requirements to activities involving ionizing sources in Ukraine are regulated by the following documents:

- Law of Ukraine "Human Protection from Ionizing Radiation" № 15/98-ВР dated 14.01.98 [5];
- "Radiation Safety Standards of Ukraine NRBU –97" [6], "Radiation Safety Standards of Ukraine NRBU -97/D-2000" [7];
- "Basic Radiation Safety Sanitary Rules" [8];
- "Safety rules for storage and transportation of nuclear fuel at nuclear power plants PNAEG-14-029-91" [9].

The numerical values for main dose limits are specified within the rates, which eliminate occurrence of exposure deterministic effects and at the same time they guarantee such a low probability of stochastic effects that they can be acceptable for both individuals and the society in the whole.

These data and criteria include the following:

- All numerical values for dose limits specified by NRBU-97[6];

Data for community of people who may be subjected to radiation exposure due to construction, commissioning, operation and decommissioning of the CSFSF and who are classified into the categories as specified by the NRBU -97:

Category A (personnel) - Individuals permanently or temporarily dealing directly with ionizing radiation sources;

Category Б **(personnel) -** Individuals who do not deal with the ionizing sources but due to location of their work places in the rooms and industrial sites of corresponding facilities involving radiation-nuclear technologies can be additionally exposed to radiation;

Category B - All population.

The dose limits (limits) for Categories А and Б are specified as individual effective and equivalent doses per calendar year. These values are given in Table 1.3.1.

Table 1.3.1 (Table 5.1 NRBU-97[6])

Exposure dose limits (mSv/year)	**Categories of individuals exposed**		
	А[а)б)]	**Б)**[а)]	**В)**[а)]
DL_E (Effective exposure dose limit)	20[в)]	2	1
Equivalent dose limit due to external exposure:			
DL_{lens}(for lenses)	150	15	15
DL_{skin} (for skin)	500	50	50
DL_{extrim}(for hands and feet)	500	50	-

а) distribution of an exposure dose within one calendar year is not regulated.

б) distribution of an equivalent dose for women under 45 shall not exceed 1 mSv for any two months (i. 5.6.2 NRBU-97[6]).

в) in average for any subsequent five years, nevertheless without exceeding 50 mSv per year (DL_{max})

Permissible levels (PL), which are included into radiation-hygienic regulations for the first group, are the following:

For Category А individuals:

- Permissible intake of radionuclides through respiratory organs;
- Permissible concentration of airborne radionuclides within the work areas;
- Permissible density of a flux of particles;
- Permissible dose rate due to external exposure;
- Permissible contamination level for skin, uniforms and work surfaces.

For Category Б individuals:

- Permissible intake of radionuclides through respiratory organs;
- Permissible concentration of airborne radionuclides within the work areas.

Individual Exposure for Category А

For Category А an individual effective dose per year shall not exceed the DL value given in Table 1.3.1.

Measurements of personnel exposure are regulated by the corresponding section of the “Basic sanitary rules …” (OSPU-2005)[8].

The scope and types of radiation surveys shall be compliant with OSPU -2005.

Individual dosimetry monitoring in the scope specified for each specific case is mandatory for people, whose annual exposure dose can exceed 0,5 of the DL_E value.

Individual Exposure for Category Б

For Category Б personnel an individual effective dose per year shall not exceed the DL value given in Table 1.3.1.

The requirements to arrangement and performance of radiation measurements for Category Б personnel are based on the condition that an annual effective dose limit is not exceeded. The structure, scope, methods and techniques of these measurements are regulated by the corresponding section of the “Basic sanitary rules …” OSPU-2005 [8]. To ensure the permissible level of radiation safety the control levels are specified for any radiation-nuclear facility. The control levels for Categories А and Б personnel are specified by administrations of radiation-nuclear facilities, which are to be approved by the state regulatory authorities.

Tables 1.3.2-1.3.4 provide permissible levels specified by Ukrainian normative documents.

Table 1.3.2 - Permissible levels for skin exposure of individuals out of the personnel by monoenergetic electron (П3.1 NRBU-97[6])

Electrone energy, MeV	**Equivalent dose per one fluence hm, x10^{-10} Sv-cm^{2}particle^{-1}**		**Permissible flow density PDR$_A$, particle cm^{-2} s^{-1}**	
	Isotropic field	**Parallel beam**	**Isotropic field**	**Parallel beam**
0.1	3.2	16.0	260	50
0.2	4.5	8.7	180	90
0.3	4.0	6.3	190	130
0.5	3.8	4.6	210	180
0.8	3.7	3.9	230	210
1.0	3.7	3.7	230	230
2.0	3.7	3.3	230	240
3.0-10	4.0	3.2	200	260

Table 1.3.3 - Permissible levels for skin exposure of individuals out of the personnel by beta-particles (Table П3.2 NRBU-97[6])

Boundary energy of beta-spectrum, MeV	**Maximum equivalent dose per one fluence hm, 10^{-10} Sv-cm^{2}particle^{-1}**		**Permissible density rate PDR$_A$, particle cm^{-2} s^{-1}**	
	Isotropic field	**Parallel beam**	**Isotropic field**	**Parallel beam**
0.2	40.0	28	1900	30
0.3	2.0	19	410	40
0.4	2.6	14	300	60
0.5	3.0	12	270	70
0.7	3.5	8.6	230	95
1.0	3.7	6.3	220	130
1.5	3.8	4.7	210	180
2.0	3.9	4.2	210	200
2.5	4.0	4.0	200	200
3.0	4.0	3.9	200	210
3.5	4.0	3.8	200	210

Table 1.3.4 – Permissible levels of total radioactive contamination of work surfaces, skin (within one work shift), uniforms, individual protection equipment, particle min^{-1} cm^{-2} (Table П3.3 NRBU-97[6])

Contaminated object	Alpha-nuclides		Beta-nuclides
	Separate*)	Others	
Intact skin, special underwear, towels, internal facial surface of individual protection equipment	1	1	100
Main special clothing, internal surface of additional individual protection equipment	5	20	800
Floors and equipment installed in the rooms assigned for permanent personnel attendance, external surface of special footwear	5	20	2000
Floors and equipment installed in the rooms assigned for temporary personnel attendance	50	200	8000
External surface of additional individual protection equipment taken off in the sanitary locks	50	200	10000

*) –alpha-radiant radionuclides are considered to be different, which annual average permissible airborne activity is less than 0,3 Bq/m^3 in the work rooms.

Radioactive release value within an industrial site shall be justified in the CSFSF design.

Individual Exposure for Category B

Regulation and monitoring of public exposure are implemented based on estimate of annual effective and equivalent exposure doses for critical groups. The estimates are performed in accordance with the techniques approved by the Ministry of Health of Ukraine.

Limitation of exposure is implemented through regulation and monitoring of the following:

- Gaseous and aerosol releases and water discharges during operation of radiation-nuclear facilities;
- Content of radionuclides within separate environmental medium (water, food products, air, etc.).

During designing of the CSFSF it is necessary to ensure non-excess of population exposure dose (refer to Table 1.3.5) for Category B individuals due to release of radioactive substances from the CSFSF above the levels, specified by NRBU-97 [6] (Table 5.2), by considering the quota of 4 %, which constitutes 40μSv/year.

Table 1.3.5 – Dose limit quota used for specification of permissible content and permissible releases (NRBU-97 [6])

Radiation-nuclear facility	**Releases: dl_e quota due to all paths of dose formation**		**Discharges: dl_e quota due to critical kind of water use**		**Total quota dl_e quota due to air and water paths of dose formation**	
	%	μSv	**%**	μSv	**%**	μSv
CSFSF, total	4 %	40	1 %	10	8 %	80

Excess of permissible discharges and releases under normal CSFSF operation is prohibited.

In accordance with i. 3.6.15 PNAEG-14-029-91 [9] the CSFSF considered as a "dry storage facility" requires implementation of measures to monitor and limit generation of airborne radioactive matters in the storage facility, water ingress, humidity and temperature.

The storage facility shall provide radiation monitoring in accordance with the requirements of documents specified in i.3.4 PNAEG -14-029-91[9].

In accordance with requirements of OSPU-2005[8], design of protection from external ionizing exposure shall be developed by considering safety factor of 2 (two) for an equivalent dose rate. It is necessary to consider additionally such factors as availability of ionizing sources affecting the people, perspective increase of rates of radiation sources, radiation resistance of materials and equipment as well as sorption of radioactive matters by structural materials.

1.4 Data from the Client, Contractor, Input Data Including Survey Data and Information Provided by the other Companies and their Status

1.4.1 Client's Data

The Client is the National Atomic Power Generating Company "Energoatom" (NAEK).

1.4.2 EIA Contractor's Data

- **The Main Contractor is** OJSC Kiev Scientific Research and Design Institute "Energoproject" (KIEP). The Institute is certified (License dated April 19, 2005. Series AB № 104154, issued by the State Committee for Construction, Architecture and Residential Policy of Ukraine and License OB № 000340 dated September 21, 2006 issued by the SNRC for design of nuclear and storage facilities) to carry out activities for assessment of environment impact and is experienced in developing the EIAs for various nuclear power and RAW management facilities.

EIA Co-Contractors

The Institute of NPP Safety Problems for the National Academy of Sciences of Ukraine (ISP NPP) has been involved in describing siting conditions for WWER SFSF construction, assessment of WWER SFSF radiation impact on the environment during construction, normal operation, design accidents, beyond the design basis accidents.

The ISP NPP has a valid license for development of specific design sections related to environment impact assessment (License AB № 204593, issued by the State Committee for Construction and Architecture on August 9, 2005).

The ISP NPP personnel have practical experience and available engineering capacities to develop the EIAs for various nuclear power and RAW management facilities within the Chernobyl Exclusion Zone.

The data regarding the current condition of environment components located within the area affected by the WWER SFSF are provided as a result of long-term surveys performed by the SSIE "Ecocenter", ISP NPP and the SSE ChNPP departments. In assessing the radiation impact the results of scientific and research studies received by the Institutes of the NAC of Ukraine and published in scientific publications were used.

Ukrainian Scientific and Research Institute of Ecological Problems (UkrNIIEP) provided advisory assistance for preparation of the EIA data and development of a comprehensive SFSF EIA.

1.4.3 Input Data Including Survey Data and Data Provided by the Other Companies

The input data required for development of the CSFSF EIA are the following:

- Archival data describing environmental features of the ChNPP Exclusion Zone;
- Monitoring data received for the ChNPP Exclusion Zone;
- Results of engineering-geological surveys performed within the Complex "Vector" site;
- Annual bulletins of ecological condition of the Exclusion Zone;
- Survey data from the state preserve areas located in the Exclusion Zone;
- Maps of Ukraine;
- Maps of the Exclusion Zone;
- Data of investigations of disperse, radionuclide and microcomponent content of aerosols within the Complex "Vector" area;
- Data provided by the Chernobyl Scientific Technical Center of International Studies for nature conservative measures at the Exclusion Zone;
- Radiation background site features for the Complex "Vector";
- Safety Analysis Report and Environment Impact Assessment developed for the Complex "Vector" site;
- Data from international conferences and reports investigating radiation impact on soil, flora and fauna at the ChNPP Exclusion Zone;
- Official data published as a result of investigations performed for the ChNPP Exclusion Zone;
- Safety Analysis Report and Environment Impact Assessment developed for the ICSRM LOT-3.

In describing the main decisions for the SF management work processes as well as in assessing releases and possible consequences of design and beyond the design basis accidents the data from Holtec International, designer and supplier of SF storage technologies for the CSFSF, were used.

Specific references used for development of the EIA sections are given in the list of normative documents and references included in this document.

2 PHYSICAL-GEOGRAPHICAL AND CLIMATIC DESCRIPTION OF THE AREA AND SITE

2.1 Physical and Geographic Description

2.1.1 Geographical Location

The site selected for construction of the CSFSF is administratively located in Ivankiv district, Kiev region, which is included in the Exclusion Zone and Mandatory Resettlement Zone (Figure 2.1.1).

The Exclusion Zone and Mandatory Resettlement Zone (EZ and MRZ) is an area with a specific form of administrative management, which lands are out of economical use and where the population was evacuated due to severe contamination with radionuclides during Chernobyl accident in 1986. In 1987-2000 the local people were resettled from the most contaminated parts of the Mandatory Resettlement Zone located westwards the Exclusion Zone. Regulation of all activities carried out in the EZ and MRZ is implemented in accordance with the Law of Ukraine "About Legal Regime at the territory affected due to radioactive contamination as a result of Chernobyl accident" [10]. The total area of EZ and MRZ is 2600 km^2.

The site is located in the south-western part of the most radiation hazardous area. It was identified to provide monitoring over the most contaminated area surrounding the "Shelter" and the ChNPP [11]. The zone of the most severe radiation hazard has a complicated configuration, which, mainly, matches the contours of the fields with the highest rates of radioactive contamination. In various areas the distances from the ChNPP site varies from 8 to 20 km (Figure 2.1.1).

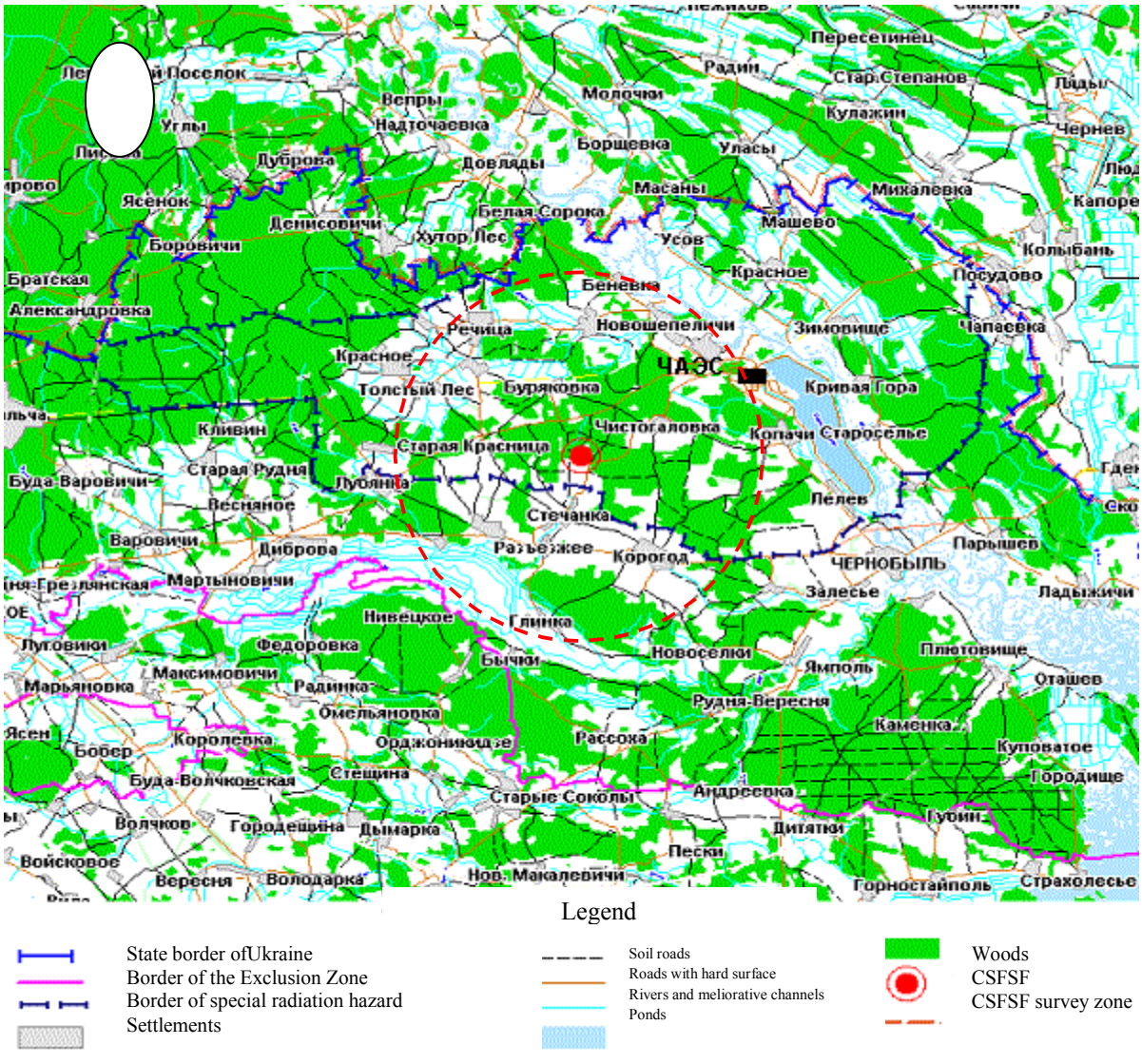


Figure 2.1.1 – Layout of Construction Site for the CSFSF at the EZ and MRZ

The CSFSF site is located between villages with no people living in them, which are Buryakovka, Chistogalovka and Stechanka, adjacent westwards to the Center for RAW treatment and disposal (Complex "Vector") (Figure 2.1.2).

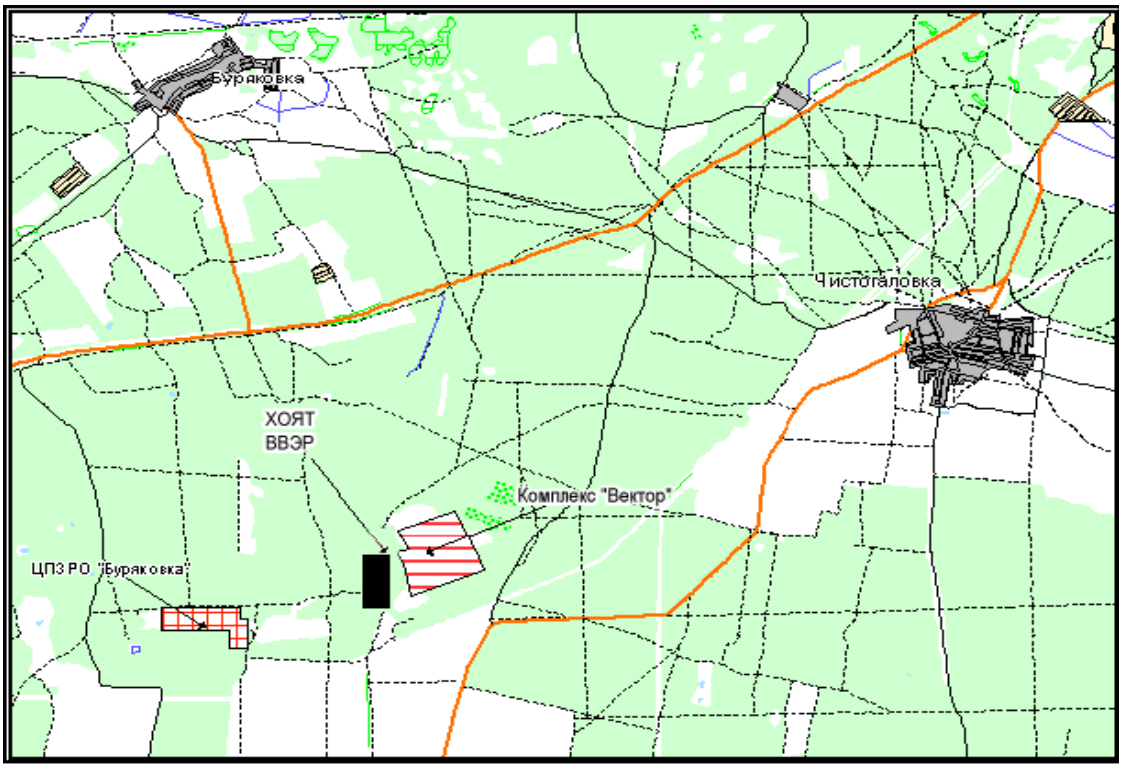


Figure 2.1.2 – Map of the CSFSF Site Location

The distance and directions from the CSFSF to the nearest cities and facilities are given in Table 2.1.1.

In accordance with the construction layout, the CSFSF site is located within the control area of the radiation hazardous facility, the Complex for radioactive waste treatment and disposal "Vector", and adjacent to its industrial site from the west. In accordance with the construction layout the shortest distance from the CSFSF facilities to the "Vector" facilities is 230 m.

Table 2.1.1 – Directions and distances from the CSFSF site from the nearest towns and important facilities

Description	**Direction from the site**	**Distance from the site, km**
Chernobyl	South-east	20
Ivankov	South	43
Slavutich	North- east	58
Chernigov	North - east	90
Kiev	South	110
State boundary of Ukraine with the Republic of Belarus	North -west	13
Boundary of the Exclusion Zone and Mandatory Resettlement Zone	North East	13 28

Description	Direction from the site	Distance from the site, km
	South South - west West North - west	23 12 39 29
Internal boundary of the 10-km zone of the most radiation hazard (ChNPP 10-km zone)	South - west	2
CRWDF "Buryakovka"	South - west	1,1
ChNPP industrial site	North - east	12
Object "Shelter"	North - east	12
Floodplain of the r. Sakhan	North	9
Floodplain of the r. Uzh	South - west	11
Floodplain of the r. Pripyat	North - east	12
Chernobyl	South - east	32

Geographical coordinates of the CSFSF site are the following: 51°19'30" of northern latitude and 29°56'40" of eastern longitude.

2.1.2 Geology and Tectonics

The geological structure of the area locating the CSFSF site includes Pre-Cambrian crystalline formations classified into rocks of Proterozoic group: sedimentary layers of Palaeozoic, Mesozoic and Cainozoe groups.

The structure of the crystalline bedding is studied insufficiently. The crystalline rocks were investigated off-site in the area, where they are exposed at the surface or are bedded at insignificant depth (50 m). In the other part of the region they are at the significant depth (400-600 m) and are exposed only in the north of the region.

The Pre-Cambrian includes Proterozoic group of rocks covering the series of gneisses, kirovograd-zhitomir and dneprovsky complexes of granitoid. The main varieties of rocks included into the gneiss series are biotite-plagioclase and amphibolites-biotite-plagioclase. The crystalline rocks are mostly covered by weathered products, primary kaolin.

The residual soil within the investigation area has Mesozoic and Cainozoic deposits with the total thickness of 600 m. The depth of sediments is increased towards depressions.

The Mesozoic deposits include the following:

- Triassic deposits consisting of speckled stratum of clays interspersed with sandstone, sand and siltstone. The thickness of these deposits is 130-170 m;
- Jurassic deposits consisting of medium and top strata. Middle-Jurassic formations (Bathonian and Bayoss stages) consist of dark-grey clays with the interlayers of sand and sandstone, 93-95 m thick. The deposits of the top Jurassic (Callovian, Oxford and Kimeridgian stages) consist of clays interspersed with limestone and sandstone, the thickness varies from 50 to 100 m;
- Deposits of Cretaceous age are presented by bottom and top stages. The bottom layer consists of speckled stratum of clays with the interlayers of various granular sand and sandstone. The top Cretaceous layer consists of sediments of Cenomanian stage formed of quarts- glauconitic sands with the interlayers of sandstone as well as sediments of Turon, Cognac, Santon, Campagn and Maastricht stages consisting of chalk and chalk-like marls. The thickness of chalk rock is decreasing from the depression side towards the crystalline shield (from 350-400 m to 0 m).

The Cainozoic group is characterized with sediments of Palaeogene, Neogene and Quaternary ages. The thickness of the Cainozoic rocks is gradually increasing from the Ukrainian shield (0-20 m) to the center of Dniepr-Donetsk Basin (to 200-250 m).

The Palaeogene strata occur everywhere above the underlying Mesozoic sediments with the sharp cross bedding. They are classified into Sumi, Kanev, Buchakskiy, Kiev and Kharkiv suites and consist of Paleogen strata of sand, sandstone and clay marls.

The Neogene strata consist of quarts sand and speckled clays of insignificant thickness. They do not occur within a significant part of the area except for the watersheds.

The Quaternary strata include clays, sand, loess-like loam, by genesis they have fluvioglacial, alluvial, atmogenic and other sediments.

The Quaternary strata within the Pripyat river valley consist of sands with rare interlayers of clay soil. The first above-floodplain terrace intended for the CSFSF site consists of top- and middle-Quaternary strata, 30-35 m thick. The top-Quaternary stratum is formed of the following facies: floodplain, old river-bed, beach, river-bed, wash-out. The Quaternary overburden within the Pripyat river valley are bedded above the washout surface of marl clays of Eocene Kiev suite.

In terms of tectonics the CSFSF site is located at the junction of two regional structures of the East-European platform: Ukrainian shield, Dnepr-Donetsk Avlacogene (DDA) and Pripyat Depression. These large-scale structures are joined within the Bragin-Loevskiy saddle splitting the Dnepr-Donetsk Avlacogene and Pripyat Depression.

Analysis of tectonic maps, neotectonic map, map of discontinuous abnormality, copies of which are given in Attachment K, Figures K1-K3, large number of publications and reports was the basis to identify the following faults close to the CSFSF location, which can be considered as tectonic active:

- Southern Pribort zone of faults including the Southern-pribort zone of Pripyat depression and Southern-pribort zone of Dnepr-Donetsk Avlacogene split by the Teterev fault;
- Western line of the Teterev fault;
- Eastern line of the Teterev fault.

The other faults and zones of faults identified by various authors on the maps do not correspond to requirements specified for tectonic active faults which are considered as seismically active under the platform conditions.

The Southern-pribort zone of Pripyat depression is the zone of deep fault at the “M” surface. In the field of gravity it is characterized with the gravitational degree extended for 150 km. Within the magnetic field the Southern-pribort zone is considered as a boundary between the fields of positive (in the north) and negative (in the south) values Za.

The map of discontinuous abnormalities and main lineaments (Attachment K, Figure K3) shows the time of Southern-pribort zone location as $D_3^1 fr_3$, and activation time as kD^2_{3c}.

The zone of lineaments outlined in accordance with space pictures matching with the Southern-pribort zone of faults is considered as regional mantle neo-tectonically active discontinuous abnormality of the Archaean-Proterozoic stratum.

The map of neo-tectonics (Attachment K, Figure K2) identifies the southern part of the crush zone as discontinuous abnormality, active during Neogene-Quaternary time and controlling location of benches throughout relief and the northern part as an abnormality active during Neogene-Quaternary time controlling the change of thickness, lito-facies and hypsometry of the bottom of Neogene and Quaternary strata. Therefore, all above-mentioned allows considering the Southern-pribort zone of the Pripyat depression as a tectonically active structure. In addition, the results of investigations published by the Institute of Geophysics of the National Academy of Sciences of Ukraine demonstrate that the pribort zones of faults within the Pripyat- Dnepr-Donetsk region considered to be seismotectonic and potentially seismically active. The structural-tectonics diagram of surface within the CSFSF area is given in Attachment B.

The Teterev area of faults consists of two branches: I – western branch, II – eastern branch. The western branch of the Teterev fault is longer than the eastern one. The CSFSF site is located almost in the middle between two branches of the Teterev fault area.

The Teterev fault area complies with the system of deep faults of the early Pre-Cambrian stratum of multiple tectonic activation including neotectonical one. In various periods activity of the Teterev fault area is characterized mostly by upward movements. This is the area of intensive

solution exfiltration, shearing, occurrence of hydroterms of various content, increase of the carbonate section and secondary transformations in the Carpathian region.

Both branches of the Teterev fault are identified in the “M” surface and considered as deep faults.

There is a significant change of magnetic and gravitational fields along the Teterev fault, with the gravitational stage being applicable to the south-west from Zhitomir. The gravitational stage is not specific for the Teterev branch I close to the CSFSF site. There is a number of positive magnetic anomalies.

The Teterev zone II is characterized with the chain of local positive anomalies of the magnetic field and a gravitational stage clearly identified in the gravity field.

Both branches of the Teterev fault match the lines of the deep faults of the “M” surface.

The map of discontinuous abnormalities shows the Teterev fault area as a discontinuous abnormality of shearing nature classified into the Archaean-Proterozoic stratum and Palaeozoic activity. The length of the Teterev fault I is about 350 km, of the Teterev fault II of about 150 km.

The map of neotectonics (Attachment B, Figure B2 to this document) do not show the north-western branch of the Teterev fault I, with the south-western branch shown as a discontinuous abnormality, active during the Neogene-Quaternary time by localization of linear forms of the relief beginning from the crossing area with the Zvizdal-Zalesskiy fault, and considered as the abnormality controlling the change of thickness, lito-facies and hypsometry of the bottom of Neogene and Quaternary strata. The extent of tectonic activity of the Teterev fault area is significantly bigger in Zacarpatia, Carpathian regions, Pre-Carpathian depression and Pripyat-Dnepr-Donetsk than that within the Ukrainina shield. The type of shearing is a left shear. Based on the geodetic data the rate of modern movements is 0,1-0,6 mm/year for Teterev fault area I and 0,1-0,4 mm/year for Teterev fault II.

Therefore, the following can be considered as tectonically active: the south—eastern line of Teterev fault I and Teterev fault II from Radomishl to the crossing point with the southern-pribort zone of the Dnepr-Donetsk Avlacogene faults.

The most ancient strata exposed in the on-site wells at the depth of 73.5 m are the rocks of Buchak-Kanev suite of Eocene age P_2bc+cn. The moraine-chalky bedding of Turon stage located underneath 90 m are not of interest in terms of engineering-geological analysis of the area.

The strata of Buchak-Kanev suite (Eocene) P_2bc+cn consist of fine sand and dusty sand interspersed with glauconite and large-grained material. They underlie the rocks of Kiev sunk. The absolute sheet levels are 70,6-80,7m.

The deposits of Kiev sunk (the top Eocene stage) P_2 kv spread everywhere and consist of mica marls of blue-green color interspersed with glauconite and clays. The clays happen to be cracked. The absolute levels of the sheet vary from 73 to 84 m.

The Quaternary deposits consist of bottom- and middle-Quaternary alluvial fluvio-glacial (af I-II), middle-Quaternary lacustrine fluvio-glacial (lf II) and moraine formations (g II). Their thickness in average varies from 58 to 71 m.

The bottom- and middle-Quaternary deposits (af I-II) are bedded above the rocks of the Kiev sunk within the buried Pripyat valley, the transition from the ancient alluvial deposits to the fluvio-glacial is gradual. The bottom- and middle-Quaternary deposits are the sand of various coarseness (from dusty to medium-grained) of grey and brown color with rare interlayers of clay soils. The thickness varies from 20,6 to 37,7, in average 25-30 m.

The middle-Quaternary deposits (f II + g II) are in the top part of the Quaternary section and consist of fluvio-glacial (f II), lacustrine fluvio-glacial (lf II) and moraine (g II) strata. In general, these rocks belong to glacial complex of Dnepr glaciation.

The fluvio-glacial deposits consist of sand and clay soil. The sands are fine, medium-grained with interlayers of dusty sands.

The clay soil consists of loamy sands, loam and rarely clays. They are bedded as lenses and interlayers within the aeration zone and discretely spread. Their thickness varies from 0,3 to 12,7 m, in general 3-6 m.

The thickness of fluvio-glacial deposits includes interlayers and lenses of moraine formations consisting of red-brown and brown sandy loam and loamy soil interspersed with large-scale material with the thickness from 0,4 to 7,9 m, in average 1,5-3,4 m. The total thickness of middle-Quaternary stratum varies from 23,5 to 38 m, mostly 30-35 m.

The physical-mechanical properties of soil (normative values) are given in Attachment B, table B1.

There are no dynamically unstable, tightly compressed, subsidented and water-permeable soils within the entire on-site 45-m thickness.

No active karst, erosive-karst processes, tectonically active faults, landslips, creeps were detected for the site.

2.1.3 Seismic

The East-European platform locating the site for the storage facility is weak active in terms of seismic.

Adjacent Carpathian and Crimean seismically active regions are the most investigated. There are data of seismic occurrence, seismic conditions and seismic activity. The zones of maximum probable earthquakes were identified and wave attenuation rates were assessed for the various directions from the seismic centers.

Vibrations of soil due to severe Carpathian earthquakes with the magnitude of 7 and more spread far to the Russian platform, reaching 5 points in Kiev region. The seismic intensity in Kiev was 3-4 points as a result of the 1927 earthquake in the Crimean.

In accordance with the seismic micro-zoning map for Ukraine the intensity of a design earthquake for the selected site is 5 points and the maximum design earthquake is 6 points [12,13].

The seismic stations nearest to the site are located in the Carpathians, Crimea and Belorus at the distance of 350-550 km, which are capable to record this area seismic with the magnitude exceeding 4 points. The weaker earthquakes within this area are impossible to record.

2.1.4 Geomorphology and Relief

In terms of geomorphology the site selected for the storage facility is located in the northern-eastern part of Kiev moraine-zandr plain (Kiev Polessie) included in Polessie lowland classified into strata-accumulative plains.

In terms of its structure the site area is within the Dnepr-Donetsk depression joining to the northern-eastern slope of the Ukrainian shield.

The surface of the area is gently, occasionally swampy, generally inclined northwards (towards the valley of the Pripyat river). Wide-meandering shallow valley rivers are typical for this area. The depth of the river valleys is mostly insignificant.

The main water artery of the region is a navigable river, the Pripyat, which is a right tributary of the Dnepr. This is a typically lowland river with a typical spring high water and relatively low summer low water. The width of the river is 200-300 m, the depth varies from 3 to 8 m at the reaches and about 1,5 m at the rifts. The bottom of the river is sandy undercurrent, and sometimes silty in the middle current. The river is freely meandering. Due to availability of the Kiev water reserve the lower part of the Pripyat bed is in the backup, the mouth part is flooded with the Kiev sea. The river valley is well developed. In addition to the floodplain, there are four over-floodplain terraces. The absolute surface levels within the Pripyat valley are 105-135 m.

The other large river is the Uzh, the right tributary of the Pripyat. The Uzh valley is well developed, it has a floodplain and three floodplain terraces. The absolute surface levels within the Uzh valley are 105-125 m.

The moraine-zandr plain in-between the Pripyat and Uzh stretches stripe-shape from the west to the south-east. It has the highest area with levels 145-150 m, and separate hills, 160 m high.

The site is located at the watershed between the Pripyat and Uzh and is characterized with the flat-wavy relief formed due to water-glacial accumulation.

Some part of the site is a right-bank watershed of the Pripyat valley and a left-bank watershed of the Uzh valley. The distance to the Pripyat is 8 km, and 18 km to the Uzh river.

The specificity of Chernobyl-Chistogalovka region is availability of moraine ridges and hills, forming the range of heights of 15-20 m, which is quite obvious in Polessye lowland. The main range of heights stretches from the north-west to south-east from Buriakovka village to Chernobyl through villages Chistogalovka and Lelev. It consists of a number of dome-like or long hills which are often connected with each other and create asymmetrical ranges with steep (up to 8^0) convex-concave northern and northern-eastern slopes and gentle (about $2\text{-}4^0$) southern and south-western slopes.

The absolute height of separate ranges echelon adjacent to each other displaced to the right is decreased from the north to the south from 160-165 to 135-140 m. The southern ranges lose their integrity and fall apart into separate massifs and hills [14]. Between separate hills there are secluded over-wet round valleys with flat bottoms. One of such vast depressions locates Chistoganovka village.

The tops and the slopes of the hills are covered by moraines with a large number of boulders and fragments of rocks of various petrographic content (boulder loamy sand and sands). The secludede depressions between the hills, as a rule, are filled with loamy sand deposits. The fluvio-glacial deposits are the main in forming these hills, therefore, they can be considered as erose specific shapes of the glacial relief: kames or oses[15].

The slopes of finite-moraine ranges are drained by depressions and gullies (up to 0,9 km/km^2). The steep northern slopes are characterized with short trough-shaped gullies with flat bottoms bedding dealluvial dusty sands. The gentle dealluvial slopes and in-range saddles are drained by hollows with concave bottoms bedding dusty sands as well. The tops of the gullies and hollows, as a rule, have drainage depressions which accumulate the matters traveling in the forms of slurries through the landscape.

An important element of the landscape morphology at the CSFSF site assumes availability of internal-drained and half internal-drained tracks of depressions. Some of them are swampy which evidences their location over local aquifuges. Such depressions have soils with sufficiently thick (up to 0.4 m) organo-genic (peaty) horizon, which is also a potential trap for radionuclides travelling as solutions and slurries.

The southern part of the range is characterized with unswampy depressions. Their bottoms are covered with dealluvial loamy sand and loam with the slopes evidencing erosive processes. Absence of swampy bottoms and slope erosion indicate to water outflow through the bottoms of depressions as well as to continuous subsidence. The detail investigations identify the unswampy depressions as the “windows” in the solid cover of kiev marls, which allow for relatively quick infiltration ingress of PH into protected aquifers[16].

The type of the relief is accumulative, flat-wavy and of various genetic categories as follows:

- Relief of glacial accumulation: moraine-zandr plain;
- Relief of water-glacial accumulation: kames;
- Accumulative denudation relief created due to atmogenic processes: “kuchugura”.

Kames and kuchuguras do not spread widely.

The relief of the storage facility site is the result of atmogenic processes. The site assigned for construction of the storage facility has a flat-wavy relief with insignificant disjunction depth.

The absolute levels of the ground surface within the site are in the range of 135-145 m, reach 150 m in the central part and 139-144,40 m at the area of the facility itself.

The micro-relief of the CSFSF site has a flat-wavy relief with insignificant disjunction depth and absolute levels from 145 to 148 m.

2.1.5 Hydrological Conditions

2.1.5.1 Hydro-graphical network

The CSFSF site is located at a far distance from open basins at the watershed plateau between the right bank of the Pripyat river and the valleys of its tributaries, the Uzh and Sakhan (Figure 2.1.3). The shortest distance to the Pripyat is 12 km and to the Uzh and Sakhan - 11 and 9 km correspondingly. There are not any permanent or drying up streams, water reservoirs and swamps.

The annual humidity balance of the site is positive (+80 mm). Due to high permeability of soil and insignificant ruggedness of the relief the infiltration of excessive moisture into the groundwater prevail with no surface water flow. Nevertheless, the local aquicludes allow for probable paludification.

The surface of the CSFSF site has a general flat grade northwards (towards the r.Pripyat valley).

The main water artery within the CSFSF area is the Pripyat crossing the EZ and MRZ from the north-west to the south-east and flowing into the Kiev water reservoir. The length of the river is about 50 km within the EZ and MRZ (from village Dovlyadi to the mouth) with the drainage area being two thousand km^2.

The Pripyat is a lowland river with the snow feeding prevailing. The maximum drain and the maximum river levels are typical for the high water in spring. There are often rain and snow floods at the Pripyat when the maximum flow rates and water levels are, as a rule, lower than those during the spring high water.

After the Kiev water storage was filled to the headwater level in 1966 the mouth part of the Pripyat was flooded and the water storage backup spreads upstream for several dozens kilometers (during low water it is higher the town Pripyat).

The Pripyat bed width is 160-200 m within the EZ and MRZ. The average depth of the river within this part is 2,5-4 m, and the maximum is up to 6-8 m. The floodplain (with the exception of the part running close to Chernobyl town) is two-sided, with the general width being 4-5 km, and in the vicinity of Pripyat town, villages Krasno, Plyutovishche, Ladizhichi, its width reaches 7-8 km.

The average flow velocity of the Pripyat is 0,4-0,6 m/s within the area from the boundary of the EZ and MRZ to the southern edge of the ChNPP fuel cooling pool in the low water period and the maximum (at the streamflow) is 0,7-1,0 m/s. The average flow velocity within the area from the ChNPP fuel cooling pool and downstream is 0,2 m/s less due to a bigger impact of the Kiev water storage backup. In the periods of high flow rates the flow velocities within the main riverbed can be 1,5-2 times bigger.

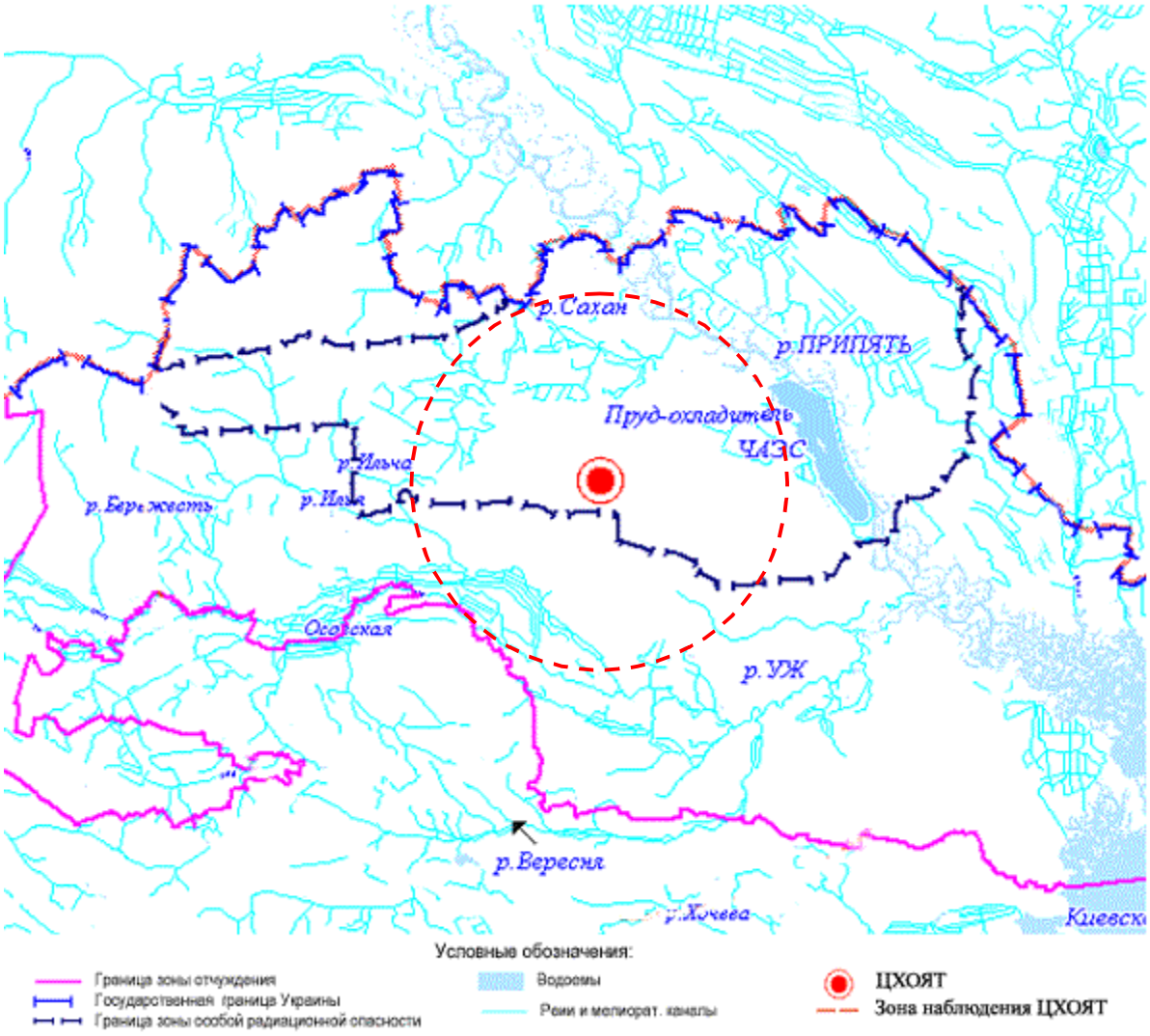


Figure 2.1.3 – Map of hydro-graphical network within the CSFSF site

Development of the Pripyat riverbed under natural conditions assumed free meandering with intensive treatment of banks. Often and continuous floodplain floods in the pre-accident period required construction of protective dams, mainly, at the left bank, such as an "old" polder in the proximity to villages Usov, Krasno, Zimovishche, the areas down the railway bridges at the villages Zimovishche, Krivaya Gora, Starolessye. The accident at Chernobyl power unit-4 and construction of water-protection facilities led to additional significant changes within the area adjacent to the river. Some part of the Pripyat right-bank floodplain down the railway bridge is occupied by the ChNPP fuel cooling pool. The riverbed is straight within this area, which is 9km. Existing dams separate a number of right-bank floodplain water basins and adjacent area from the main riverbed. The right bank of the river up the bridge is reinforced with stones along several kilometers. Some part of the left-bank floodplain called Krasnenskaya floodplain ("new" polder) significantly contaminated with radionuclides has been protected from flooding by a sand hydraulic dam, 11.2 km long since 1992. Therefore, the deformation of the Pripyat bed in a plan view is currently limited at the significant part of the EZ and MRZ.

Due to the backwater of the Kiev water storage the flow velocity is decreasing at the at-mouth part of the Pripyat leading to accumulation of sediments.

The main hydrological features of the Pripyat river are the following:

- Average annual flow rate at the ChNPP alignment - 420 m^3/s.

- Maximum annual flow rate:
  - probability 0,01 % - 13000 m^3/s;
  - probability 0,1 % - 9000 m^3/s;
  - probability 1 % - 6000 m^3/sec.
- Minimal annual monthly flow rate 97 %:
  - Period of open channel - 61,1 m^3/s;
  - Freezing-over period - 55,9 m^3/s.
- Maximum level at the ChNPP intake alignment:
  - probability 0,01 % - 111,3 m (Baltic System);
  - probability 1 % - 109,9 m (Baltic System).
- Minimal daily level with probability 99 %:
  - Period of open channel - 102,20 m (Baltic System);
  - Freezing-over period - 102,32 m (Baltic System).

Flooding of the most floodplain at the area 5 km up and down alignement of Yanov railway bridge is higher the levels 106,5-106,7 mBS.

The basin of the Pripyat includes the other waterways of this area (with the exception of The Braginka river, which flows through the Dnepr-Pripyat interfluve to the Kiev water storage).

The biggest tributary of the Pripyat is the Uzh river flowing through the sourthern part of the EZ and MRZ to the Pripyat below Chernobyl town. About 20 % of the r.Uzh basin is located within the EZ and MRZ, which is mainly its lower left-bank part from village Poleskoye to the mouth. The biggest left-bank tributaries of the Uzh are rivers Grezlya and Illya, the right-bank rivers are the Bober and the Veresnya.

The right-bank area of the Pripyat occupying the EZ and MRZ locates the basins of the Sakhan river flowing into the Pripyat close to village Novo-Shepelichi and the Glinitsa river whose mouth is at the village Lelev.

The total length of permanent waterways of the Sakhan river within the EZ and MRZ is 157 km with the basin area being 113 km^2.

The river Braginka used to flow into the Pripyat some kilometers up its mouth before completion of the Kiev water storage. At present the Braginka flows directly to the water storage.

The hydrographical network of the EZ and MRZ includes closed and weak running water basins including Kosharovsky and Novoshepelich cut-offs, Semikhodi and Pripyat inlets separated from the Pripyat nowadays, the lake Azbuchin and others.

The left-bank (Krasnenskaya) floodplain protected since 1992 locates cut-off parts of channels of the Muromka, Krasnenskaya old riverbed, lake Glubokoye, Vershina and others. Some part of these water basins is connected by a drainage channel from which the water excess is pumped to the "old" polder at the villages Usov, Krasno, Zimovishche. As above-mentioed the water excess from the polder (occuring in the high water periods) is discharged through an opening in dam #7 to the Pripyat.

In the vicinity to the ChNPP there is a ChNPP fuel cooling pool located along the Pripyat right bank, its area is 22 km^2. Support of the water level in this pool, which is 6-7 m higher than that of the river leads to permanent water filtration through the bed and the dam and its entry to the Pripyat through the streams, a southern drain channel and underground ways.

2.1.5.2 Hydrogeological conditions

The EZ and MRZ is located at the edge part of the sourth-western slope of Dnepr-Donetsk artesian basin. In considering feeding and drain conditions, water-contained deposits and chemical content, the groundwater within the area in question can refer to free water-exchange zone.

The hydrogeological conditions of the CSFSF site depend on the features of the aquifer complexes and weak permeable deposits stratigraphically sequenced as follows:

- aquifer system of Quaternary strata;
- weak permeable strata of Eocene kiev sunk (aleurite –marl thickness);
- aquifer system of Eocene strata;

- weak permeable strata of marl-chalky thickness of the top Cretaceous;
- aquifer system of Cenomanian-Lower-Cretaceous deposits.

Due to certain permeability and nature of distribution of weak-permeable deposits the above-mentioned aquifer systems are interrelated and form a common hydraulic system.

Aquifer system of Quaternary strata. The underground water of Quaternary strata aquifer spreads everywhere. Based on the age and lithologic content they can be classified into various rocks: from modern (top-Quaternary – alluvial, lacustrine- alluvial) to middle-Quaternary (alluvial, water-glacial and lacustrine-glacial), developed within a floodplain, valleys of the first and second floodplain terraces and moraine-zander plain.

The water-contained deposits are fine- and medium-sand, occasionally coarse sand, intersersed with gravel and pebbles at the bottom part of the section with the interlayers of clay sand and loam. The water-glacial deposits consist of anisomerous sand; lacustrine-glacial of green-grey fine sandy loam. The water-contained alluvial sand has a prevailing fraction of 0,25-0,05 mm constituting in average 42-58 %; the content of clay particles reaches 3,5-4 %.

The aquifer as a rule is un-confined. In some areas where the sandy rocks are inter-stratified with denser clay rocks there is a local head of 0,5-4,0 m sometimes increased to 7,0 m. Some separate areas have temporary or permanent "perched" water. The depth of the groundwater varies from 0,0 m at the joints of groundwater with the surface water basins (track "Rodvino") to 19-21 m within Chistogalovka-Chernobyl ridge. The absolute levels can reach 132-137 mBS. The range of annual level change is from 0,5-1,0 m at the watershed to 1,0-2,0 m and more at the Pripyat floodplain.

The thicknness of water-containing rocks changes in average from 10-15 m at the the Pripyat floodplain to 20-30 m at the terraces and moraine-zander plain.

Depending on the lithologic and granulometric content of water-containing deposits the filtration factor widely varies from 0,2 to 20-30 m/day. The water conductivity is 100-400 m^2/day at the river terraces and 40-100 m^2/day at the watersheds. Well flow rates reach 10-20 l/s, in the most cases it is 2,5-4 l/s and 2-15 m under decrease. The specific production does not exceed 1-1,5 l/s.

By the salt content the water is mostly hydrocarbonate calcic, rarely, hydrocarbonate calcic magnesium with mineralization value ranging 0,1-0,8 g/dm^3. The reaction of groundwater changes from subacid to alkalescent with pH =6,7-7,4. The total water hardness varies from 0,3 to 3,6 milliequivalent /dm^3, the content of total iron is 2-6 mg/dm^3.

Accumulation of groundwater resources is mostly of infiltration nature due to precipitation. The value of infiltration feeding is in the range of 80-200 mm/year depending on landscape-lithologic conditions with the rate of precipitation being about 600 mm per year. The module of undergoundwater runoff is 150-450 mm/year.

The main regional area of the groundwater dischage is the Pripyat river. The absolute base levels is 98-100 mBS.

The aquifer of the Quaternary strata, the first from the ground surface, is actually not protected from radioactive contamination. At present, the groundwater is used as potable and sanitary by a few unauthorized dwellers, operating wells.

Weak permeable strata of Eocene kiev suite *(aleurite–marl thickness)* spread in the region separate the groundwater of Quaternary strata from confined and unconfined aquifer of Eocene (buchak-kanev) strata. The top of weak permeable strata is at the depth of 20-30 m within the terraces and up to 90 m at the watersheds. The thickness varies from units to 30 m. The marls are occasionally eroded and the "windows" are made of sand-loamy deposits. The filtration coefficient of marl clays is from $2{,}5 \cdot 10^{-4}$ to $1{,}8 \cdot 10^{-2}$ m/day.

The aquifer system of Eocene strata consists of buchak and kanev aquifers between which there are no separating weak permeable deposits due to which they form a unified hydraulic system and are considered as a single aquifer.

The water-contained thickness consists of fine- and rarely medium-sand of glauconite-quartz nature and clay sand with interlayers of sandstone, siltstone and clays. The regional plan

view shows uniform water-containing rocks, the thickness varies from 30 to 50 m, in average from 35 to 38 m.

The depth of bedding varies from 20 m in the west of the Exclusion zone to 90 m in the north-eastern direction and underneath the moraine ridgtes. The water is confined, the height of waterhead is 30-60 m. The levels are at the depth from 0,5 to 17 m. The total drop of piezometric level of Eocene aquifer is closer to the valleys of the Pripyat and the Dnepr. The absolute piezometric levels vary from 97-103 to 114-118 mBS.

The water content of deposits is uneven. The well flow rates vary from 1,0 to 4,2-8,9 l/s, in separate cases they reach 13-14 l/s and under decrease of water level it is 3-18 m. The specific flow rate is 0,2-1,5 l/s. The values of water conductivity are in the range of 70-180 m^2/day, in average it is 100-150 m^2/day; the coefficient of piezoconductivity is 10^4-10^6 m^2/day.

By the salt content the water is hydrocarbonate calcic, magnesion with mineralization value reaching 0,3 g/dm^3. The reaction is characterized from neutral to alkalescent with the pH value of 7,0-7,5, the total hardness is 2,0-5,7 milliequivalent /dm^3.

Accumulation of groundwater resources happens mostly outside the area under consideration. The water "age" is about 30 years. The discharge of an aquifer happens due to drainage by the Pripyat intake facilities and the rivers Pripyat and Dnepr. This aquifer system is the basis for arrangement of centralized potable and service water supply to the SSE "Chernobyl NPP".

Weak permeable strata of marl-chalky thickness of the top Cretaceous are developed everywhere and consist of white writing chalk and chalky-like marls 56-85 m thick. They are increasing from the west to the east towards the central graben of Dnepr-Donetsk depression. The depth of the bedding is 85-145 m. The infiltration coefficient is about $n \cdot 10^{-6}$ m/day.

The aquifer system of Cenomanian-Lower-Cretaceous deposits spreads everywhere. In terms of lithologic the water-containing thickness is not stable and consists of anisomerous sand with rare lenses and interlayers of sandstone and marls. The thickness of water containing rocks varies from 2 to 40 m, which is in average 25-30 m. The depth of the aquifer system varies from 150 to 217 m, increasing eastwards.

The aquifer is confined. The piezometric levels in the wells are at the depths of 2,5 - 28,5 m, which corresponds to the absolute levels of about 104-109 mBS. The height of the head above the top is 150-190 m. Due to uneven lithologic and granulometric content of water-containing rocks the well flow rates widely vary from 2,6 to 18,1 l/s (under decrease of level 6-45 m). Specific well flow rates are 0,12-1,1 l/s. The largest water productivity is typical for the wells located in the south-eastern part of the region. The filtration factor of water-containing deposits is 0,5-14 m/day, the conductivity is 30-80 m^2/day.

By the salt content the water is mostly hydrocarbonate calcic, rarely, magnesium with mineralization value 0,5-1,0 g/dm^3. The total water hardness is 1,9-5,6 milliequivalent /dm^3.

Accumulation of groundwater resources happens mostly outside the area under consideration. The water "age" is about 30-70 years. The discharge of an aquifer happens due to drainage by the intake facilities.

This aquifer system belongs to Cenomanian-Lower Cretaceous stata and is a basis for arrangement of centralized potable and service water supply to Chernobyl town.

2.1.5.3 Hydrogeological characteristics of the site

The specificities of the geological and hydro-geological conditions of the CSFSF site are predetermined by its location at the watershed plateau between the valley of the rivers Pripyat, Uzh and Sakhan. The geological section of the site underneath the layer of soil and sand filling (2,2-3,2 m thick), clearly shows vertical zoning from the top to the bottom [17]:

- The top part include *Middle Quaternary fluvio-glacial sediments* consisting of quartz sand, mainly fine sand, with the lenses of dust and medium-grain sand and clay sand. The colour of soil is grey and yellow. The thickness varies from 3,4 to 11,9 m, the absolute levels of the layer bottom are 138,3–127,1 m;

- Below there are Middle Quaternary glacial (moraine) sediments of the Dnepr glaciation stage consisting of red-brown clay sand, occasionally, loam interspersed with large-scale material. The top of the sediments is rather uneven. The thickness of these sediments is insignificant from 0,6 to 2,8 m, the absolute levels of the bottom are 135,8-124,3m. Some areas include moraine deposits twice: at the depth 8,4-9,4 m and 11,8-13 m (lenses);
- The moraine sediments are bedded above Middle Quaternary fluvioglacial sediments of various lithologic content with the sand from dusty to medium-grain size prevailing. The thickness of sand at the various depths is interspersed with lenses of clay soil ranging from clay sand to clay (mainly clay sand). The thickness of lenses of clay soil varies from 0,3 to 4 m. The total thickness of the second layer of fluvioglacial sediments varies from 5,3 to 15,6 m.

Within the investigated depth (80-90 m) there are beddings of Quaternary and Eocene deposits including Quaternary and Buchak-Kanev aquifers as well as the aquifer of the Top Cretaceous (lower aquifuge of Buchak-Kanev aquifer).

The deposits of the Top Cretaceous consist of marl and chalkyrocks of Turon stage the top of which is at the depth of 90-100 m. Above there are beddings of Buchak-Kanev sunk consisting of fine and dusty sand, about 30 m thick; that is also the location of Buchak-Kanev aquifer. The top of the aquifer assumes the thickness of marl clay of Eocene Kiev sunk in average 10 m thick, the top of the clay is at the depth of 50-60 m.

The above-lying thickness of Quaternary fluvioglacial sediments has mostly medium-grain sand in the bottom part and sandy-clay interlayer formations in the top part with the sand prevailing. There are occasionally interspersed with lenses of moraine loam, in general, 3-4 m thick. The thickness of interlayers and lenses of clay soil is various from 1-2 to 6-8 m. The Quaternary sediments include the ground water [18].

The island spread of loam interlayers including moraine through the Quaternary stratum and their insignificant thickness predetermines imperfection of the confining bed assuming availability of numerous hydro-geological “windows".

The Quaternary aquifer is unconfined, Buchak-Kanev aquifer has a head. Their levels are almost similar and are at the depth from 11 to 25 m. Based on the survey results (spring 2002) the absolute levels are at 12,3-124,1 m [17]. Correspondingly the thickness of the aeration zone varies from 11 to 25 m, mainly from 18 to 21 m. In the nearest parts of the Pripyat and Uzh valleys the levels of the underground water are at the absolute levels of 109-115 m.

In accordance with the earliest engineering-geological survey data (1991-1992) the absolute levels of the water table are lower 120,0-124,8 m, that evidences a tendency for its increase [19].

The analysis of distribution of hydrohypses leads to the conclusion that the incline of watertable within the site is 0,002 units and is directed to the north-west (towards the Pripyat).

The main source of the aquifer is precipitation, which predetermines seasoning change of the groundwater level. In accordance with the hydro-geological survey at the RWDF Buryakovka located at the distance of 1.1km from the CSFSF site the annual change of the groundwater level is 0,02-0,14 m [20].

The areas, where the aeration zones have exposed moraine loam or significant (by thickness and areas) interlayers of clay soil, allow for generation of possible perched water. During the survey the perched water was detected at the separate areas at the depth from 1,4 to 6,8 m. The interlayers and lenses of clay soil functioned as a confining layer. In the high-water periods the area of the perched water distribution and its thickness can increase.

In accordance with the other data [20], the perched water can occur in the eastern part of the CSFSF site. The depth of the perched water varies from 1,3 to 7,2 m, increasing from the south-west to the north-east. Its average thickness is 0,3-1,0 m varying from 0,2 to 1,9 m.

The latest survey (February 2002) for the Complex “Vector” site the depth of the perched water level was 1,6 m with the thickness being 0,3 m [17].

Construction and operation of the CSFSF can lead to the man-induced generation of the perched water. That might require implementation of comprehensive protection measures for

drainage, runoff, etc. Filtration coefficients for geological rocks within the CSFSF site are given in Table 2.1.2.

Table 2.1.2 - Filtration coefficients for geological rocks within the CSFSF site [20]

Geological rock	Filtration coefficients, m/day
Dusty sand in the aeration area	1,75
Dusty sand in the phreatic zone	3,5
Fine sand in the aeration area	3,0
Fine sand in the phreatic zone	4,0
Medium-grain sand	15
Fluvio-glacial loam	0,1
Moraine loam	0,04
Fluvio-glacial clay sand	1,0
Moraine clay sand	0,8

The Quaternary aquifer is not protected from the surface radioactive and chemical contamination. The Buchak-Kanev aquifer is protected.

Kiev clay functions as a confining layer for the Quaternary aquifer. The clay spreads everywhere at the site of the adjacent Complex "Vector", nevertheless it is washed out at the Buryakovka area. The depth of the confining layer is from 70 to 84 m. Its thickness varies from 1,6 to 10 m (in average 6,9 m). The filtration coefficient for Kiev clay varies from 10^{-2} to 10^{-4} m/day [20].

Based on the results of the chemical analysis of the groundwater at the site of the Complex "Vector" the groundwater was classified into non-aggressive or weak-aggressive towards the reinforced concrete structures and as medium-aggressive towards non-steel structures [20, 21]. The chemical content of Eocene strata aquifer is hydrogen carbonate calcium, natrium-calcium, magnesium –calcium, calcium - natrium , natrium, sometimes chloride- hydrogen -carbonate natrium. Mineralization does not exceed 0,8 g/l. The aquifer is confined, the piezometric surface is at the same level as the level of the groundwater, in some cases it is 1-2 m lower. The thickness of the aquifer is 35 m. The filtation coefficient can vary from 2 to 20 m/day, but the average value is 3-6 m/day. The confining layer of the Eocene strata aquifer consists of the marl-chalky thickness of the Turon-Cenomanian period with the filtration coefficient being 10^{-2}-10^{-3} m/day.

The Complex "Vector" site is located between the valleys of rivers Pripyat and its right tributary the Uzh. The distance to the Pripyat is 10 km and 9 km to the Uzh. The site has no permanent or drying waterways, reservoirs or swamps. The moisture balance is positive (80 mm). Weak ruggedness of the relief and absence of surface flow allow for prevailing infiltration of excess water into the ground water. Clearance of woods for construction facilitates increase of water ingress into the aquifers due to decrease of evaporation. This can lead to local flooding of shelters.

The distance to the Pripyat is 10 km and 8 km to the Uzh (1989). The distance to the drainage intake channel Maryanovka is 3 km. The valley of the r.Maryanovka is 12 km long till it flows into the r.Uzh. The length of the Uzh from the Maryanovka mouth to the Pripyat is 30 km.

The water from the r.Maryanovka and from the Uzh between the Maryanovka mouth and the Uzh inflow into the Pripyat is not used.

The maximum design water level of the Pripyat , ChNPP off-take (1989) is as follows:

- P 0,01 % - 110,80 m/s;
- P 0,1 % - 110,20 m/s;
- P 1,0 % - 109,50 m/s.

The height of the site leveling over the maximum Pripyat water level is 26,7 m.

Chemical contamination values of the Uzh are (1986-1987) (mg/dm ^{3}):

- mineralization - 373 (138-582);
- HCO_3^-=205 (33-387);
- SO_4^{2-} =46 (19,0-74,9);

- Cl^-=20,4 (46,0-8,3);
- Ca^+ =29,9 (8,8-43,3);
- Mg^{2+}=13,4 (4,9-60,8);
- $Na^+ + K^+$=57,8 (706-131,0);
- Total hardness = 2,57 (1,12-7,0) mmole/dm^3;
- NH_4^+=1,75 (0,0-4,5);
- NO_2^-=0,06 (0,00-0,16);
- NO_3^-=1,3 (0,0-4,9);
- Biological index of oxygen $_5$=4,1 (0,2-10,8);
- Chemical index of oxygen =34,2 (12,0-57,6);
- pH=7,1 (6,8-8,2);
- O_2=9,5 (6,34-12,8);
- Oil products = 0,01 (0,00-0,11);
- Surface active matters=0,04 (0,1-0,0);
- Fe_{total} =0,28 (0,06-0,58).

The sum of maximum permissible concentration excess is = 7,3.

The depth investigated (25 m) has the Quaternary aquifer (groundwater) spread everywhere, which is included into the Middle Quaternary fluvioglacial sediments. The water in general is un-confined.

The water containing rocks are the sand of various grain-size content with interlayers of clay sand and loam.

During survey (February 2002) the groundwater was detected at various depths from the surface *from* 15,0 to 21,0 m (the corresponding absolute levels are 123,30-124,10 m). The water table is inclined into the north-east direction (towards the Pripyat).

The main source of the aquifer is precipitation. This mode is related to the meteorological factors. The amplitude of groundwater level change is 1,5 m.

The confining layer of the Eocene strata aquifer consists of the marl-chalky thickness of the Turon -Cenomanian period.

The discharge direction of the groundwater is the r.Maryanovka – The Uzh. The general direction is towards the Pripyat basin.

Velocity of the groundwater flow is 44,0 m/hour.

The distance to the groundwater intake facilities and their capacities are as follows:

- "Vector" groundwater intake - 0,5 km; 0,15 thsd.m^3/day;
- Yanov groudwater intake - 10,5 km; 3,5 thsd.m^3/day;
- Novoshepelichi groundwater intake – 8km; 2,4 thsd.m^3/day;
- Shepelichi groundwater intake - 7 km; 1,5 thsd.m^3/day.

2.1.6 Soil Cover

The soil cover within the CSFSF site can be characterized with significantly mosaic, micro-complex and contrast bedding of soil, which is predetermined by a variety and change of soil generation factors. This includes the following:

- Large variety of soil-forming rocks by the grain-size and mineralogical content;
- Complicated meso- and micro-relief leading to significantly different watering conditions;
- Expressed climate damping;
- Various vegetation.

The soil- forming rocks include Quaternary sediments, over-moraine water-glacial sand, as well as ancient and modern alluvium. The floodplain and floodplain terraces often consist of sediments of organic nature, which are mainly lowland peaty areas of various thickness.

The soil cover of the EZ and MRZ is rather various and complicated. There are more than 14 mostly spread types of soil [22]. When considering the soil variety by grain-size, matrix, gleization degree and other features the number of soil types can be estimated in hundreds.

The complexity of soil cover depends not only on typological variety of soil but also on their combinations, size and shape of outlines. Considering the above-mentioned, the soil cover of physical-geographical regions of European marshy woodlands including the EZ and MRZ area can be classified into the most complicated on the Earth.

Genetic types of soil

The specific feature of the CSFSF construction area is availability of combined floodplain terraces of rivers forming flat valleys between the rivers stretched for dozens kilometers which are characterized with the most spread types of soil.

The main genetic type of soil is sod-podzol. It includes cespitose hidden- weak- and medium-podzol sandy and clay-sandy gleized and non- gleized soil usually stratified in combination with cespitose gleized sandy and clay-sandy soil. They occupy 54,4 % area which is about 129,9 thsd. hectares. (Table 2.1.3). The age of this soil by various estimates is 5-8 thousand years, therefore, the soil is young and lack of nutritive materials for soil-formation led to insignificant humus generation in the process of soil genesis. Low content of humus in combination with the washed type of water mode leads to the low level of natural soil fertility.

The other widely-spread genetic type of soil is the sod soil occupying 18,4 % area (Table 2.1.3). This type of soil is characterized with micro-complex bedding. They occur in combination with sod-podzol soil. Large areas of sod soil are located in the central and at-riverbed parts of floodplains and other lower periodically significantly moistened elements of the relief. They are all more or less gleized. By the grain-size feature the sod soil does not actually differ from the sod-podzol type. Nevertheless, significant humidity and a relatively large amount of vegetation waste allow for larger generation of humus, that allows considering this type of soil as the most fertile within the EZ and MRZ area.

Marshy soil together with the peatbogs and lower peat swamps occupy a significant area of 9,6 %. They are formed in relatively deep saddles of the relief at the river floodplains under continuous excessive humidification which leads to generation of peat. The marshy soil is widely spread in the northern part of the EZ and MRZ occupying large areas. The peatbogs and lower peat swamps are located in the central part of this area.

Table 2.1.3 – Distribution of genetic types of soil within the EZ and MRZ

Group of soil by outlines	**Area of outlines, %**
Weak- cespitose, weak-humus and non-humus sand	1,9
Hidden- cespitose and weak-podzol sand and clay-sand gleized and non- gleized soil in complex with cespitose gleized sabulous soil	4,7
Cespitose-, weak- and medium- podzol sand and clay-sand soil	12,7
Cespitose-podzol sabulous soil	3,0
Cespitose - hidden-podzol sand and clay-sand gleized soil in complex with cespitose gleized sand, clay-sand and sabulous soil	31,7
Cespitose - weak-podzol gley sand and clay-sand in complex with cespitose-medium- and strong- podzol gley sabulous and cespitose- gleized sabulous soil	10,0
Cespitose - weak-podzol gley sabulous soil in complex with cespitose-medium- and strong- podzol gley sabulous soil	2,5
Cespitose - medium- and strong- podzol gley sabulous soil in complex with cespitose gleized sabulous soil	5,5
Cespitose – podzolized soil and its variety	0,1
Cespitose – gleized sand and clay-sand soil in complex with cespitose-hidden- podzol sand and clay-sand gleized and marshy soil	8,3

Group of soil by outlines	Area of outlines, %
Cespitose – gleized sabulous and loamy soil in complex with cespitose – gleized sand and clay-sand and marshy soil	10,0
Marshy soil in complex with peaty and marshy soil	5,7
Peaty – and peaty - marshy soil	1,1
Lowland peatbogs	2,8
TOTAL:	**100,0**

The soil cover of the CSFSF site is given in Figure 2.1.4. The most part of the site is occupied by cespitose hidden- and weak- podzol sandy and clay-sandy gleized and non- gleized soil as in the other the EZ and MRZ area. These types of soil were formed at the sandy ancient-alluvium non-carbonate sediments, which led to lack of fine-disperse particles.

The hard phase of sand and clay sand soil is actually of mono-mineral (95 %) content and consists of chemically inert quartz (SiO_2). These specificities lead to negative features of soil in terms of ecological characteristics such as high water permeability under insignificant sorption capacity (3,4-3,8 milliequivalent/100 g), low level of potential fertility due to insignificant reserve of humus and vegetation feeding elements, low moisture capacity and high acidity (pH_{CL} - 4,6-4,9) (refer to Tables 2.1.4 and 2.1.5).

Table 2.1.4 – Gross chemical composition and content of organic matters in the most spread soil of the the CSFSF site [23]

Description of soil complex	Gross chemical composition, % per burnt unit						Content of humus, %
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	
Cespitose - hidden-podzol sand and clay-sand gleized and non- gleized	95,7	3,1	0,6	0,4	0,5	0,6	0,7
Cespitose and weak-podzol sand and clay-sand gleized and non- gleized	94,4	1,7	2,1	0,7	0,5	0,5	0,9

Table 2.1.5 – Physical-chemical and agrochemical properties (layer of 0-20 cm) for the most spread soil of the the CSFSF site [23]

Description of soil complex	pH KCL, unit	Capacity of cation exchange, milliequivalent /100	Nitrogen alkali-hydrolyzable, mg/1000 g	Mobile forms, mg/100 g	
				P_2O_5	K_2O
Cespitose and weak-podzol sand and clay-sand soil	4,6	3,8	60	5	6
Cespitose - hidden-podzol sand and clay-sand gleized and non- gleized	4,9	3,4	70	8	7

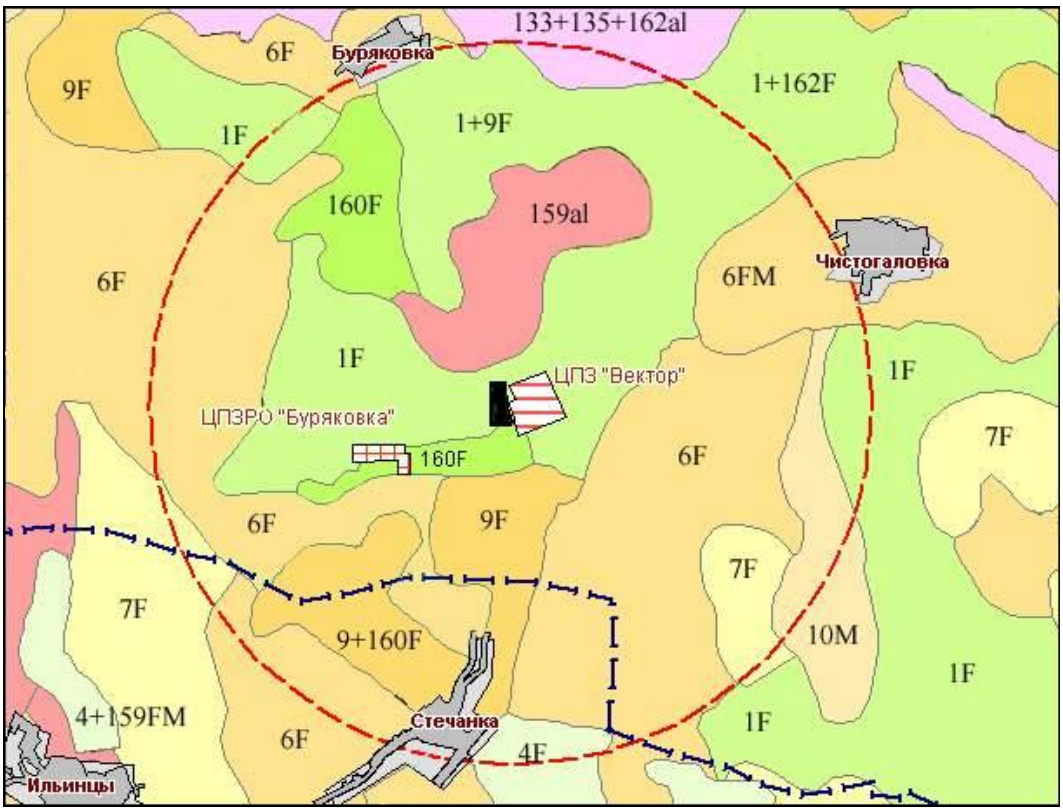


Figure 2.1.4 – Map of the soil cover of the 5-km zone around the CSFSF site (based on the data from reference [22])

Legend:

- CSFSF construction site;
160 - reference soil number;
1+162F - soil complex;

Soil forming rocks: **al** - alluvial sediments; **F** - fluvioglacial sediments; **FM** - fluvioglacial sediments, underlaid by moraine (< 1 m).

*Soil:***1** - cespitose hidden podzol (sands); **4** - sod-podzol sabulous; **6** - cespitose weak- podzol gleyey sand and clay sandy soil; **7** - cespitose weak- podzol gleyey sabulous; **9** - cespitose weak- podzol gleyey sandy and clay-sandy; **10** - sod-podzol gleyey sabulous soil; **133** - marshy; **135** - peat –marshy soil; **159** - sod gleized sandy and clay-sandy; **160** - weak-sod and weak-humus sand; **162** - cespitose gleized sabulous.

2.1.7 Preserve Area Objects

Richness of flora and fauna of the EZ and MRZ locating the CSFSF site led to establishment of 11 preserve area objects before the Chernobyl accident to enable maintenance of European biocoenotic, specific and population interfaces and flows. (Table 2.1.6 and Figure 2.1.5).

Table 2.1.6 – Preserve area objects at the EZ and MRZ

No.	Description	Distance from the CSFSF	Area, hectares
1.	National Ilyin preserve (hydrological)	41	2000
2.	Age-old oak woods (botanical)	34	12
3.	Alder-woods originated by prof. D.I. Tovstoles (botanical), partially destroyed	12	4,8
4.	Reserve "Gorodishche" (complex)	9	5
5.	Archangel fir area (botanical)	26	5,8
6.	Oak (botanical)	9	0,02
7.	Oak woods (botanical), partially destroyed	34	11

8.	Age-old pine-woods (botanical), not survived	11	2,1
9.	Age-old oak woods (botanical)	30	14,6
10.	Tract "Zagorye" (botanical)	32	110
11.	Black asper woods at the r.Pripyat (botanical)	14	14,3
The total area of preserve area objects at the EZ and MRZ		-	2180

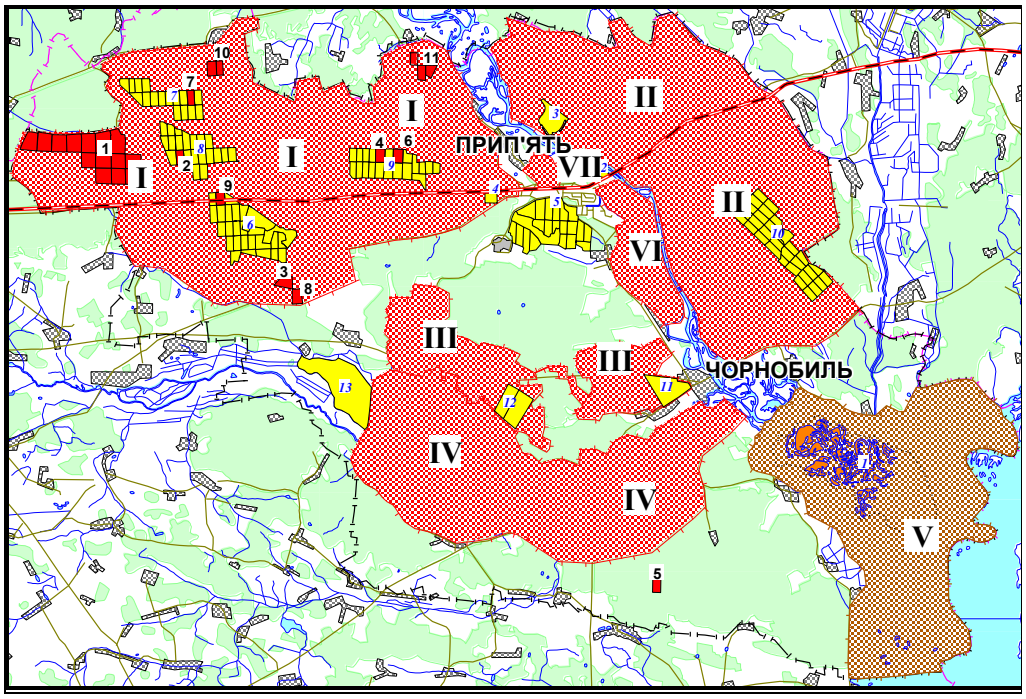


Figure 2.1.5 – Map of preserve area objects at the EZ and MRZ (red), and proposed new preserves (yellow and red hatch line). The numeration is given in accordance with Table 2.1.6.

In the post-accident period the wildlife preserve mode was maintained at the EZ and MRZ, which led to significant increase of fauna species and arrival of rare species under protection. Radiological conditions within the 30-km zone in the first years after Chernobyl accident affected stability and development of fauna complexes and individual species. Radiation influence became apparent within the areas with the highest radiological contamination levels up to 2 R/hr [24].

The areas adjacent to Chernobyl NPP site were particularly affected and as a result of fatal exposure dose the main wood species, a pine-tree, as well as the most species of above-ground and soil fauna died. Under the current conditions the species and animals, which for the first time entered this area, experienced significant inhibition of basic living functions. In addition, the newly established fauna complexes were extremely unstable. In the process of decay of short-live radionuclides and improvement of radiological conditions as well as due to development of seral complexes the initial fauna complexes gradually renewed.

At present, the most contaminated areas of the EZ and MRZ (in the radius of 5-7 km from the ChNPP site) subjected or not to decontamination are inhabited by practically all animal species adapted to local ecological conditions including the species specified in the “Red Book”, such as eme, osprey, eagle-owl, black stork, catcher, lynx, otter.

In separate most contaminated parts of the «Red Forest» small vertebrates can receive daily doses of 30-100 mGy/day [25], that leads to implicit stochastic effects. In addition, within each population the radio-biological effects are leveled by adaptive protection body reactions and absence of reproduction isolation, which assumes constant exchange of specimen with the neighboring ones from more favorable in terms of radio-ecology areas.

The main parameters of radiological conditions at the preserve area are given in the Table 2.1.7.

Table 2.1.7 – Radiological conditions at the preserve area objects within the EZ and MRZ, 1995 [26]

Object	GRER, μR/hour	Rate of surface contamination, Ci/km^2	
		^{137}Cs,	^{90}Sr,
National Ilyin reserve	50-250	-	-
Age-old oak woods	225	5-10	-
Alder-woods originated by prof. D.I. Tovstoles	65-70	10-20	4
Reserve "Gorodishche"	390-410	25-55	26
Archangel fir area	33	1-3	1,6
Oak	400	25-35	15
English oak woods	36	5	10
Age-old oak woods	105	25-100	10
Tract "Zagorye"	33-36	2	8
Black asper woods at the r.Pripyat	195-210	20-30	15

At present the exact number of protected flora and fauna species living at the EZ and MRZ is not identified. Based on the latest data there are 22 vegetation specimen referred in the "Red Book" of Ukraine and 16 species of rare plants [27, 28]. There are also 15 " Red Book " specimen and 12 rare animal species [29].

Due to increase of flora and fauna variety and the specific status of the EZ and MRZ the scientific community of Ukraine suggest the preserve area to be extended for a larger number of objects shown in Figure 2.1.5, with the total area being 13640 hectares [26,29,30,31].

2.1.8 Unfavorable Environmental and Technogenic Processes and Phenomena

The CSFSF site is located within the area which is classified into the category of radioactively contaminated lands [10], which are regulated by sanitary limitations for certain types of activities. Specific parameters of radiological conditions at the site and their impact on the personnel during construction and operation of the object will be described in part 2 of this EIA.

The area locating the CSFSF site is characterized with various unfavorable environmental and technogenic processes and phenomena. They include erosion-accumulative processes in the soil cover (soil erosion at the elevated areas due to flat washout and atmogenic deflation), fallout of acid precipitation, swamping etc. Nevertheless, their influence is insignificant to worsen the normal operation of the facility.

The potential hazard likely to interfere with the normal construction and operational conditions of the CSFSF are the following environmental and technogenic processes and phenomena:

- Forest fire;
- Flooding with groundwater.

The hazard of forest fire impact on normal construction and operational conditions of the storage facility might occur due to large dry coniferous forests located adjacent to the site from the northern and western sides. In addition, these forest areas are characterized with the high rates of radioactive contamination since they are located within the western plume of 1986 fallouts. Therefore, to reduce the risk of fire impact on normal construction and operational conditions of the storage facility it is necessary to implement fire protection measures which are described in sections 3.5.10 and 3.6.10.

Flooding with the groundwater (occurrence of perched water) was described in detail in section 2.1.5 of this document. The potential risk of local flooding is increased due to positive

water balance at this area, insignificant ruggedness of the relief and absence of surface flow. The local flooding of the site can be caused due to the following natural and technogenic reasons:

- Clearance of wood in the area located up the ground flow that can lead to decrease of moisture evaporation and increased infiltration of precipitation to the level of groundwater;
- Progressive increase of precipitation amount and uneven falling caused by nowadays warming and humidification of climate.

Probable local flooding can be easily prevented through arrangement of corresponding drainage and surface flow removal.

Analysis of the latest tectonic movements, structural-tectonic layout of the area and the nature of strata in the top part of sedimentary cover evidences that the CSFSF site is located beyond the zone of the newest discontinuous abnormalities [32].

Therefore, environmental and technogenic processes and phenomena will not significantly affect the normal conditions of the CSFSF operation.

2.2 Climatic Description of Region and Site

Description of environment conditions of the CSFSF site is based on input data collected by "Technocenter" and KIIZI "Energoproject" [17,20],

2.2.1 Climatic Description

The storage facility site is open for inflow of air masses generated in Atlantic, Arctic zones, the Mediterranean and the Black Sea. The area is also affected by the continental area from the Eurasian plains.

The climate in the area locating the site is moderately continental with the positive balance of moisture. The winter is mild, the summer is warm and humid. The most precipitation (70 %) falls in the warm seasons of the year. The transient periods (spring and autumn) are long since the inflow of warm sea air from the moderate latitudes is accompanied by clouds and rains preventing the air from warming in spring and cooling in autumn. The transition to the colder period is related to the beginning of Arctic air invasion leading to sharp and significant falls of temperature, first frosts and snow. Reoccurrence and intensity of invasions gradually increase reaching the maximum in winter.

The climatic conditions of the site are considered as well studied. Within the radius of 20-50 km around the site there are 3 meteorological stations (Chernobyl, Polesskoye, Bragin) and the other stations (Teterev, Ovruch, Vasilevichi, Gomel, Oster, Chernigov, Kiev, Borispol) within the radius of 60-120 km. The surveys have been performed at the stations for a long period of time.

Description of the site climatic conditions was based on the data from the meteorological station «Chernobyl» which is the nearest to the site and experiences the same physical-geographical effects. It provides monitoring over the air temperature, humidity, precipitation, snow cover, velocity and direction of wind, clouds and atmospheric phenomena, formation of glaze, temperature and depth of soil freezing, surface evaporation and radiological conditions.

All information about climatic conditions and meteorological survey of the facility location area are taken from the documents [33-39], if not otherwise identified.

Detail monitoring over radiological conditions within the ChNPP Exclusion zone is implemented through the Automated Radiation Monitoring System (ARMS). The ARMS allows measuring of the exposure doses at 30 monitoring points.

The ARMS monitoring point in the town of Pripyat is equipped with additional sensors to measure meteorological parameters: velocity and direction of wind, temperature, pressure and air humidity.

The ARMS sensors are also located at the ChNPP facilities, and in villages: Shepelichi, Pripyat, Kopachi, Krivaya Gora, Starolessye, Chistogalovka, Mashevo, Usov, Buryakovka, Krasnoye, Benevka, Zimovishche, Chernobyl, Chernobyl-2, Dityatki, Stechanka, Korogod, Zeleniy Myss, Ilovnitsa, Slavutich.

Meteorological data received from the long-term surveys are given in the sections below.

2.2.2 Air Temperature

The main temperature data at the CSFSF site are given in Table 2.2.1.

Table 2.2.1 - The main temperature data at the CSFSF site

Description	Temperature, ^{0}C
Average annual	6,7
Absolute maximum (July)	39,0
Absolute minimum (January)	-35,0
Average monthly for the coldest month (January)	-6,7
Average monthly for the warmest month (July)	19,1

The average temperature in January can exceed +3 ^{0}C with the probability 1 % , the same probability is for the temperature drop to -16,0 ^{0}C or lower.

The absolute minimum of the air temperature of–35 ^{0}C was recorded in 1940.

The probability of the absolute minimum of the air temperature drop below - 40 ^{0}C is less than 1 %.

The design temperature [12, Attachment 8] for the coldest five days is minus 22 ^{0}C.

The warmest month of the year is July. An average monthly temperature in July is +19,1 ^{0}C. July was the warmest in 1936 (+24,3 ^{0}C) and the coldest in 1979 (+16,1 ^{0}C).

The absolute maximum air temperature +39,0 ^{0}C was recorded in July in 1936 . The maximum air temperature at the site can increase to +40,0 ^{0}C and higher with the probability 1%.

Extremely high temperatures can lead to droughts and associated forest fires. The data about average temperature at the CSFSF site (from the meteorological station «Chernobyl») are given in Table 2.2.2.

Table 2.2.2 - Average monthly temperature at the CSFSF site

Month	Average monthly temperature, ^{o}C	Mean-square Deviation
1	-6,7	4,01
2	-5	3,88
3	-0,13	2,78
4	7,5	2,01
5	14,3	1,83
6	17,7	1,53
7	19,1	1,61
8	18,2	1,42
9	13,1	1,43
10	7,2	1,83
11	1,7	2,20
12	-2,7	2,47

2.2.3 Wind

The wind conditions at the site have been monitored for 40 years (since 1961). The prevailing wind direction at the site has a western constituent.

Table 2.2.3 provides information about wind of various directions and calm winds.

Table 2.2.3 - Wind of various directions and calm winds

Month	North	North-east	East	South-east	South	South-west	West	North-west	Calm wind
1	10	11	11	15	10	16	15	12	7

Month	North	North-east	East	South-east	South	South-west	West	North-west	Calm wind
2	9	8	12	16	9	14	15	17	6
3	11	9	13	15	9	14	13	16	6
4	13	9	14	15	11	13	13	12	6
5	15	13	13	14	7	9	11	18	7
6	18	9	9	11	5	12	13	23	8
7	16	8	8	8	5	9	19	27	9
8	17	12	10	9	6	10	16	20	10
9	12	7	7	11	10	17	19	17	8
10	8	8	12	15	12	15	16	14	7
11	6	7	14	24	10	16	13	10	6
12	8	8	12	21	12	18	12	9	5
Annual	12	9	11	14	9	14	15	16	7

Note: Frequency of wind directions is estimated in percentage from the frequency of occurring winds, frequency of clam winds is estimated in percentage to the total number of days monitored.

An average annual wind velocity is 4,2 m/s, the highest wind velocity occurs in winter and spring, the lowest is in summer. The average percentage of clam wind is 7 %.

Average monthly and average annual wind velocities are given in Table 2.2.4.

Table 2.2.4 - Average monthly and average annual wind velocities (the height of the weather vane is 15 m)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Wind velocity, m/s	4,4	5,0	4,6	4,5	4,1	4,1	3,4	3,4	3,6	4,1	4,4	4,7	4,2

The highest wind velocity is at the daytime, the lowest is at night.

The probability of baffling wind in percentage to the total number of wind cases is given in Table 2.2.5.

Table 2.2.5 - The probability of baffling wind in percentage to the total number of wind cases

Velocity, m/s	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-20
%	20,0	27,8	27,6	14,3	6,4	1,3	1,8	0,2	0,5	0,1

The average annual number of days with strong wind is 13 (wind velocity is 15 m/s and more), the maximum number of windy days is 38.

Wind with velocity:

- 18 m/s occurs once per year;
- 21 m/s occurs once per 5 years;
- 22 m/s - occurs once per 10 years;
- 24 m/s - occurs once per 20 years.

The maximum design wind velocities with the following probabilities:

- 0,01 % - 47,3 m/s;
- 0,1 % - 40,4 m/s;
- 1,0 % - 33,3 m/s [12].

2.2.4 Air Humidity

There are 122 humid days (relative humidity is 80 % and more) and 19 dry days (humidity is 30 % or lower) in average per year at the site.

The minimum values of absolute humidity are in January-February. The partial pressure of water vapour is 3,7-4,0 gPa .

Average annual relative air humidity is 77 %, the partial pressure of water vapour is - 8.6 gPa.

2.2.5 Evaporation

Average annual evaporation from the surface is 524 mm.

The maximum summary evaporation per month (July) is 98 mm, the minimum (December) - 1 mm.

2.2.6 Fogs

In autumn and winter there can be from 5 to 9 foggy days per month. In summer the fogs are rare.

Average and maximum numbers of foggy days by the months of the year are given in Table 2.2.6.

Table 2.2.6 - Average and maximum numbers of foggy days by the months of the year

Month	1	2	3	4	5	6	7	8	9	10	11	12	Per year
Average	7	5	5	2	0.7	0.7	0.9	2	3	6	9	9	50
Maximum	20	20	15	6	4	3	4	4	7	12	17	17	79

An average duration of fogs per year is more than 291 hours.

Duration of fogs in winter months varies from 30 to 69 hours and in summer months from 2 to 5 hours.

An average duration of fog in a foggy day is 6 hours.

An average duration of fog (hours) by months of the year is given in Table 2.2.7.

Table 2.2.7 - Average duration of fog by months of the year

Month	1	2	3	4	5	6	7	8	9	10	11	12	Per year
Duration, hour	38	32	3	10	2	2	2	5	9	3	60	69	291

2.2.7 Precipitation

By the amount of precipitation the CSFSF site is located in a rather humid area. There are all precipitation types within this area.

An average annual amount of precipitation prevails over evaporation.

The long-term average amount of precipitation per year is 604 mm with its maximum in July (76 mm) and minimum in March (37 mm).

In the high water years the amount of precipitation increases to 762 mm, in the low-water (droughty) years decreases to 301 mm.

The number of precipitation at the CSFSF site is given in Table 2.2.8 [12].

Table 2.2.8 – Amount of precipitation at the CSFSF site

Probability, %	0,01	0,1	1,0	5,0	50,0	95,0
Design annual, mm	-	-	890	800	602	417
Daily maximum, mm	190	146	105	-	-	-
Maximum layer for 20 min, mm	72	53	38	-	-	-

Precipitation norms by the months of the year based on the meteorological center “Chernobyl” data are given in Table 2.2.9.

Table 2.2.9 - Precipitation norms at the CSFSF site by the months of the year

Month	Precipitation norms, mm	Mean-square deviation
1	28	20,7

Month	Precipitation norms, mm	Mean-square deviation
2	26	19,9
3	29	18,6
4	38	25,4
5	45	31,5
6	29	44,1
7	74	46,2
8	60	38,1
9	44	29,3
10	39	27,9
11	46	26,8
12	35	22,6

Absolute daily maximum of precipitation once recorded over the entire monitoring period was in May 1983 and was equal to 81 mm. The absolute daily maximum can reach or exceed 100 mm with the frequency of once per 100 years.

2.2.8 Thunderstorms

The thunderstorm can mainly occur from April till September and are rare in March and October (1-2 times per 10 years).

The number of thunderstorm days is:

- May - 5;
- June-August - from 6 to 8;
- September - 2.

The average number of thunderstorm days per year is 29, the maximum is 45.

The average and maximum number of thunderstorm days is given in Table 2.2.10.

Table 2.2.10 - Average and maximum number of thunderstorm days

Month	3	4	5	6	7	8	9	10	Per year
Average	0,07	0,7	4	8	8	6	2	0,1	29
Maximum	1	6	12	15	17	15	5	1	45

Note: value 0,07 assumes 7 thunderstom days occurring per 100 years, value 0,7 assumes 7 thunderstorm days occurring per 10 years.

Duration of thunderstorms is in the range from several minutes till several hours. In average a thunderstorm lasts 2,3 hours. The summary duration of thunderstorms per year is 65,6 hours.

Average duration of thunderstorms (in hours) is given in Table 2.2.11.

Table 2.2.11 - Average duration of thunderstorms

Month	3	4	5	6	7	8	9	10	Per year
Duration, hours	0,08	1,1	9,7	19,8	16,0	15,4	3,2	0,3	65,6

2.2.9 Hail

There might be hails from April to October at the storage facility site. June can be with hail once per two years. July and August can have hails once per every 5 years. Hail does not occur up to 20% years of monitoring. In average, there might be 2 days with hail per year. In individual years there might be 3 hail days every month and 9 hail days per year. Hail in general falls unevenly at insignificant areas.

2.2.10 Snow Cover

The snow cover is stabilized in the twentieth days of December. In separate years (probability- 5 %) a stable snow cover can be formed in the first ten days of November or January.

The stable snow cover can be destroyed in the middle of March. The probability of its destruction at the beginning of February or in the middle of April is 5 %. The snow cover totally disappears in average at the end of March.

The height of the snow cover within winter varies from 10 cm in December (but can also reach 20 cm), it gets higher to 15 cm in January and to 20 cm and more in February. The maximum height is 75 cm. Such height can occur once per 100 years. 7 % of winters are with no snow cover.

The maximum height of snow cover per 10 days with various probability is given in Table 2.2.12 [12].

Table 2.2.12 - Maximum height of snow cover per 10 days with various probability

Probability, %	5,0	10,0	50,0	95,0
Maximum height of snow cover per 10 days, cm	57	51	27	5

2.2.11 Glaze

The storage facility site is located within the area with moderate glazing. The glaze can occur within the etire cold period of the year (from October till April). It can seldom occur in early autumn and late spring, once per 5-10 years.

The most glaze hazardous are December and January, there might be about 4 glazy days per these months. There are winters with 32 glazy days. Recurrence of glaze from year to year can significantly differ from the average values provided.

Considering the glaze formations the CSFSF site can be classified into the 2nd icing zone [40].

The thickness of icing for 10 m height above the surface is 5 mm, for 200 m height is 35 mm, for 400 mm height is 60 mm with occurrence once per 5 years.

2.2.12 Soil Freezing

An average frost zone per winter is 50 cm, the least is 38 cm, the biggest is 121 cm. An average duration of the frozen condition of the ground is 116 days.

The normative season frost zone is as follows:

- Clay and loam - 90 cm;
- Sand and sabuluous - 110 cm.

Data of the average, maximum and minimum soil temperature by months (based on the meteorolical station “Chernobyl” data, 1995) are given in Table 2.2.13.

Table 2.2.13 - Soil temperature by months

Soil temperature, °C	1	2	3	4	5	6	7	8	9	10	11	12
Average	0,3	0,6	5,5	13,5	16,9	23,6	24.2	22.2	14.4	8.0	-0.2	-5.3
Maximum	2,0	11,0	20,7	31,0	49,1	50,6	51.5	48.8	39.3	28.2	12.5	6.0
Minimum	-1,0	-7,0	-2,0	1,5	-1,9	9,1	8.4	6.2	-1.3	-4.4	-14.5	-22.0

2.2.13 Snow Falls

The average number of days with snowstorms per year is 11.

The maximum number of days with snowstorms per year is 32.

Average duration of snowstorms per year is 64 hours.

Average snowstorm duration per day is 5,8 hours.

2.2.14 Atmospheric Stability

Inversion data are given in accordance with the data from the nearest meteorological station in Kiev, where the sondes are launched twice a day, at night and in the afternoon.

The most part of at-surface inversion is recorded at night (particularly in warm months), at the daytime it is less frequent.

Recurrence of at-surface inversion per year (as the percentage ratio of radiosonde launches per a specific month and period) is 47at night and 3 at the daytime.

The average annual rate of at-surface night inversion (thickness of the layer) is 0,38 km, and at-surface daytime inversion is 0,65 km.

The average annual intensity (temperature drop between the top and bottom inversion boundaries) of at-surface night inversion is 2,4 degree, at-surface daytime inversion is 3,6 degree.

Data of the at-surface inversion by months of the year are given in Table 2.2.14.

Table 2.2.14 - Data of the at-surface inversion by months of the year

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Per year**
Recurrence of at-surface inversion (as the percentage ratio of radiosonde launches per a specific month and period)													
Night	38	32	35	46	67	61	61	67	43	51	28	29	47
Day	23	3	3	-	-	1	0,7	1	-	-	5	3	3
Average rate (km) of at-surface inversion													
Night	0,62	0,52	0,40	0,35	0,31	0,30	0,32	0,30	0,33	0,41	0,48	0,54	0,38
Day	0,70	0,86	0,67	0,00	0,18	0,23	0,18	0,00	0,00	0,74	0,60	0,65	0,65
Average intensity of at-surface inversion (degrees)													
Night	5,0	2,8	2,9	1,8	1,9	1,8	1,8	2,1	2,2	2,5	2,9	3,9	2,4
Day	4,0	3,1	3,1	0,0	0,0	0,9	0,7	3,1	0,0	0,0	4,3	3,1	3,6

At the daytime and night there is no significant difference between recurrence of relief inversion. The most significant recurrence of relief inversion is fixed for cold seasons of the year.

Recurrence of relief inversion per year (as the percentage ratio of radiosonde launches per a specific month and period) is 40 at night and 46 at the daytime.

The average annual intensity of relief inversion at night and the daytime is 0,36km.

The average annual intensity of relief inversion at night and the daytime is 2,2 degrees.

The data of relief inversion by the months of the year are given in Table 2.2.15.

Table 2.2.15 - Data of relief inversion by the months of the year

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Per year**
Recurrence of relief inversion per year (as the percentage ratio of radiosonde launches per a specific month and period)													
Night	62	65	59	42	16	13	12	15	26	53	62	57	40
Day	74	74	82	63	41	11	13	20	30	61	72	71	46
Average intensity (km) of relief inversion													
Night	0,42	0,45	0,42	0,32	0,25	0,28	0,29	0,27	0,30	0,35	0,39	0,30	0,36
Day	0,36	0,39	0,41	0,35	0,28	0,18	0,22	0,24	0,27	0,37	0,38	0,38	0,36
Average intensity of relief inversion (degrees)													
Night	2,5	3,2	2,5	1,9	0,9	0,8	1,0	0,8	1,2	1,8	2,6	2,5	2,2
Day	2,7	2,8	2,7	1,4	0,6	0,6	0,4	0,8	1,2	2,1	2,3	2,5	2,2

2.2.15 Gusts

At the CSFSF site the gusts can mainly occur during a warm half a year, within a period of powerful development of convection and availability of significant temperature difference. Recurrence of gusts is 5 cases per 10 years.

The gust zone usually occupies an insignificant area, therefore, the gust is of local nature. The gust can last from 10 minutes to 1 hour. The velocity of wind with gusts varies from 20 to 40 m/sec.

2.2.16 Tornado

The construction area is considered as tornado-hazardous. The frequency of tornado in this area is 20 cases per 100 years. The most tornados monitored at the CSFSF site refer to the first class by intensity. Nevertheless, the area can also experience tornados, which are strong enough to be referred to class 3. The Gosstroy of Ukraine Decree № 64 dated 21.10.02 adoped a normative document [67] specifying the main normative requirements and design features of tornado for the

Chernobyl NPP site. The document is designed for identification of tornado loads and can be used for design of new facilities and assessment of facilities under construction, operation and reconstruction at the Chernobyl NPP site. Taking into consideration the location of the CSFSF site is in the same area as the ChNPP site, the tornado of class 3 shall be used as design criteria for the newly constructed CSFSF in accordance with [67] .
The design features of tornado with the specified probability are given in Table 2.2.16

Table 2.2.16

Design features of tornado	**Value for tornado with probability $1 \cdot 10^{-5}$**	**Value for tornado with probability $1 \cdot 10^{-6}$**
Design class of probable tornado, k_p	1,5	3,0
Exceedance probability (event/year)	$1 \cdot 10^{-5}$	$1 \cdot 10^{-6}$
Maximum velocity of funnel rotation, V_p (m/s)	50	81
Velocity of tornado progressive motion, U_p (m/s)	12,6	20,3
Differential pressure between the funnel center and periphery, ΔPp (gPa)	31,0	81
Length of tornado movement, L_p (km)	5,0	28,6
Width of tornado path , W_p (km)	0,05	0,29

In accordance with PiN AE-5.6[51] the tornado load refers to specific impacts and shall be only considered for structures of Category 1 by radiation and nuclear safety.

2.3 Description of Flora and Fauna

2.3.1 Vegetation Growth

The CSFSF site is characterized with the collection of ecotopes (forest, meadow, swamp) typical for Ukrainian Polessye and EZ and MRZ and parameters of corresponding phytocenosis.

Before the accident of 1986 the artificial and environmental phytocenosis occupied 80% of the area. The forests constitute 36 %, dry agrocenosis - 27,5 %, meadows and grass swamps - 18 %. About 10 % of the area was occupied by reclaimed land (Table 2.3.1).

The following main factors were significant in forming the modern vegetation growth:

- Artificial forestry growing, intensive forestry management, oriented at growing of pine-tree in the pre-accident period, intensive agriculture;
- Damage of forests due to radiation, fires, flooding, diseases and depredators as well as absolute termination of care for forests in the first post-accident period and total stoppage of agriculture;
- Generation of fallow land in lieu of plough-land;
- Overgrown fallow land and repetitive waterlogging of reclaimed land;
- Beginning of natural vegetation growth formation and re-newal of modern monitoring over forests nowadays.

Table 2.3.1 – Structure of EZ and MRZ (as of 1997) [31]

List of lands	**Area**	
	hectares	**%**
Covered with forests (including protective plantation), including	98870	48,5
- Conifers	78700	38,6
- Deciduous trees	20170	9,9
Other forest land (arboretums, forest roads, glades)	2170	1,1
Total forest land	101040	49,6
Not covered with forest including	68050	33,3
- Burnt wood	7185	3,5

List of lands	Area	
	hectares	%
- Cleared wood	700	0,3
- Agricultural land out of use (fallow land)	60170	29,5
Swamps	4930	2,4
Sand	380	0,2
Water	17360	8,5
Towns, villages, roads and land of special use	12280	6,0
Total	**204040**	**100**

The composition of forests, their reserve, specificity of forest medium formation depend on forest conditions. There were significant changes in the typological structure of the forest land within the EZ and MRZ in comparison with the pre-accident period. They are predetermined by the more fertile former agricultural land included into the forests (Table 2.3.2). The dominating types of forests are new pineries (22 %) and subors (30 %). Relatively fertile sudubrava types constitute 21 %, fertile dubrava forests occupy only 0,1 % of the forest area.

Table 2.3.2 – Distribution (%) of forest land at the EZ and MRZ by types of forest conditions (as of 1997) [31]

Trophotopes	Hygrotropes						
	Very dry	Dry	Fresh	Humid	Damp	Wet	Total
Pineries	0,2	5,1	22,4	1,9	0,2	-	29,8
Subors	-	0,4	29,8	16,1	2,5	0,4	49,2
Sudubravas	-	-	3,1	9,8	7,7	0,2	20,8
Dubravas	-	-	-	0,1	0,1	-	0,2
Total	0,2	5,5	55,3	27,9	10,5	0,6	100

Shut-down of reclamaition work led to gradual increase of area damping. The area of damp and wet types of forest conditions is above 11 %, humid -above 28 %.

The typological specificities of the area predetermined prevalence of pine forests (about 50 % of forest lands) in the forest structure constituting 74 % of the total reserve of timber (Table 2.3.3). The most pine forests were grown on the land of former agricultural use in the 40-60th of the last century. The area of the pine timber stand has significantly decreased for the last ten years due to fire, radiation exposure, flooding, damage by diseases and depredators.

The other main forest forming tree at the EZ and MRZ is birch, which grows at 23 % of forest areas and constitutes 12 % of timber reserve. The oak forests occupy 4 % of the area and constitute 5 % of timber reserve. They mainly include the trees planted in the 50-60th of the last century and natural shrubwoods aged 70-100 years. Aspen forests occupy insignificant areas.

The forests growing in the EZ and MRZ have changed since the accident happened, caused by direct (radiation exposure) or indirect (absence of forestry activities) radioactive contamination of the environment (Table 2.3.4). Termination of maintenance of forests in the post-accident period is the reason for their dying at significant areas due to natural disasters of various nature (fire, flooding, damage by diseases and depredators, etc.).

Table 2.3.3 – Share of areas covered with forests by groups of tree types and trees at the EZ and MRZ [31]

Groups of tree types and trees	Total forests of 1 and 2 groups		Average age, years
	area, hectares	thsd. m^2	
Coniferous			
Pine tree	65828	13149,03	48
Fir tree	46	6,42	32
Subtotal conifers	65874	13155,45	45

Groups of tree types and trees	Total forests of 1 and 2 groups		Average age, years
	area, hectares	thsd. m^2	
Hard deciduous			
Long-boled oak	4716	864,81	69
Low-stemmed oak	1292	21,01	43
Hornbeam	101	17,63	49
Ash-tree	32	4,62	35
Maple	3	0,12	28
Acacia	143	16,14	36
Subtotal hard deciduous	6287	1024,33	63
Soft deciduous			
Birch	25318	2065,85	26
Aspen	1167	251,53	43
Alder-tree	7935	1205,13	41
Poplar tree	53	7,10	37
Willow arborescent	261	14,57	18
Subtotal soft deciduous	34734	3544,18	30
Subtotal main forest forming types of trees	106895	17723,96	42
Other wood species			
Apple tree (gardens)	115	2,65	41
Willow-bushes	5498	62,99	10
Total	112508	17789,60	41

Table 2.3.4 – Main factors, leading to damage and loss of forests at the EZ and MRZ [42]

Factors	Damaged area, thsd. hectares
Radiation effect	1,5
Forest fires, total	17,0
- including crown fire	4,2
Flooding	2,0
Windfalls and windfallen trees	0,5 % of total area
Diseases and depredators	0,2 % of total area

2.3.2 Faina Complexes

The fauna within the CSFSF site assumes the fauna complexes typical for north forests of the physical-geographical zone of Kiev Polessye. Formed in the late glacial period it has significantly changed by today.

By the beginning of the last century the forest part of the current the EZ and MRZ has decreased from 100 % to 11-12 %. In addition, the main part of land with no forests was used as agricultural land and pasture [26]. The fauna species grew poor, particularly, commercial species.

Development of state plans for forestry management, protection and enhancement of hunting resources led to the 48 % increase of forest areas by the 70-ties of the last century. There were some species re-introduced such as beavers, red deer. The number of elks, wild boars has increased. The upland fowl can be met in the forests. In addition, musk beavers, American minks, racoon dogs and other species were introduced. Nevertheless, industrial development of the region, reclamation of swamping land and construction of Chernobyl NPP resulted in termination of wild fauna development. There was a tendency for reduction of some species and even extinction (bustards, birds of prey, cranes, upland fowl, beavers) with the exception of some species whose growth was indirectly related to industrial development (some fish species brought into the ChNPP fuel cooling pool, synanthropic types) or extension of natural habitats (some bird species gradually spread from their natural habitats northwards and eastwards).

A new stage of regional fauna development was a result of secondary ecological consequences due to Chernobyl accident. It was predetermined by evacuation of population and significant reduction of economic activities.

Due to natural processes the structure of zoological complexes started steadily changing by coming nearer to the initial state typical for this natural –geographical zone. The first five post-accident years were characterized with significant drop in the number of animals, which was related to establishment of new balance relationship within the trophic pyramids, and, in particular, in the triads "vegetation forage resources-animals- phytophages – predators". First of all, it was evident with significant increase of the number of insect-phytophages, murine rodents and corresponding increase of predators.

In comparison with the pre-accident period, the established variety and mosaic of vegetative coenosis as well as absence of chemical treatment of agricultural land led to enrichment and stabilization of entomocomplexes, increase of the number of rare insects and insect-fertilizers (with the exception of weak, non-maintained woods of arboreal monocultures and fire areas).

The portion of synanthropic types was reduced (sparrows, swallow, rock pigeons, rooks, jackdaws, white storks; rats, mice, stray cats and dogs). The portion of arboreous shrubby and forest complexes increased. Absence of human activity impact led to the increase of commercial species (hazel grouses, black grouses; beavers, musquashes, roes, wild boars, elks, red deer; wolves, foxes, racoon dogs). Some other extinct or not-numerous species, which are under protection, can be met (cranes, black storks, ernes, serpent eagles; trots, otters, badgers).

Since the the EZ and MRZ is located at the crossroad of historically established migration paths of the animals, its preserve status and variety of landscape conditions facilitate maintenance of potential for migrant birds and mammals (bats).

The the EZ and MRZ was assumed to inhabit 399 species of vertebrals as of 2002 (Table 2.3.5), 290 species of which were proved to inhabit permanently or by seasons (73 %) [43]. This is actually the maximum number of species, which can populate or be met at this natural-geographic zone.

Table 2.3.5 - Taxonomic variety of vertebral fauna at the EZ and MRZ [43]

Taxon	Cyclostomes	Fishes	Amphibian	Reptiles	Birds	Mammals	Total
Orders	1	10	2	2	17	7	39
Families	1	16	6	5	52	20	100
Generations	1	47	6	6	141	45	247
Species	1	65	11	7	245	70	399
Out of them detected:	0	48	11	6	178	47	290

The number of the "Red Book" species assumed to inhabit the EZ and MRZ is rather large constituting 50 species (Table 2.3.6). 15 out of 50 species are proved to populate the area (as of 2002) (black storks, golden-eye, fish hawks, red kites, sea-eagles, spotted and lesser spotted eagles, serpent eagles, hazel grouses, catchers, eagle-owls, great grays, otters, badgers, trots). In addition, the EZ and MRZ was populated with Przewalski's horse in 1998, which is also referred to in the "Red Book".

Table 2.3.6 - Taxonomic variety of vertebrals at the EZ and MRZ included into the "Red Book" of Ukraine [43]

Taxon	Cyclostomes	Fishes	Amphibian	Reptiles	Birds	Mammals	Total
Orders	1	2		1	8	6	18
Families	1	2		1	16	7	27
Generations	1	3		1	26	11	42
Species	1	3	-	1	31	14	50

Taxon	Cyclostomes	Fishes	Amphibian	Reptiles	Birds	Mammals	Total
Out of them detected:	0	0	-	0	12	3	15

The current condition of the biocenoses at the EZ and MRZ assumes its further development. Modification of vertebral species will be insignificant. The number of animals is unlikely to increase since the fauna complexes have reached the certain stage of changes and due to the absence of interference with the environmental processes their development (number and geographical distribution) will mainly depend on the current feedstuff and interspecific interactions (capacity of ecological niches).

3 GENERAL DESCRIPTION OF FACILITY AND ECONOMICAL ACTIVITY IN THE AFFECTED AREA

3.1 Economical Activity in the Affected Area

At present, the economical activities at the EZ and MRZ locating the CSFSF site are aimed at the following:

- Decommissioning of the ChNPP and maintenance of the "Shelter";
- Mitigation of the accident consequences and maintenance of the Exclusion Zone.

There are about 30 enterprises, companies and institutions of various subordination operating at the EZ and MRZ, which are involved in implementing the measures (activities) to mitigate the consequences of Chernobyl accident.

The economical activities at the CSFSF site are performed as a part of mitigation of Chernobyl accident consequences and maintenance of the Exclusion Zone. These activities are mainly associated with transportation, treatment and disposal of low- and medium-radioactive waste.

3.1.1 Transportation Facilities

After the accident in 1986, movement of transport through the transit motorways crossing the EZ and MRZ was stopped.

The only operated railway station "Semikhodi" is designed for passenger trains travelling from Chernobyl NPP to Slavutich.

The network of operated roads in the center and the periphery of the EZ and MRZ are connected with the network of common motorways in the proximity to the village Lelev (motorway Kiev-Pripyat) and at the boundary of the EZ and MRZ).

The CSFSF site is connected with the SSE ChNPP site by the asphalt road (commonly-used road ChNPP-RWDF "Buryakovka", 16 km long). It is intended that this road will be used for transportation of RAW packages from the LRTF and the ICSRM constructed at the SSE ChNPP site for disposal in ICSRM LOT-3. (Figure 3.1.1).

The roads inside the zone can be used for transportation of combustible oil products, nevertheless, the risk of impact on the CSFSF due to explosion caused by some transport accident is unlikely to occur since the site is located at some distance from the road (more than 10 km). There is a hazard of radioactive aerosol release and contamination of the surface air due to heavy movement of transportation towards RAW treatment and disposal facilities (Vector, LOT-3, RWDF "Buryakovka").

The nearest helicopter site is located at the north-west outskirts of the town of Chernobyl at the distance of 18 km from the CSFSF area.

The power lines of 110 kV and 330 kV "ChNPP- Pripyat-Buryakovka" are at the distance of 100 m from the south-east side of the complex "Vector". The distance from the power lines to the western side of the CSFSF site is 26 m.

3.1.2 Industrial Facilities

The layout of industrial facilities is given in Figure 3.1.2.

3.1.2.1 Chernobyl NPP

The Chernobyl NPP includes three power units with the reactors of RBMK-1000 type (power capacity of each is 1000 MW) being decommissioned at present and the "Shelter".

To enable the ChNPP decommissioning some facilities are constructed for RAW management and storage of spent fuel. There is a boiler constructed.

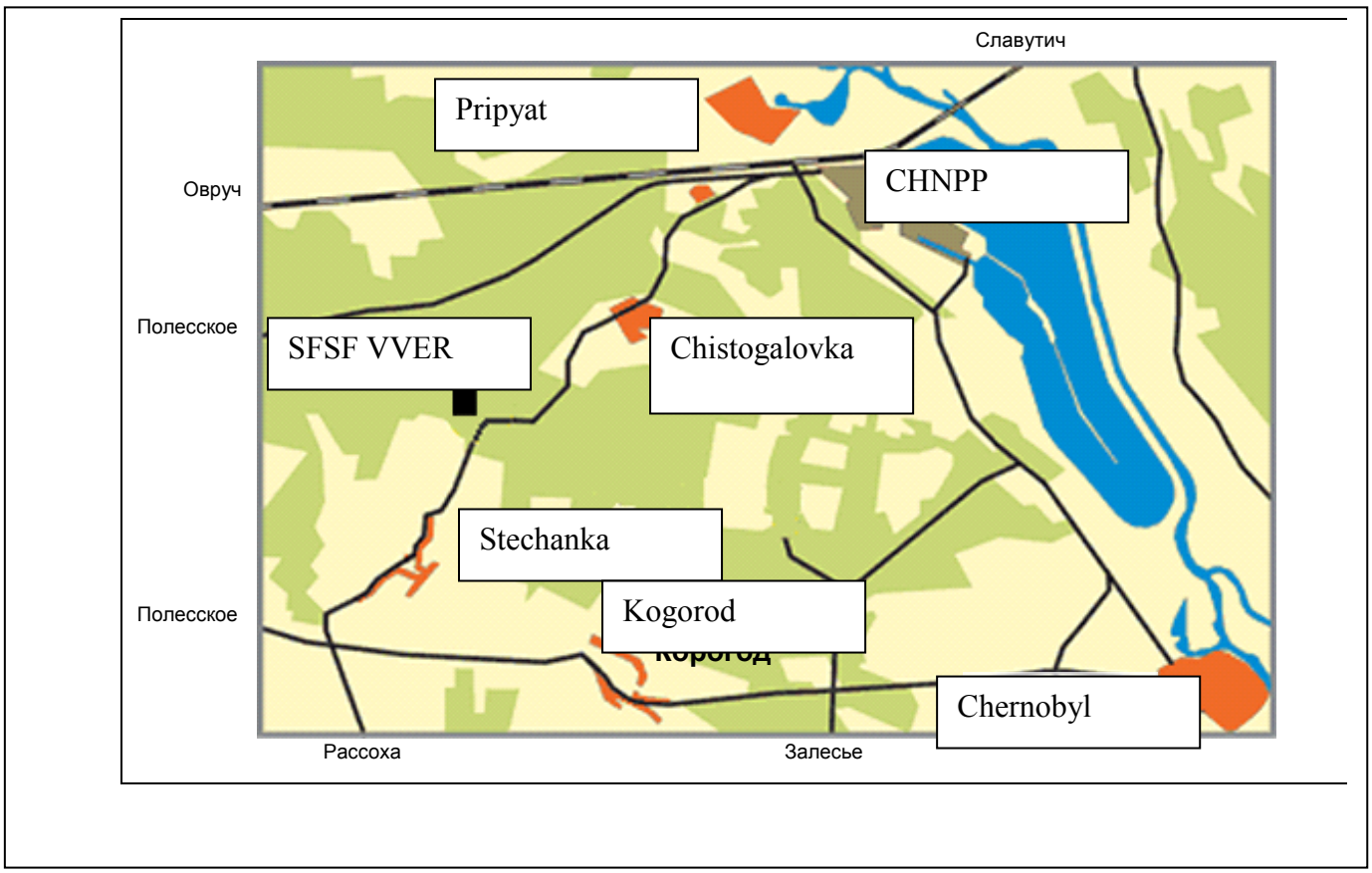
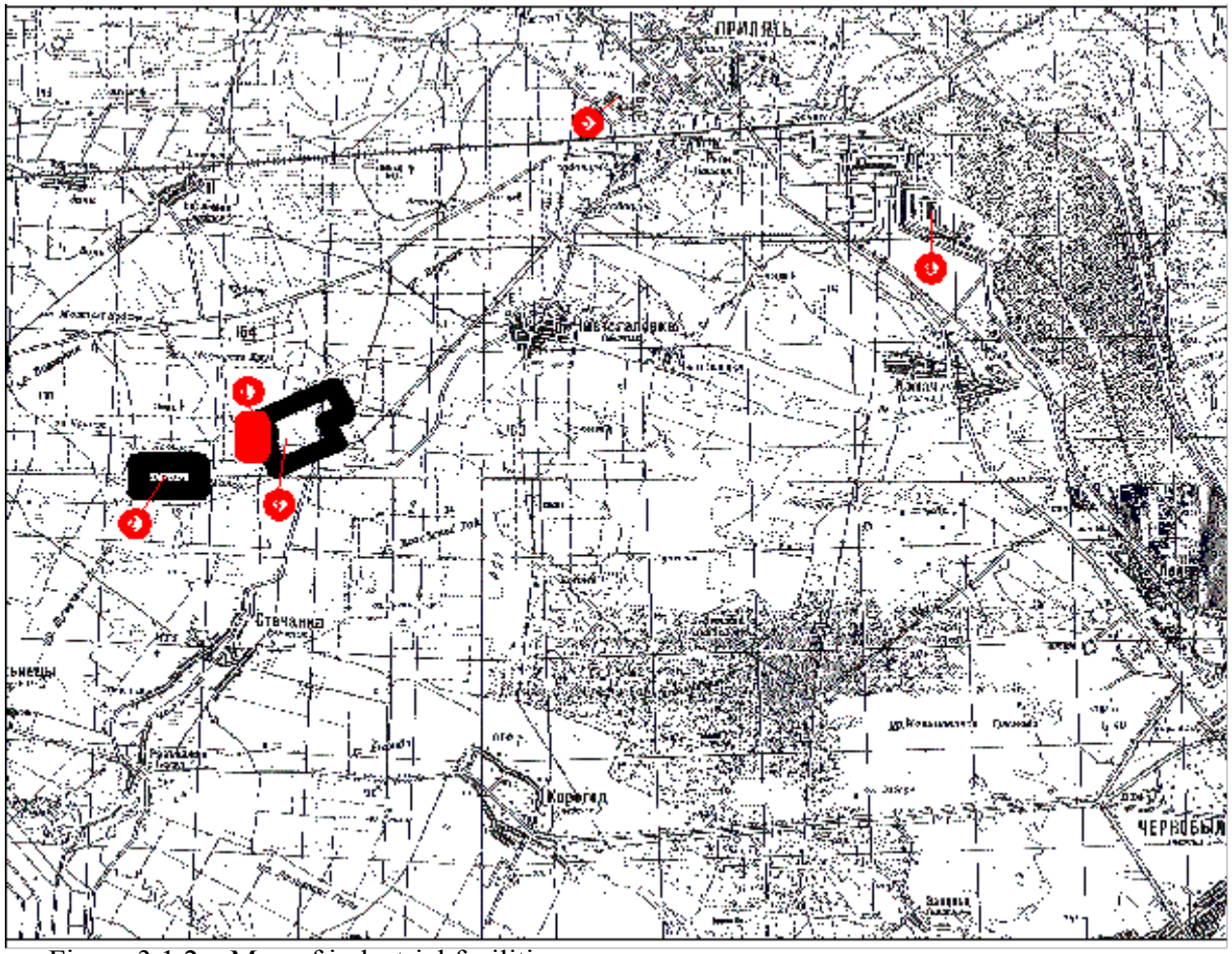


Figure 3.1.1 – Map of roads with hard cover and railroads within the CSFSF site



1.CSFSF
2.RWDF Buryakovka,
3.RAW processing and disposal center (Complex «Vector»),
4.CHNPP

Figure 3.1.2 – Map of industrial facilities

Power unit № 1 was completely shut down in 1996 and is at the stoppage stage. Some activities included into the "ChNPP power unit-1 stoppage plan" are being performed. The nuclear fuel is in the active core and reactor pools. Comprehensive engineering and radiation survey of equipment and rooms was completed.

Power unit № 2 was shut down in 1991 due to a fire in a turbine hall. The nuclear fuel was unloaded from the reactor into the reactor pools. The work related to"ChNPP power unit-2 stoppage plan" is carried out. Comprehensive engineering and radiation survey of equipment and rooms was completed.

Power unit № 3 was shut down in 2000 in accordance with the Cabinet of Ministers of Ukrtraine Decree about prescheduled termination of operation. The nuclear fuel remains in reactors and the reactor pools. The work related to"ChNPP power unit-3 stoppage plan" has been performed since 2001.

The ChNPP in-process releases into the air are given in Table 3.1.1.

Table 3.1.1 - ChNPP in-process releases into the air

Year	**Summary release of PH through the ChNPP ventilation stacks, MBq/year**			
	1 commissioning stage		**2 commissioning stage**	
	^{137}Cs	**^{90}Sr**	**^{137}Cs**	**^{90}Sr**
2000 (before ChNPP shut-down)	18	3,1	510	60
2001 (after ChNPP shut-down)	23	2,4	300	14
2002	23	3,3	190	8,9

Spent fuel from the ChNPP reactors is in the cooling ponds, in the reactors of power units № 1-3 and in ISF-1. The amount of spent fuel and its location at the ChNPP site is given in Table 3.1.2. The amount of spent fuel specified is planned for subsequent storage in ISF-2.

Table 3.1.2 - amount of spent fuel and its location at the ChNPP site as of 17.05.2006

Facility	**Total number of spent fuel assemblies (SFA)**	**Number of SFA in reactor**	**Number of SFA in fuel cooling pools**
Power unit № 1	1832	557	1275
Power unit № 2	1057	-	1057
Power unit № 3	2323	1354	969
ISF-1	16046	-	-

The ChNPP industrial site locates completed facilities and new ones being constructed as the infrastructure and communication facilities and designed for decommissioning of power units, spent fuel and RAW management.

Beyond the guarded ChNPP perimeter there is a fuel cooling pool with auxiliary hydraulic facilities.

3.1.2.2 Object "Shelter"

ChNPP unit-4 destroyed during beyond the design basis accident lost all functional features of a power unit, which required performance of top-priority measures to mitigate the accident consequences and improve nuclear and radiation safety and is transformed into the "Shelter".

The "Shelter" is considered as a temporary storage facility of radioactive waste generated due to the accident. It contains large-tonnage uncontrollable amounts of substances and materials consisting of significant amount of long-live fission-fragment and fuel radionuclides [45].

Radioactive sources thrown out of the active core of reactor unit-4 during the accident are in the reactor unit, deaerator stack and the turbine hall. These rooms are separated by a wall from unit-3 and new structural and encasing members from the environment. The facility is equipped with

systems for diagnostic purposes, dust-suppression, supply of neutron-absorbent solutions, power and fire water supply and other elements integrated into a common Shelter safety assurance system.

Availability of fuel-containing materials inside the "Shelter" makes it potentially nuclear hazardous. For the entire monitoring period the relase of radioactive aerosols outside the "Shelter" has not exceeded 0,3 Ci/year (with the plutonium quote 0,4 - 1,2%). Since 1991 the concentration of airborne alpha-active aerosols at the "Shelter" site has been less than control concentration levels specified by normative documents and it is decreasing with the time.

The main activities for conversion of the "Shelter" into the ecologically safe system include the following:

- Stabilization of structures;
- Construction of a new safe confinement;
- Disassembly of unstable structures, removal of fuel containing materials, treatment and disposal of radwaste.

In accordance with the preliminary estimates stabilization of structural elements will allow for their stability for more than 15 years, which is sufficient for construction and commissioning of the new safe confinement.

3.1.2.3 New Safe Confinement (NSC)

The main purpose of the NSC is conversion of the "Shelter" into the ecologically safe system, which includes:

- Assurance of protection for personnel, public and environment from the impact of nuclear and radiation hazardous sources related to the "Shelter" existence;
- Establishment of conditions required for removal of remaining nuclear fuel and fuel-containing materials, RAW management, disassembly/stabilization of unstable "Shelter" structures.

The NSC functions assume the following:

1) Limitation of radiation impact on personnel, public and environment through the limits specified for the NSC normal operation, abnormal operation, emergencies and accidents including the accidents in the process of disassembly of unstable structures and subsequent FCM and RAW management.

2) Limitation of migration of radioactive matters contained by the "Shelter". This function shall be provided under normal or abnormal operation, emergencies and accidents. It is provided through the following:

- Duration of the NSC lifetime (not less than 100 years);
- Prevention from the collapse of "Shelter" unstable structures through disassembly or stabilization for the period defined by the safe NSC operational conditions;
- Limitation of ingress of rain (storm water) and snow water;
- Protection of the groundwater from contamination with radioactive matters contained by the NSC.

At present the NSC is at the design stage. The NSC commissioning dates were revised and delayed for 2010.

3.1.2.4 Liquid Radwaste Treatment Facility (LRTF)

The Liquid Radwaste Treatment Facility (LRTF) is designed for treatment of liquid radioactive waste generated during operation and decommissioning of the ChNPP as well as operational liquid RAW from the "Shelter".

The LRTF is designed for treatment of existing LRAW within a 10-year operation life. Its minimum design capacity is 2500 m^3 LRAW per year.

The distance from the LRTF to the CSFSF site is about 13 km in the north-east direction. At present the LRTF is at completion and commissioning stage.

The LRTF construction and operation activities can radioactively and technogenically affect the above- and underground infrastructure facilities at the ChNPP site and adjacent area.

In accordance with the LRTF design, all releases of radionuclides in liquid, gaseous and aerosol forms under normal operation and failures will not migrate outside the constructed facility and will be mitigated by the systems designed for clearance, LRAW confinement and decontamination [46].

The maximum design accident is related to the rupture of a pipeline routed through an enclosed process tunnel during transportation of LRAW from existing facilities to the facility for treatment. The design includes all engineering measures to confine the leaks: trays for collection and directed (inclined) drain of LRAW to the facility, waterproofing, equipment and systems for decontamination of contaminated areas [46].

3.1.2.5 Spent Fuel Storage Facility (Interim Storage Facility (ISF-2)

The ISF-2 is designed for long-term (within 100 years) storage of spent fuel assemblies and spent absorbers generated during ChNPP decommissioning.

The ISF-2 is located at the distance of 11 km in the north-east direction from the CSFSF site. The first loading of spent fuel into the ISF-2 was scheduled for the beginning of 2003, nevertheless, due to engineering problems the beginning of loading was delayed.

The ISF-2 is designed for "dry" storage of 25000 of spent fuel assemblies and 5000 spent absorbers, currently stored in the fuel cooling pools of the power units and ISF-1.

The ChNPP ISF-2 safety analysis evidenced that there is unlike to be any significant impact on the personnel and environment under normal operation or in case of operational failures or design accidents including the maximum design accident related to the drop of one spent fuel assembly. The normal operation of the ISF-2 might assume release of Cs-137 through the ventilation stack of the Spent Fuel Preparation Facility building, which is $6 \cdot 10^7$ Bq/day. The total release of activity due to all fission products will be $8 \cdot 10^8$ Bq/days.

When assessing releases from the spent fuel storage modules it was assumed that the release included surface absorption and leakage through the cladding. Estimate of radionuclide release outside the modules was given in the ISF-2 EIA. The release outside 256 modules will conservatively constitute $1{,}6 \cdot 10^3$ Bq/day.

A hypothetical (beyond the design basis) accident associated with the plane crash against the site locating the reinforced modules loaded with the SFA, will lead to severe radiation consequences within the ChNPP site requiring implementation of specific actions to protect the ISF-2 personnel and personnel from other companies located within ISF-2 affected zone. Beyond the design basis accident at the ISF-2 will lead to release of $1 \cdot 10^{17}$Bq Cs-137 .

At present due to significant difficulties in implementing the ISF-2 design developed by NUHOMS, some activities are performed to make a final decision for its completion.

3.1.2.6 Industrial Complex for Solid Radwaste Management (ICSRM)

The ICSRM is designed for acceptance, treatment and/or disposal of soild radioactive waste generated during ChNPP operation and decommissioning as well as operational RAW from the "Shelter.

The ICSRM consists of three facilities:

1. SRAW removal plant designed for removal of solid radwaste of all categories from the existing SRAW storage facility (LOT-1). The capacity of the plant is 3 m^3 per day;

2. SRAW treatment facility designed for sorting of solid radwaste of all categories as well as treatment of low- and medium radoiactive short living waste (LOT-2). The capacity of the facility is 3500 m^3 of untreated radwaste per year;

3. The above-ground storage facility for low- and medium radoiactive short living waste, which will be located at the site of the Complex "Vector" (LOT-3). The storage facility is designed for final disposal of 55000 m^3 of conditioned low- and medium radoiactive short living waste generated after waste treatment at the ICSRM and LRTF (solidified liquid radwaste).

At present the ICSRM is being constructed.

3.1.3 ChNPP Fuel Cooling Pool

The CSFSF site is located at the distance of 12 km to the south-west from the water edge of the ChNPP fuel cooling pool.

The fuel cooling pool is used for heat removal from the ChNPP. It is stagnant hydro-engineering facility of a closed type.

After completion of the ChNPP 2nd commissioning stage the total area of the water table under the worst weather conditions was 22,9 km^2.

The bottom deposits of the fuel cooling pool contain significant amount of radionuclides generated after the accident [48]:

- 5550-170200 GBq ^{137}Cs;
- 5550-74000 GBq ^{90}Sr;
- 5000-7400 GBq transuranium elements.

The main factors, defining its potential hazard is the high level of the ground water, which might lead to flooding of the adjacent facilities and deflationary transfer of deposited radionuclides in case of the water level decrease (the height difference between the water levels in the fuel cooling pool and the Pripyat river is about ~7 m).

3.1.4 Other Companies Involved in Accident Mitigation

The State Specialized Industrial Complex Water Protection Enterprise (SICWPE) "Chernobylvodexpluatatsia.

The main task of this company is implementation of water protection measures to prevent migration of radionuclides outside the EX and MRZ, construction and operation of water protection facilities.

The State Specialized Industrial Complex Forestry Enterprise (SSICFE) "Chernobylles". Activities of Enterprise (SSICFE) "Chernobylles" are aimed at implementation of fire protection measures for forests, performance of specialized forestry work. The annual scope of work performed for clearance of woods covers 400-450 hectares; maintenance of forest plants is carried out at 1400-1500 hectares; maintenance of fire barriers is implemented along 3600-3700 km.

The other industrial facilities located in the 30-km zone around the CSFSF site whose activities are also related to mitigation of accident consequences cannot actually affect the operation of the storage facility.

3.1.5 RAW Management Facilities

There is one operating RAW storage facility in the proximity to the CSFSF site (Radioactive waste disposal facility (RWDF) "Buryakovka"). Another facility designed for treatment, storage and disposal of low- and medium-active radwaste is constructed as a part of the Complex "Vector".

3.1.5.1 RWDF "Buryakovka"

The above-ground storage facility "Buryakovka" is located at the distance of 1,1 km in the south-west direction from the CSFSF site. The storage facility was commissioned in 1987 in order to confine solid low- and medium-active radwaste with the EDR being up to 10 mSv/hour, generated in the process of accident mitigation.

Based on the data of the SSE "Complex" the RWDF "Buryakovka" contains about $8{,}97 \cdot 10^5$ tons of radioactive waste the total activity of which is $2{,}44 \cdot 10^{15}$Bq. The waste is buried in 26 trenches separated by clay walls. The volume of one trench is 33,6 thsd m^3.

At present the storage facility is filled for 80 %. The RWDF "Buryakovka" is currently extended in accordance with the design assuming construction of additional trenches for subsequent disposal of 600 thsd m^3.

3.1.5.2 Complex "Vector" and Central Disposal Facility (CDF)

The Exclusion Zone contains the most (95-98 %) low- and medium-active radwaste generated in Ukraine. Treatment and disposal of this radwaste are expected to be implemented at

the Central Disposal Facility (CDF) as a part of the Complex "Vector". Large-size RAW will be preliminary fragmented by movable RAW treatment equipment.

The Complex "Vector" site together with the sanitary control area occupies about ~10 km^2 (3,0x3,5 km). The design of the 1st commissioning stage specifies disposal of 100 thsd. m^3 of solid short-live RAW (I and II activity groups) produced at the Exclusion Zone within 5 years. This period is planned for intensive complex operation involving preparation of RAW for disposal, disposal in the storage facilities, closure and preservation of facilities. Maintenance time of the storage facilities in the post-preservation period is 300 years [20].

The largest hazard during "Vector" operation is a radiation factor. The main radioactive hazardous sources during "Vector" operation are the following:

- Release of radionuclides into environment during preparation and disposal of radwaste;
- Release of radionuclides into environment after loading and preservation of storage facilities.

Normal operation and design accidents due to the failure of process equipment are unlikely to lead to negative impact on the environment above the normative values. Beyond-the-design-basis accident with the most severe consequences (plane crash) will lead to the surface contamination at the distance up to 2500 m with its maximum at the distance of 160-240 m from the storage facility in case of release of radionuclides into environment. The exposure dose at the maximum contaminated area will be in the range of $(1,0\text{-}1,5)\cdot10^{-6}$ Sv/hour. [49].

The planned annual capacity of designed CDF is given in Table 3.1.3.

Table 3.1.3 - Annual capacity of CDF, thsd. m^3

Types of waste			
Incinerated	**Compacted**	**Untreated**	**Total**
1st commissioning stage (5 years) Waste for disposal			
-	-	100,0	**100,0**
2nd commissioning stage (25 years) Waste for treatment			
16,5	2,5	41,4	60,4
Reduction (increase) factor of RAW volume			
32	8	1	
Transfered for disposal and storage			
0,6	0,3	41,4	42,2

The CDF will provide the following:

- Sorting of SRAW by types into those to be compacted, incinerated, and metal waste;
- Drying of waste subject to compaction;
- Compaction of RAW;
- Fragmentation of long-sized RAW;
- Incineration;
- Temporary storage of the 3rd Category SRAW;
- Disposal of the 1st and 2nd Category SRAW.

3.2 Positive Aspects of the CSFSF Realization for the Region

Taking into account the fact that the CSFSF area is located in ChNPP Exclusion zone, where the residence of population is forbidden by a current legislation, the positive aspects of the CSFSF realization are examined for the purposes of Exclusion zone, ChNPP personnel and the town of Slavutich, where it is assumed to hire a personnel for the CSFSF operation.

Slavutich is situated approximately in 200 km North of Kyiv. The town was built following the 1986 accident at the Chernobyl NPP by efforts of eight Republics of the former USSR. ChNPP is situated 50 km to the West from the town. Life of the local population is closely related to ChNPP, which is the main Employer for labour force of the town. Economy of Slavutich is at the

phase of transitional changes related to ChNPP decommissioning. Slavutich is the town of one industry, though this position is gradually changing. ChNPP was shut down in December of 2000, and many of its workers are now involved in ChNPP decommissioning.

Advantages of CSFSF construction will be the supposed effectiveness of State costs, which will be required for paying the activities related to creation of workplaces in Slavutich. In addition, the CSFSF will provide permanent employment of workers during 50 to 100 years both for residents of Slavutich and hired to work in the CSFSF.

Economic consequences of the CSFSF construction will also have impact on the state of economy of ChNPP Exclusion zone and its adjacent zones. It is related to the fact that the CSFSF construction is supposed to be carried out using labour force involved in construction of facilities in the Exclusion zone and residents of adjacent zones. In accordance with basic decisions on organization of the CSFSF construction a maximum amount of construction personnel will be to 300 persons. In addition, for supplying construction materials and structures it is assumed to use enterprises of building industry in the areas adjacent to ChNPP Exclusion zones.

In accordance with the results of Summary Cost Estimate the cost of construction of Start-up Complex will be 1.1 billion UAH. Considerable part of these costs will be invested in the economy of ChNPP Exclusion zone, the town of Slavutich and adjacent areas in the form of:

- wages of construction staff;
- procurement of construction materials;
- procurement of equipment;
- organization of residence of construction shift staff in Chernobyl;
- rehabilitation of territory of Exclusion zone (territory decontamination).

During the CSFSF realization, provisions should be made for creation of auxiliary production areas related to fabrication of containers elements. For this purpose Contractor assumes to provide the production areas in Slavutich that also will create new workplaces and will bring funds to the local budget of Slavutich.

The CSFSF construction in ChNPP Exclusion zone will influence the rates of reconstruction of railway of national significance Ovruch – Vilcha that will allow to increase railway cargo transportations, not entering into the territory of Byelorussia.

The CSFSF construction would provide costs and cause the need in conducting the retraining of workers, whose number has increased after ChNPP decommissioning. The retraining could provide them skills, allowing to find a place in the construction and other works related to construction. Such retraining should be started before the beginning of real works on construction in order to allow companies to define a kind of training that could satisfy the needs of future construction.

Thus, a number of positive consequences and benefits could be expected if the CSFSF construction is carried out:

- creation of workplaces for those, who are unemployed presently, or provision of full employment;
- possibility to promote the standard of living;
- to conduct diversification of local economy without dependence on ChNPP;
- possibility to improve economy;
- to reduce potential self-destruction and destruction of families caused by leaving Slavutich;
- general decline of level of economic uncertainty.

3.3 Alternative Options of the CSFSF Location

3.3.1 Sequence of Site Selection in the Feasibility Study

Site selection is given in Volume 1 Part 5 of this Feasibility Study.

3.3.2 CSFSF Alternative Sites

3.3.3 Comparison of Sites Based on Ecological Criteria

3.3.3.1 Substantiation of considered factors

3.3.3.2 Choice of comparison criteria

3.3.3.3 Comparison of the cites based on ecological maps of Ukraine

3.3.3.4 Determination of different factors values

3.3.3.5 Ecological comparison criteria

3.3.3.6 Ecological comparison

3.3.3.7 Conclusions of ecological comparison of the sites

3.3.4 Recommended Site

In addition to ecological comparison Volume 1 Part 5 of this Feasibility Study contains a comparison of the sites based on the following criteria:

- Adequacy of the sites to the requirements of Normative Documentation (ND);
- Adequacy to the radiation criteria;
- Adequacy to technical and economic criteria.

As a result of review of the sites as to their adequacy to the requirements of Normative Documentation the most adequate to the requirements of Normative Documentation is a site of the Centralized Disposal Facility “CDF”.

As a result of performed comparison of three sites as to radiation factors the preferable sites are sites in ChNPP Exclusion zone. Insignificant (at the level of error) advantage is taken by the site of «CDF». This conclusion is made proceeding from the fact that the population is absent in ChNPP Exclusion zone that reduces accumulative collective exposure dose of the population under normal operation conditions and during the design basis accident and hypotetical (beyond the design basis) accident.

The results of the performed comparison of technical and economic indices showed advantage of the «KhNPP» site. A difference between «KhNPP» site and nearest to this site «ChNPP» site makes 30,92 million UAH based on variable capital costs. This advantage is conditioned foremost by the fact that this site is located in the non-contaminated area that excludes:

- expenses on the waste removal when preparing the site;
- additional expenses for the CSFSF construction and operation related to the shift method, additional charges for work in radiation conditions and expenses related to transportation of personnel.

A difference between the variable capital costs of the «CHNPP» and «CDF» sites is related to the extent of the again erected access railways. The segment of a way to the «CDF» site is larger that causes higher cost on preparatory work for infrastructure for this site. In this case a possibility of the participation of complex «Vector» was not taken into account in building of access railway to ISF (the general section of way of 3.7 km length is to be erected in co-operation of the CSFSF and the "Vector", while a sector of 2.7 km length from the access branch line to the CSFSF fence is to be erected by the CSFSF).

Taking into account the conducted analyses of comparison of three sites for construction of the CSFSF, the site can not be chosen on the basis of some one of the conducted analyses.

The most determining are comparisons based on ecological, radiation and technical and economic criteria. Taking into account the long period of operation of the Spent fuel storage facility

(100 years), ecological and radiation criteria have advantage over technical and economic criteria. In this case it was taken into account that «KhNPP» site is preferable proceeding from economic criteria but it is not acceptable from the point of view of its expansion. Besides, the conditions of the CSFSF construction in the KhNPP area are related to considerable problems caused by potential simultaneous construction of the new Power Units.

The most preferable site is the «CDF» site, having advantage over the other sites on ecological criteria and being preferable on radiation factors as a site located in the ChNPP Exclusion zone.

When assessing the comparisons of the sites in the Exclusion zone the following organizational and technical conditions determining advantage of the CDF site were considered:

- the analysis of ISF-2 buildings showed that a set of auxiliary buildings proposed for the CSFSF should be built both in the «ChNPP»area and in the «CDF» area. Thus, a set of buildings for the sites will be identical;
- the analysis of the planned works related to ISF-2 showed the necessity of additional co-ordination of spent fuel transportation from Ukrainian NPPs and from ChNPP. In this case during transportation of spent fuel to ISF-2 and ISF there will be crossing of interests in connection with the use of one railway branch line unlike the site of «CDF»;
- the analysis of the planned works in the Exclusion zone showed that a high concentration of construction and assembly works will be observed in the area of ISF-2, ChNPP and «Shelter" Object i.e. NSC construction base, NSC, ChNPP decommissioning in contrast to the «CDF» site, where active work related to construction of «Vector» infrastructure will be completed by the moment of ISF construction and operation;
- taking into account the prospects for construction of the Centralized Waste Treatment Plant within the «Vector» and preparedness of «Vector» to receive radioactive waste from the NPPs, a co-operation is possible in exploiting and maintaining the operability of the rolling stock.

3.4 Alternative Technologies Variants

The analysis of alternative technologies for spent nuclear fuel handling is given in Volume 1 Part 2 of this Feasibility Study.

3.4.1 Bunker Storage Facilities

3.4.2 Module Storage Facilities

3.4.3 Metallic Containers

3.4.4 Metallic and Concrete Containers

3.4.5 EIA Technology

A technology reviewed in this EIA, which is proposed to be implemented for the CSFSF was chosen according to International Tender Procedure «turnkey».

It is described in Volume 1 of the Feasibility Study.

3.4.5.1 Technical proposal of HOLTEC INTERNATIONAL

3.4.5.2 Evaluation of Technical Proposals

3.4.5.3 Choice of a Successful Tenderer

3.5 CSFSF Normal Operation

3.5.1 Basic Functionality

A Centralized Spent Fuel Storage Facility (CSFSF) for WWER reactors of Ukrainian NPPs is intended for placing and long-term storage (no less than 100 years) of spent nuclear fuel of WWER reactors:

- 12500 spent fuel assemblies of WWER-1000 reactors;
- 4000 spent fuel assemblies of WWER-440 reactors;.

Taking into account the existing situation with available spent fuel assemblies at the NPPs, NAEK «Energoatom» plans as to the export of the spent fuel assemblies to Russia and the terms of extension of operation of the Power Units as to Energy Strategy of Ukraine up to 2030 a design capacity of CSFSF will be as follows:

- 12010 spent fuel assemblies of WWER-1000 reactors;
- 4519 spent fuel assemblies of WWER-440 reactors;

The CSFSF capacity ensures placement and storage of the WWER spent nuclear fuel produced at Power Units № 1-4 of Rovno NPP, Power Units № 1-2 of KhNPP and Power Units № 1-3 of South-Ukrainian NPP (design loading of the fuel cooling pool, fuel loaded in the reactors and the spent nuclear fuel which will be produced in the process of operation of the Power Units).

Within the CSFSF Project a start-up stage is foreseen, covering all buildings located in the CSFSF area and the storage overpacks of 2500 spent fuel assemblies of WWER-1000 and 1080 spent fuel assemblies of WWER-440.

When preparing the EIA Report a HOLTEC INTERNATIONAL technology as the technology of the successful Tenderer of the CSFSF «turnkey» construction (CSFSF Startup Complex construction) was reviewed.

The spent nuclear fuel handling technology developed by HOLTEC INTERNATIONAL, is a system, consisting of the following basic components:

- Multi-purpose canister (MPC);
- Metal-concrete storage overpack (HI-STORM);
- Transportation overpack (HI-STAR);
- Transfer cask (HI-TRAC).

The type of the Container storage of HOLTEC INTERNATIONAL is shown in fig. 3.5.1.

In 1999 HOLTEC INTERNATIONAL got a license issued by Nuclear Regulatory Commission (NRC) for using MPC and HI-STAR for spent nuclear fuel of USA NPPs. In 2000 HOLTEC INTERNATIONAL got a license issued by Nuclear Regulatory Commission (NRC) for a unique storage complex, including MPC, HI-STAR and HI-STORM. Actually the elements of spent nuclear fuel storage system of HOLTEC INTERNATIONAL are used in the USA, Great Britain, South Korea, Taiwan and Brazil.

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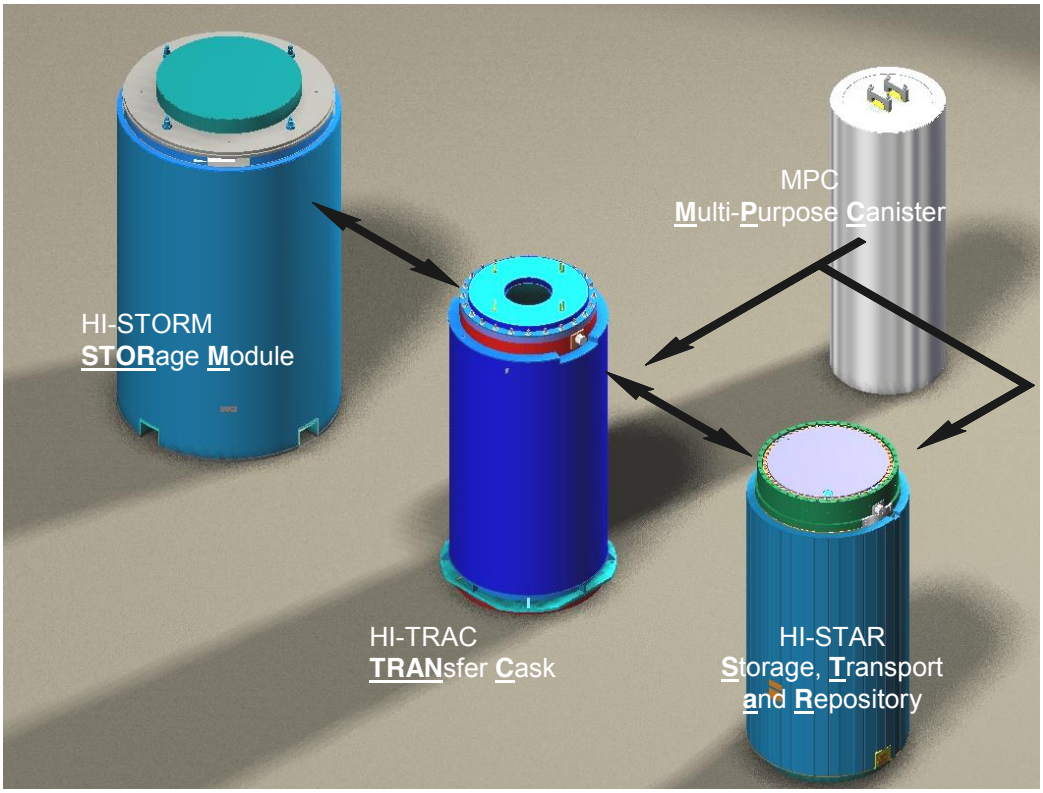

Fig. 3.5.1 – General View of HOLTEC International Container System

Spent fuel storage system is a fully passive system and provides for the following basic safety functions:

- Safe and leak-tight localization of radioactive fissionable material via two static barriers of the MPC, preventing the loss of radionuclides from the spent fuel assemblies to environment;
- Safe long-term storage of the above mentioned localizing structures (MPC) in a shielding structure (a HI-STORM storage overpack), preventing from the direct influence of ionizing radiation of spent fuel assembly to personnel and environment;
- Protection of spent fuel assembly against extreme influences of natural and man-caused origin in the process of their storage in the HI-STORM storage overpacks.

The main tasks of the CSFSF in the process of spent fuel loading at NPPs Power Units are as follows:

- Loading of spent fuel assemblies into a multi-purpose canister in the fuel cooling pool;
- MPC preparation for storage (drying, sealing, welding), using HI-TRAC transfer cask ;
- MPC transfer from HI-TRAC transfer cask to HI-STAR transportation overpack;
- Forming the railway HI-STAR transportation overpacks train and its departure to the CSFSF area.

The main tasks to be implemented in the CSFSF area, using HOLTEC INTERNATIONAL technology are as follows:

- Receipt of multi-purpose canisters, containing spent fuel assemblies (of WWER-440 type, or WWER-1000 type) in the HI-STAR transportation overpack;
- Placement of multi-purpose canisters in the HI-STORM storage overpack;
- Transportation of HI-STORM storage overpack to the place of storage;
- Long-term storage of multi-purpose canisters, containing spent fuel assemblies in the HI-STORM storage overpacks;
- Collection and shipment of liquid and solid radioactive waste for treatment/disposal;
- Protection of spent fuel assemblies against probable external extreme phenomena of natural and man-caused origin;

- Protection of personnel and environment from influence of ionizing radiation;
- Provision of physical protection and nuclear material accounting.

3.5.2 Composition of Buildings and Structures in the CSFSF Area

At arrangement of General layout of the CSFSF site the following functional areas were determined:

- MPC receiving and transfer building;
- Container storage area;
- Maintenance building with MPC storage;
- Buildings and structures for storage and maintenance of transporter and motor transport;
- Electrical building;
- Water supply and sewage systems;
- Buildings and structures of physical protection technical means and barriers;
- Administration building;
- Railway holding and maneuvering tracks

The general size of the industrial site within the limits of the fence is 644x182 m. Two motor transport accesses from South and North and one railway access from North are provided on the site.

Receiving of the railway container train with HI-STAR transportation overpacks from NPP and maneuvering operations for separation of each container car will be carried out on the railway train holding and maneuvering tracks on the CSFSF industrial site.

An unloading of the container cars, containing HI-STAR transportation overpacks, MPC transfer from HI-STAR to HI-STORM will be carried out in the receiving building, which is located in the southern part of the site and is provided with a railway access line and an access road for caterpillar transporter.

The location of the receiving building in the area ensures the shortest way for the transporter of HI-STORM spent fuel storage overpacks to the storage area and prevents from crossing of personnel and the transporter.

A garage for holding and maintaining the transporter is blocked with a garage provided for 4 vehicles and located, taking into account a traffic diagram of the transporter in the direct vicinity of the western facade of the receiving building.

The main part of the CSFSF area is occupied by the container storage area having a form of a rectangle, elongated in the direction from North to South. Railway train holding and maneuvering tracks pass along the area from its East side.

The operating reserve of empty HI-STORM overpacks and MPCs will be stored and HI-STORM shells will be filled with concrete in the maintenance building provided with MPC storage facility, which is located in the southern part of the CSFSF area. Delivery of empty HI-STORM storage overpacks and MPCs to the CSFSF will be carried out by railway. For this purpose provisions will be made for joining a dead-end railway line with the maintenance building, containing a MPC storage facility.

Water supply facilities along with the storm water accumulating tanks are located in the same ground in the South-West part of the area.

A double fence will be provided along the perimeter of the area together with the required instruments of physical protection system of the area. This system also includes a guard building and two access control points for transport and personnel.

A guard building is located to the South from water supply facilities in the area of the main entrance to the CSFSF area. Electric building and Administration building are also provided here by the design. Provisions are made for blocking the Administration building with a deepen auxiliary building having two entrances to the surface from different sides of the building.

For access of fire trucks to the buildings and facilities of the CSFSF area two access motor roads and hard standings areas are provided.

Future expansion of the area could be carried out as follows:

- in the northward direction approximately to 350 m;
- in the westward direction in case of removal of 110 kV high voltage lines to 300 m.

General layout of the CSFSF is given in Appendix C.

Actually the territory of the CSFSF area has a softly expressed slope from North to South with levels varying from 142.00 to 139.00 m in the northern part and from 138.50 to 137.00 m in the southern part. Organization of relief supposes a massive leveling of the territory. A reference level of CSFSF layout is 138.50 m. Surface water will be drained from the territory, motorways and CSFSF sites to storm water sewage inlets with subsequent supply to accumulating tanks of storm water.

For organization of construction works the design provides a construction yard in the South-East part of the CSFSF area. In the construction yard in addition to temporary facilities and sites foreseen only for the period of construction a batching plant will also be designed for providing concrete of the required quality for the CSFSF construction and for filling HI-STORM shells with concrete under the CSFSF operation.

According to the Client's Terms of Reference the CSFSF scope of work is divided into a Startup Complex stage and ISF construction stages.

When determining a composition of buildings of Startup Complex it was decided to provide the full scope of physical protection system and engineered barrier of this facility, taking into account that fact that special container train holding and maneuvering tracks are located within the boundary of the fence of the CSFSF and at arrival of the special container train the physical protection system is to be provided in full. Thus, CSFSF Startup Complex includes all buildings and facilities and also the total physical protection system.

The area for storing containers and fabricating HI-STORM storage overpacks will be prepared stage-by-stage during four phases. Foundations for HI-STORM storage overpacks of the storage area are stripes designed for 32 HI-STORM storage overpacks each. The storage area includes fifteen foundations for 32 HI-STORM storage overpacks on each foundation, i.e. the storage area is provided for 480 HI-STORM storage overpacks.

The total number of HI-STORM storage overpacks required for ensuring the design capacity of CSFSF is 458 storage overpacks. This number of storage overpacks ensures storage of 12500 spent fuel assemblies of WWER-1000 and 4000 spent fuel assemblies of WWER-440, taking into account that fact that 5% of spent fuel assemblies of WWER-1000 are leaking that leads to reduction of spent fuel assemblies within multi-purpose canister of WWER-1000 to 24 pieces and 3% of spent fuel assemblies of WWER-440 also are leaking that leads to reduction of spent fuel assemblies within multi-purpose canister of WWER-440 to 78 pieces.

For Startup Complex (I stage) three foundations for 96 HI-STORM storage overpacks, 32 HI-STORM storage overpacks per each foundation, will be erected. However, the number of overpacks foreseen for the first stage makes 94 pieces (81 pieces for WWER-1000 and 13 pieces for WWER-440).

At the second stage four foundations will be erected for 128 HI-STORM storage overpacks, 32 HI-STORM storage overpacks per each foundation. However, the number of storage overpacks foreseen for the first stage makes 130 pieces.

At the third stage four foundations will be erected for 128 HI-STORM storage overpacks, 32 HI-STORM storage overpacks per each foundation. The number of storage overpacks foreseen for the third stage makes 128 pieces.

At the fourth stage four foundations will be erected for 128 HI-STORM storage overpacks, 32 HI-STORM storage overpacks per each foundation. However, the number of storage overpacks foreseen for the fourth stage makes 106 pieces.

When assessing the number of HI-STORM storage overpacks it was assumed that HI-STORM storage overpack includes one MPC containing 31 leaktight spent fuel assemblies of WWER-1000 and 85 leaktight spent fuel assemblies of WWER-440 or 24 leaking spent fuel assemblies of WWER-1000 or 78 leaking spent fuel assemblies of WWER-440.

3.5.3 Description of the Main Technology

The functional diagram of spent fuel assemblies management is shown in fig. 3.5.2. The detailed description of technology is given in Volume 1, Part 3 of the Feasibility Study.

Spent fuel assemblies management technology within the limits of this Feasibility Study includes the following:

- Loading of MPC at NPP Power Units, using HI-TRAC transfer cask;
- Drying, filling of inert gas (helium) and welding of two barriers of leak-tight MPC at NPP Power Units;
- Checking of MPC leak-tightness and lids quality at NPP Power Units;
- Transfer of prepared MPC into HI-STAR transportation overpack with the help of HI-TRAC transfer cask;
- Transfer of the railway container train with HI-STAR transportation overpack filled with MPC to CSFSF;
- Receiving of the railway container train at CSFSF on the train holding and maneuvering tracks;
- Transfer of MPC from HI-STAR transportation overpack to HI-STORM storage overpack in the receiving building;
- Transfer of HI-STORM storage overpack with MPC to the storage area with the help of an on-site caterpillar transporter;
- Long-term storage of HI-STORM storage overpack along with MPC.

Spent nuclear fuel operations to be carried out at NPP are similar to those which are implemented actually at NPP during spent fuel shipment to treatment and/or storage to Russia. Consequently, environmental impact in the process of performance of these works is considered in environmental impact of the Power Units of SUNPP, RNPP and KhNPP. Preparation of more exact environmental impact assessments when using HOLTEC INTERNATIONAL technology will be carried out at Basic Design stage.

The main zones of CSFSF area, where spent fuel management is executed are as follows:

- Holding and maneuvering tracks of railway transport;
- Receiving building;
- Container storage area.

To ensure the main technological process the following facilities will be provided:

- Maintenance building along with MPC storage facility;
- Garage for a transporter.

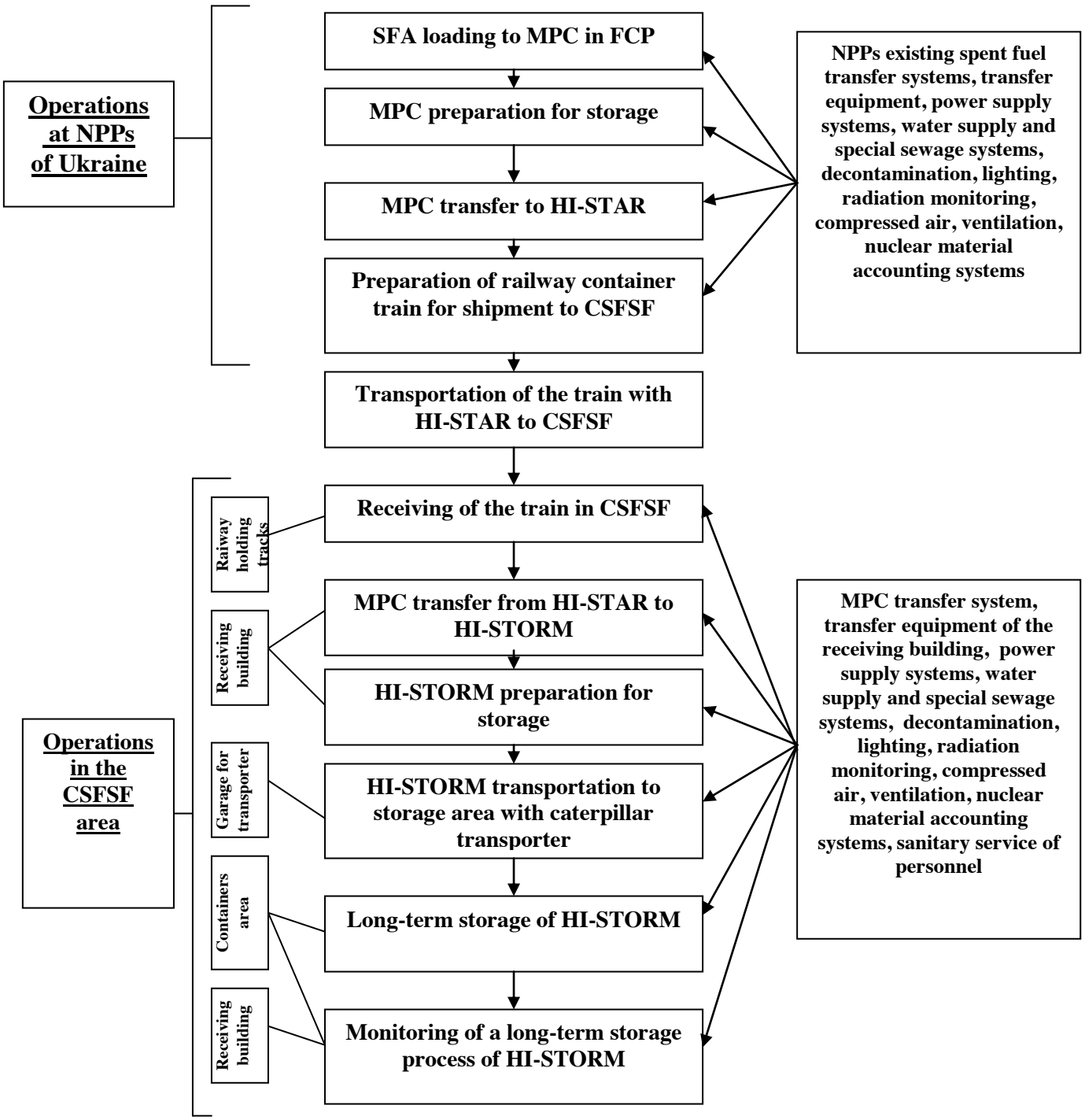

Fig. 3.5.2-CSFSF functional diagram

3.5.3.1 Railway train holding and maneuvering tracks

Railway container train holding and maneuvering tracks are located within the limits of the protected perimeter of the CSFSF area. Provisions will be made for creation of three branch lines for maneuvering of a diesel locomotive with one of elements of railway container train. After arrival of railway container train into the middle line of the maneuvering tracks the maneuvering diesel locomotive moves one by one the cover and escort cars to the parallel line. When only the containers cars remain on the middle line, the maneuvering diesel locomotive hooks one of the container car and ahead of itself transports it to the receiving building.

Before transportation of the container car to the receiving building a monitoring of its external radioactive contamination is carried out.

The acceptance of the train and its control are carried out in the presence of the representatives of security service and radiation monitoring staff on duty.

3.5.3.2 Receiving building

The receiving building is the main facility, where MPC transfer operations and HI-STORM preparations for storage are carried out.

HI-STAR is transported to the receiving building by the maneuvering diesel locomotive ahead of its through the gate to the transport and process corridor. The gate is opened on the request of personnel responsible for acceptance in the presence of representatives of security service. Once the container car is transported to the transport and process corridor, the maneuvering diesel locomotive leaves the receiving building and the gate closes. The rest of operations with containers inside the receiving building are carried out when the gate is closed.

HI-STAR transportation overpack is delivered in horizontal position to the receiving building along with top and bottom shock absorbers. HI-STAR transportation overpack is equipped with special fixing devices for its fastening within railway car.

In the receiving building the following preparatory operations for a container storage are carried out:

- incoming inspection of HI-STAR transportation overpack;
- check of accompanying shipment documentation;
- removal of the HI-STAR protective covering and fixing rods;
- removal of the HI-STAR from the railway car and installation of HI-STAR on the provisional supports;
- installation of the HI-STAR into a turnover;
- turning over of the HI-STAR to vertical position;
- removal of the HI-STAR lid;
- installation of the HI-STAR on a cart;
- transportation of the HI-STAR on the cart to transfer box (General view of the transfer box see fig. 3.5.3);
- MPC transfer from HI-STAR to HI-TRAC;
- installation of the HI-STORM into the transfer box;
- movement of the HI-TRAC together with the MPC to the HI-STORM position;
- MPC transfer from HI-TRAC to HI-STORM;
- transportation of the HI-STORM from the transfer box and installation of the lid and a temperature metering device on the ventilation ducts of HI-STORM;
- transportation of the HI-STORM to the storage area by means of the caterpillar transporter;
- installation of HI-STORM on the prepared foundation for a long-term storage.

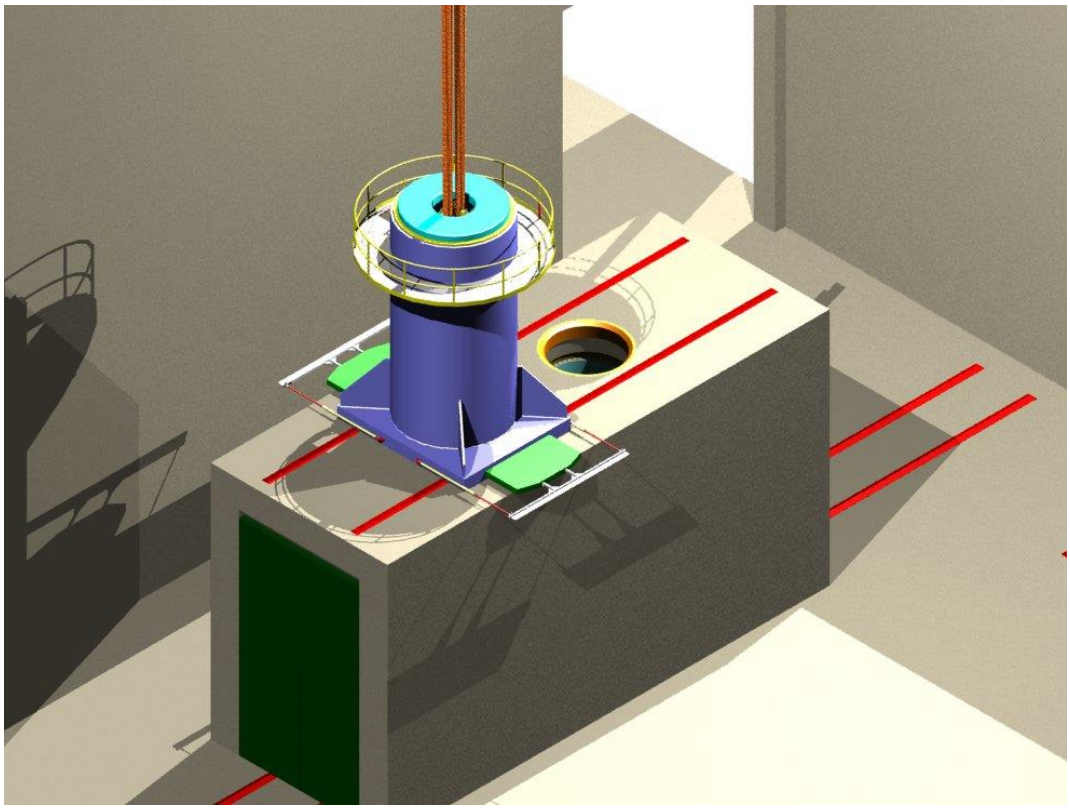

Fig. 3.5.3 – General view of the transfer box

The receiving building is provided with all auxiliary systems required for safe operation:

- control and monitoring system;
- nuclear material accounting system;
- communication system;
- radiation monitoring system;
- power supply system;
- fire protection system;
- heating and ventilation system;
- water supply and sewage system;
- liquid and solid radioactive waste collection and treatment system;
- decontamination system;
- physical protection and access control system.

Simultaneously only one MPC, containing 31 spent fuel assemblies of WWER-1000 or 85 spent fuel assemblies of WWER-440 may stay in the receiving building.

The whole cycle of MPC management is a dry process. A little quantity of liquid waste is produced if washing or decontamination of equipment is required or as a result of sanitary service of personnel or work of radiochemical laboratory.

The forced plenum and extract ventilation systems are provided in the building. Provisions are made for air cleaning by means of aerosol filters in the rooms, where MPC and radioactive waste management is carried out before air release to ventilation stack.

Receiving building lifetime is 100 years.

3.5.3.3 Container storage area

The container storage area is intended for a long-term (up to 100 years) storage of the MPC within the HI-STORM storage overpacks. The container storage area is located within the CSFSF fenced-off area.

The structure of the modules storage area provides for free movement of the caterpillar transporter delivering the containers in vertical position or service motor vehicles.

The container storage area covers the following:

- foundations for HI-STORM storage overpacks;
- HI-STORM storage overpacks;
- roads for passing the caterpillar transporter and service motor vehicles;
- mesh fence along with interception means;
- lighting;
- radiation monitoring along the perimeter;
- storm sewage system.

The container storage area includes fifteen foundations for 32 HI-STORM per each foundation.

For the Startup Complex (I stage) three foundations for the HI-STORM storage overpacks, motorways within the limits of servicing of three foundations, a fence of the area within the limits of three foundations, radiation monitoring system and lighting system within the limits of the fence of three foundations as well as storm sewage system within the limits of the fence of three foundations will be provided.

For the second, third and fourth stages four foundations per each stage will be erected. Besides, at every subsequent stage the corresponding systems and fences within the limits of four foundations will be provided via expansion of the structures of the previous stage. The construction of the stages is provided in such a way that the container storage area within the design scope will be and put in operation upon completion of the last fourth stage.

HI-STORM storage overpacks which are the main elements of the container storage area (see fig. 3.5.4) provide performance of the following functions of the MPC safe storage:

- residual heat sink from the MPC, containing spent fuel assemblies;
- protection of the MPC structures against external damages;
- reduction of personnel exposure.

Heat sink is provided in a passive mode via natural convection and therefore requires no special systems.

Radiation protection is provided via a thickness of walls (steel and concrete) and general arrangement of aerial ways of HI-STORM storage overpacks.

The storage area lifetime is 100 years.

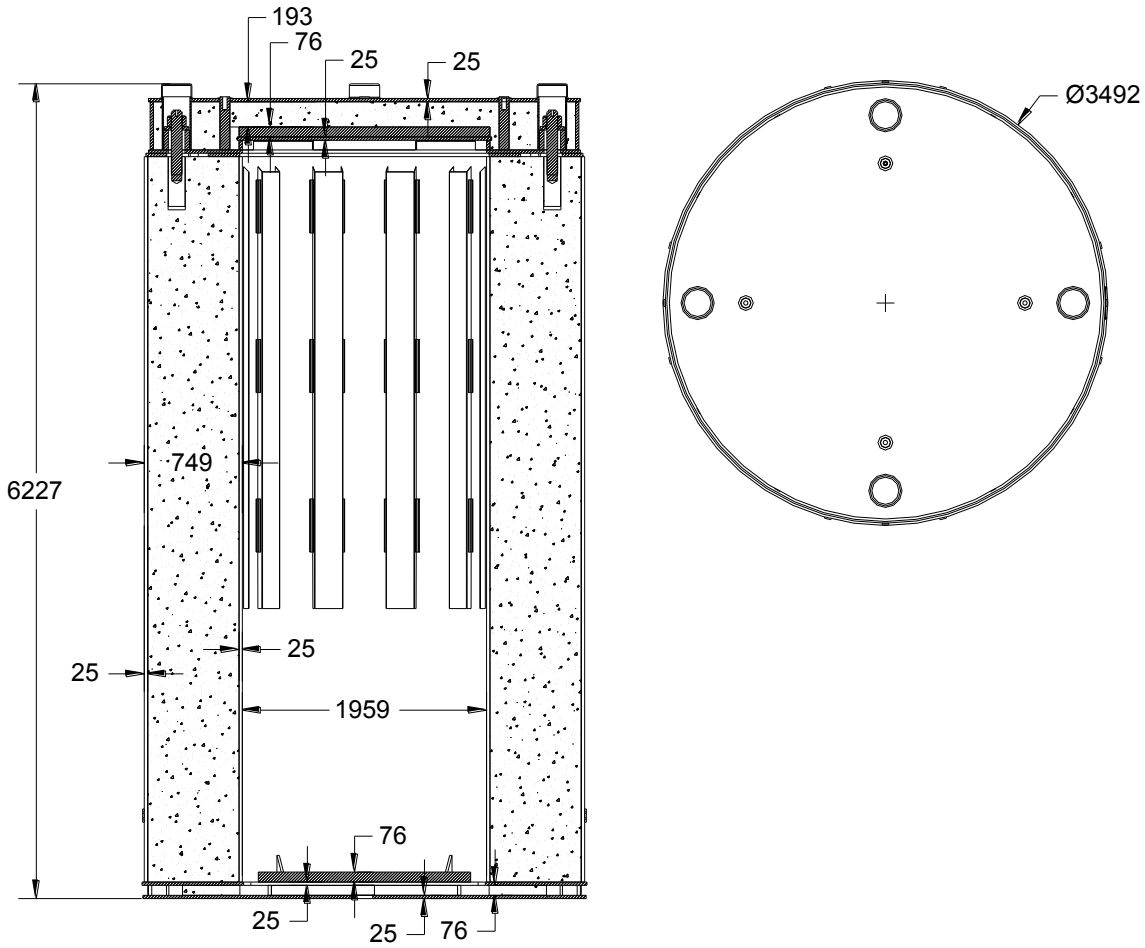

Fig 3.5.4 – Geometric characteristics of HI-STORM storage overpack

3.5.3.4 Maintenance building with MPCs storage facility

A maintenance building provided with the MPC storage facility is intended for performing the following auxiliary functions**:**

- to provide the annual supply of new shells and lids for HI-STORM storage overpacks;
- to provide the annual supply of new MPCs;
- to provide a filling of HI-STORM shells with concrete;
- to provide quality control and the required cure time of the concreted HI-STORM shells;
- to provide the possibility for execution of maintenance works of the CSFSF electrical and process equipment, I & C equipment;
- to provide the sanitary conditions for service personnel in the building.

The storage facility of new HI-STORM and MPC is the unheated part of the building equipped with a bridge crane of 125 t capacity.

Concreting of HI-STORM shells is carried out in the annex part of the building provided with a shed. Concrete is transported in concrete mix trucks from the batching plant located in the construction yard beyond the limits of the CSFSF fenced-off perimeter.

The workshops provided for equipment of the CSFSF free-access area, office and sanitary rooms for personnel are located in the heated part of the building.

3.5.3.5 Garage for a transporter

A garage is intended for holding and a minor repair of the caterpillar transporter.

Taking into account that fact that works related to loading and installing of HI-STORM are conducted during the whole year, the garage for the transporter is foreseen heated. The general view of the caterpillar transporter is given in fig. 3.5.5.

Fig. 3.5.5 – General view of the transporter

3.5.4 Architectural and Civil Engineering Solutions

The CSFSF buildings and structures are classified as per their nuclear and radiation safety functions. The classification corresponding to the requirements of PiN AE 5.6 [51] and PNAEG-5-006-87 [52] is given in Table 3.5.1.

Table 3.5.1

General layout number	Building/structure/building part	Category to PiN AE 5.6	Seismic category to PNAE G-5-006-87
1	Receing building		
1.1	Central block	I	I
1.2	Auxiliary multy-story block	I	I
2	Container storage area	I	I
3	Maintenance building with multi-purpose canister	III	III
4	Administration building	III	III
5	Electrical building	III	III
7	Garage for a transporter	III	III
8	Garage for 4 vehicles	III	III
9	Car maintenance building	III	III

General layout number	Building/structure/building part	Category to PiN AE 5.6	Seismic category to PNAE G-5-006-87
10	Gasoline station		
18.1	Pump station of fire-fighting water supply	III	III
18.2	Fire-fighting water reserve tanks	III	III
20	Sewage pump station	III	III
21	Rainwater retaining tanks	III	III
29.1	Guard building	III	III
29.2	Access control point 1		
29.3	Access control point 2		

When performing CSFSF environment impact assessment it should be taken into account that the loads of all CSFSF buildings and structures are to be calculated according to the requirements of SNiP 2.01.07-85[40].

PiN AE-5.6 requirements will be additionally considered during the designing of the structures, which functions refer to category I related to nuclear and radiation safety (table 3.5.1),.

Combined loads for CSFSF buildings will be defined according to the results of an analysis of concurrent influence of different loads on a structure or foundation, considering appearance of various temporary loads.

During designing of the buildings, their nuclear and radiation risk is taken into account as well as the requirements to structures of the walls, ceiling slabs, staircases, etc. are considered related to fire risk building category and fire resistance degree of the building structures applied. Categories of the buildings and structures related to fire risk and fire resistance degree of building structures are given in the table 3.5.2.

Table 3.5.2 – Building classification related to fire risk

General layout number	Building/construction/building part	Explosion, fire risk category	Fire resistance degree
1	Receiving building		
1.1	Central block	D	I
1.2	Auxiliary multi-storey block	D	I
2	Container storage area	-	-
3	Maintenance building with multi-purpose canister	D	II,IIIa
4	Administration building	D	II
5	Electrical Building	D	II
7	Garage for a transporter	B	II
8	Garage for 4 vehicles	B	II
9	Cars maintenance building	-	-
10	Gasoline station	-	-
18.1	Pump station of fire-fighting water supply	D	II
18.2	Fire-fighting water reserve tanks	-	-
20	Sewage pump station	-	-
21	Rainwater retaining tanks	-	-
29.1	Guard building	D	II
29.2	Access control point 1	-	II
29.3	Access control point 2	-	II

3.5.4.1 Receiving building

The receiving building consists of two building blocks:

- Central block;
- Auxiliary multi-storey block.

The building dimensions are 39,00×42,00 m on the layout, central block height is 20,5 m, auxiliary block height is 16,2 m.

The receiving building is made of cast reinforced concrete structures.

Design life time of the receiving building is 100 years.

The receiving building is calculated for normal operating and design loads.

The central block represents a transport and process corridor, equipped with a bridge electric crane of 140/25 t carrying capacity and railway entry. The central block foundation, which includes large loads due to the bridge crane and railway entry, will be a solid cast reinforced concrete slab of 1,5 m. A structure stability calculation will be made taking into account the most unfavorable load combinations. The most part of the foundation load will be represented by the static one and the greatest settlement will occur during the construction. Cast-in-place reinforced concrete walls are 300 mm.

The auxiliary multi-storey block is a cast-in-place reinforced concrete four-storey structure of 42×15 m with the floor height: ground floor of 4,2 m, the first floor of 3,6 m, the second floor of 3,3 m, the third floor of 5,1 m. Cast-in-place reinforced concrete walls are of 300 mm thick. The auxiliary block foundation is cast-in-place reinforced concrete slab 1,0 m in thickness, isolated from the central block foundation slab. This is provided for successful settlement during the construction and in order to avoid excess stress due to a nearby foundation. Staircase and elevator shafts are located in the corners.

Besides the rooms of main technological process there are also the electrical, ventilation system, water supply, compressed air supply rooms in the building. All rooms are divided into free access and restricted access areas. The entrance and exit of the personnel of the restricted access area is realized through the changing facility. Horizontal connection between the rooms is carried out through the corridors and a vertical connection by means of staircases.

Materials, used for the room finishing, provide necessary hygiene and sanitary conditions for the personnel.

3.5.4.2 Container storage area

A container storage area includes 15 cast-in-place slabs, where containers are placed. The roads of 9 m wide are foreseen between the slabs to pass through and for a conveyor maneuvers. The slabs and roads are at the same level 138,500m with rainwater slopes.

Design life time of the container storage area is 100 years.

The container storage area is calculated for normal operating and design loads.

Container storage area slabs are made of cast-in-situ reinforced concrete with 9×80 m dimensions, approx. 800-1000 mm in thickness.

Functional expansion and contraction joints are provided on the container storage area.

3.5.4.3 Maintenance building with multi-purpose canister

Maintenance building with multi-purpose canister with 21×57 m dimensions on the layout consists of three blocks both structurally and functionally:

- multi-purpose canister storage &HI-STORM;
- laboratory building;
- annex part of the building provided with a shed.

Multi-purpose canister storage is a building with 21×33 m dimensions, 14 height up to the roof girder, equipped with a bridge electrical crane, carrying capacity of 125/21t, not heated. The walls are of multi-layer panels of “Sandwich” type, consisting of profiled sheets with heat insulation. Foundations for columns are pier, monolithic, reinforced concrete. The floor is an independent cast-in-situ, reinforced concrete slab.

The laboratory building is two-story monolithic reinforced concrete with dimensions 21×12 m, the floor height is 3 m. Building frame consists of precast reinforced concrete columns, girders and stiffening diaphragms, precast floors, girder ribbed panels of 220 mm thick. The staircases are precast. The roof is flat with a conductor. Foundations are monolithic reinforced concrete for the columns with prefabricated reinforced concrete foundation beams for the walls.

The annex part of the building provided with a shed with 21×12 m dimensions, 14 m height is a shelter of steel galvanized profiled sheets, which are laid on beams, laid onto the main roof beams. The roof beams are rested upon the steel columns. Crane tracks for overhead-track hoist of 1,0 t lifting capacity are fixed to the lower roof beam chord. Pier, cast-in-situ reinforced concrete foundations, separately located are performed for steel columns. The floor around the railway will be performed cast-in-situ reinforced concrete on compacted soil of 200 mm thick.

3.5.4.4 Administration building

This is a five-storey brick building with basement, heated, with $45,6 \times 15,0$ m dimensions on the layout, with 3,60; 4,20 m floor height. Outer walls of the building are of brick, 510 mm in thickness, inner walls are also of brick, 380 mm thick. Partition walls of the building are of plaster blocks of 80 mm thick and brick of 120 mm thick. An emergency shelter for 100 persons is at level minus 4,00 m.

3.5.4.5 Electrical building

The electrical building devices is a heated one-storey building with dimensions in axes 9×36 m, rectangular in the layout with brick walls of 380 mm. The building height is h=4,8 m up to the lower roof slab. Roof slabs are precast, ribbed slabs. Foundations for columns are pier, cast-in-situ reinforced concrete with reinforced concrete foundation beams for the walls.

3.5.4.6 Garage for a transporter

Garage for transport is a brick, heated building with the dimensions in axes 24,0x12,0 m, rectangular in the layout. The building height is 9,0 m up to lower roof slab. Strip foundations are of precast foundation slabs and prefabricated concrete blocks. The floor is an independent cast-in-place reinforced concrete slab. The roof slabs are prefabricated, ribbed, reinforced concrete.

3.5.4.7 Garage for 4 vehicles

The garage building for four cars is a one-storey heated building with dimensions $30,0 \times 18,0$ m in the layout, 4,5 m height up to the lower roof slab. The walls are made of brick, outer walls of 510 mm thick, inner walls are 250 mm, 380 mm in thickness. Foundations are strip. Roof slabs are precast reinforced concrete, ribbed, prestressed, laid along the cast-in-place reinforced concrete chord of 400 mm height. The roof is with heating put in. The lower layer of the floor is concrete, the second layer is polymer-cement covering of concrete, the third layer is ceramic acid-proof tile. In the garage there are two repair pits with dimensions $8,3 \times 1,5$ m in the layout, 1,2 m depth, performed in cast-in-place concrete, there are also a monorail and steel maintenance platform.

3.5.4.8 Cars maintenance building

Cars maintenance building is a shelter of 42,0x12,0 m in the layout, 9,0 height. The shelter is made of steel galvanized profiled sheets, which are laid on beams, laid onto the main roof beams. The roof beams are rested upon the steel columns. Crane tracks for the overhead-track hoist of 1,0 t lifting capacity are fixed to the lower roof beam chord. Pier, cast-in-situ reinforced concrete foundations, separately located are performed for steel columns. The floor around the railway will be performed cast-in-situ, reinforced concrete on compacted soil of 200 mm thick.

3.5.4.9 Gasoline station

A gasoline station consists of two fuel-filling columns and two fuel tanks of 5 m^3 each. A fuel tank is a cylinder, welded of steel sheets of 4 mm thick, 2,2 m diameter. The tank is buried in soil to 3,5 m. A sand cushion serves as a base for the tank. The cushion is laid on a tray. The tray is

of cast-in-situ reinforced concrete. Process well structures are installed onto the tank with the walls and the well baseplate of cast-in-situ reinforced concrete. The well has a steel cover. The tank is covered with the tamped soil. The asphalt blind area is arranged on the top of the covering on macadam base. Monolithic reinforced concrete foundation is performed for the fuel-filling column.

3.5.4.10 Pump station of fire-fighting water supply

Pump station of fire-fighting water supply is a heated building in axes 6,0x6,0m, rectangular in the layout, equipped with a hoist of 1,0 t lifting capacity. The brick walls are 510 mm in thickness. The roof is insulated, with a downpipe. The building height is 3,0 m up to a lower roof slab. Strip foundations are of concrete blocks. The roof slabs are precast, hollow. Foundations for equipment are monolithic.

3.5.4.11 Fire-fighting water reserve tanks

A structure for fire-fighting water reserve tanks is performed in the form of two tanks, buried to 1,5 m, with 6,0x6,0 m each in the layout, height from the bottom to the lower roof slab is 3,79 m. Covering with 0,5 m soil layer is carried out over the tanks. The tank walls are factory made precast reinforced concrete panels of 200 (250) mm thick. The tanks are overlapped by precast reinforced concrete ribbed floor slabs of 400 mm height. Foundation mat is under the bottom. Man holes are provided in the tank covering. Cold asphalt mastic waterproofing is made along the external surfaces of the tank structures.

3.5.4.12 Sewage pump station of domestic waste

Sewage pump station of domestic waste is a receiving tank, buried to minus 6,270 m level. The tank is of precast reinforced concrete rings of 90 mm thick, 1500 mm diameter. The bottom is precast reinforced concrete of 2000 mm diameter, 120 mm thick on macadam bed of 100 mm thick. The process equipment is installed on the top of reinforced concrete wall rings.

3.5.4.13 Rainwater retaining tanks

Rainwater retaining tanks are factory made tanks, buried in soil to 4,5 m. Sections are with dimensions 6,0x6,0m and 5,0 m height. The walls are of precast reinforced concrete panels of variable cross-section from 150 mm up to 250 mm with console to install the overlapping. The bottom is of cast-in-situ reinforced concrete on concrete bed of 140 mm to 350 mm thick. The tanks are overlapped by metal shields.

3.5.4.14 Guard building

The guard building is heated two-storey building with dimensions 12,0x36,0 m on the layout. The floor height is 3,3 m. The walls are of brick. Foundations are strip reinforced concrete of prefabricated panels and blocks. Floor and roof slabs are round hollow, precast reinforced concrete. The staircases are precast reinforced concrete.

3.5.4.15 Access control point ACP-1

Access control point ACP -1 is a single storey heated building with dimensions $12,0 \times 24,0$ m on the layout (in axes), of 3,0 m height to the lower roof slab, with a conductor. The outer walls are of wall panels of cellular concrete (250 mm thick). Frame columns are precast reinforced concrete. Foundations are precast, reinforced concrete, of glass type. The roof is heat-insulated.

3.5.4.16 Access control point ACP -2

Access control point ACP -2 is a single storey, heated building with dimensions $6,0 \times 8,0$ m on the layout, of 3,3 m height to the lower roof slab, with a downpipe. The outer and inner walls are of brick. The outer wall thickness is 510 mm, inner walls are 250 mm. Strip foundations are of concrete blocks. Roof slabs are precast, reinforced concrete, hollow-core. The roof is heat-insulated.

3.5.5 Monitoring and Control System

Monitoring and control system of CSFSF will provide a complex monitoring and control over the technological processes on receiving and storage of containers with spent nuclear fuel.

MCS will integrate separate primary systems in one system, that allows to perform a complex processing, presentation, archiving of information in one place – in central control room in the receiving building. MCS will provide a support of radiation and technical safety during receiving of multi-purpose canisters with spent fuel assemblies and their storage and will have a function of informational support of the personnel.

The following design criteria are laid in the basis of MCS:

- System reliability (is achieved due to application of elements with high reliability indices and optimal structure, possibility of failure detection by means of hardware diagnostics);
- System openness (is achieved due to possibility to accept additional elements and systems as well as integrate in the other informational systems).

MCS is a distributed management-information system, having two levels of hierarchy.

The lower level of MCS forms the following local systems:

- control of transport container receiving;
- storage process monitoring;
- radiation monitoring;
- fissible material monitoring and keeping records;
- heating and ventilation monitoring and control;
- special sewage system monitoring and control;
- compressed air monitoring and control;
- water supply monitoring and control;
- shower water monitoring and control;
- rainfall effluents monitoring and control;
- electric power supply monitoring and control;
- fire safety assurance monitoring and control ;
- communication.

Control and monitoring of local systems will be realized with use of the distributed control system, based on microprocessor devices or logic controllers (for processes, which require complex control algorithms).

High-performance servers will be installed at the upper level of the monitoring and control system. The system bus of Ethernet type connects these servers with hardware of the lower level. The upper level of MCS has the following functions:

- collection and processing of information from the hardware of the lower level;
- controlled parameters displaying in a convenient form for perception, diagnosing and control;
- information archiving;
- information exchange with the adjacent systems.

Monitoring and control of CSFSF technological process will be realized from central control and local control rooms. A working place of a process man will be in the central control room, who, in an interactive mode, carries out monitoring and control of the object as a one process complex.

The local panels will be provided to monitor and control the following systems:

- ventilation;
- transport and process part including SFA container receiving;
- compressed air;
- sewage pump station;
- shower water.

A working place will be foreseen for an engineer on fissible material recording.

The detailed description of the monitoring system is given in Volume 1, part 3 of FS.

3.5.5.1 Transportation storage overpack receiving monitoring system

During realization of process operations, connected with SFA receiving the following will be carried out:

- surface contamination monitoring of transportation storage overpacks HI-STAR;
- monitoring of gamma and neutron radiation dose rate from surface of storage overpacks of all process chain;

Monitoring of surface contamination and gamma radiation dose rate will be realized by portable dosimeters-radiometers.

3.5.5.2 Storage process monitoring system

During SF storage the following will be carried out in storage overpacks HI- STORM:

- periodical temperature control on HI- STORM surface;
- continuous monitoring of cooling air temperature at air duct input and output;
- periodical monitoring of integrity of protective barriers;
- continuous monitoring of radiation situation at storage area.

Temperature on concrete module surface will be controlled with the help of portable and movable equipment. Control of cooling air temperature at input and output of air ducts HI-STORM will be remote-controlled with use of radio-modems, installed at each HI-STORM. Radiation situation in the storage area will be controlled by hardware of radiation monitoring system.

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3.5.5.3 System of fissible material monitoring and keeping records

Fissible materials, coming to the storage will be taken into account with the help of computerized data base on nuclear fuel management.

The system includes the complex of technical and organizational measures providing the constant control of available quantity of nuclear materials (including recording, identification and inventory of coming SFA, information archiving).

Accounting information and data archive (SFA number, decay time, initial enrichment, burnup, quantity of fissionable species) together with SFA is transmitted to CSFSF by NPP administration. The system of keeping records is agreed with IAEA.

3.5.5.4 Radiation monitoring system

Radiation monitoring system (RMS) of CSFSF is a complex of hardware and organizational measures, aimed at ensuring of radiation safety in order to:

- not to exceed the set limits of doses for the personnel and population;
- not to proliferate radioactive contamination into environment.

RMS implies collection, processing and presentation of information about radiation environment in CSFSF receiving building rooms and on container storage area, about radiation process parameters, personnel radiation dose, gas-aerosol release into environment.

RMS hardware provide:

- radiation in-process measurements;
- radiation monitoring;
- personal monitoring;
- environmental radiation monitoring;
- radiation monitoring of radioactive contamination non-proliferation

The scope of this monitoring is defined by normative documents, requirements of main equipment, CSFSF technological and assembly decisions.

RMS CSFSF consists of the following subsystems:

- radiation in-process measurements;
- radiation monitoring;
- personal monitoring;

- environmental radiation monitoring;
- radiation monitoring of radioactive contamination non-proliferation

Subsystem (radiation in-process measurements)

This subsystem is intended for radiation monitoring of process equipment, ventilation systems, efficiency of radioactive media purification systems. Radiation in-process measurements stand for control of gamma and neutron radiation dose rate from storage overpacks HI-STAR, HI-STORM & HI-TRAC of all process chain in the receiving building. In this building gamma and neutron exposure dose rates from modules HI-STAR, HI-STORM & HI-TRAC are measured as well as possible surface contamination.

Radiation in-process measurements system controls:

- volumetric activity in control tanks of the changing facility shower rooms;
- water volumetric activity in waste water sump;
- efficiency of exhaust ventilation system aerosol filters;
- gamma-radiation exposure rate on filters of exhaust ventilation systems.

Volumetric activity monitoring in control tanks of shower water and waste water sump is carried out by sampling and a laboratory analysis in CSFSF. Control of the efficiency of exhaust ventilation system aerosol filters is realized with the help of analytical filters.

Radiation monitoring subsystem

This subsystem is responsible for monitoring of radiation situation parameters in serviced and periodically serviced rooms of the restricted access area.

Radiation situation is characterized by:

- gamma-radiation exposure dose rate;
- neutron radiation exposure dose rate;
- volumetric activity of alpha, beta aerosols;
- contamination of the equipment and room wall surfaces.

Gamma radiation exposure dose rate is monitored by a stationary detector blocks in the following receiving building rooms:

- at container receiving and overloading area;
- in «contaminated» workshops;
- in shower water pump station;
- in exhaust ventilation system filter room;
- at SRW container storage area .

Volumetric activity of alpha, beta aerosols is monitored by stationary and mobile (removable) facilities in the following rooms:

- at HI-STAR, HI-STORM & HI-TRAC storage overpacks receiving and overloading area;
- at SRW storage area;
- in «contaminated» workshops;
- in the changing facility and sanitary lock;
- in shower water pump station;
- in ventilation center of the «contaminated» area (during replacement of aerosol filters).

Subsystem of radiation monitoring of radiation contamination non-proliferation

Subsystem of radiation monitoring over radiation contamination non-proliferation monitors a radioactive level at the surfaces of the personnel shoes, hands, clothes and transport.

Monitoring of skin and individual protection equipment contamination by beta-active radionuclides is carried out by stationary monitoring devices at the changing facility entrance and exit.

Monitoring of hands contamination by beta-active radionuclides is realized by stationary devices in toilet facilities of restricted access area.

Monitoring of radioactivity carried beyond the bounds of CSFSF will be realized by the stationary monitoring installation, situated in the hall of access control point-1.

Monitoring of radioactive contamination level of room walls and equipment surfaces is carried out with the help of portable radiometers as well as a wiped test with the following measurements in radiation monitoring laboratory.

Monitoring of vehicle surface contamination level is realized by portable radiometers.

Personal radiation monitoring subsystem

This subsystem is aimed at:

- monitoring and keeping records about individual doses of the personnel external irradiation;
- monitoring and keeping records about individual doses of internal irradiation from radionuclides, incorporated in a man's organism;
- a calculation of the personnel total dose loads;
- planning of the personnel dose loads at access to radiation-dangerous works on dosimetric order.

Monitoring and keeping records of individual doses of internal irradiation from incorporated radionuclides in a person's organism is carried out in specialized laboratories (human body counter ChNPP or SSE «Ecocenter»).

System of personal monitoring of external irradiation of the personnel is realised with the help of hardware of automated system of radiation dose records and based on efficient electronic direct reading individual dosimeters and thermoluminescent dosimeters.

Subsystem of environmental radiation monitoring

Subsystem of environmental radiation monitoring is responsible for sources of possible radioactive environment contamination.

The following parameters are monitored:

- activity and radionuclide composition of gas-aerosol releases into the air through the ventilation stack;
- activity and radionuclide composition of waste water with domestic sewage system;
- water activity and radionuclide composition of observation holes.

Monitoring of release activity into the atmosphere is performed on the following components:

- alpha and beta aerosols;
- inert radioactive gases.

Radiation monitoring of gas-aerosol releases to the ventilation stack is carried out by the stationary system. This system provides the measurement of specific radionuclide activities and considering the off-gas volume, the integration is carried out during a day. To define the average monthly admissible release on the separate radionuclides a full analysis of isotopic composition of a release is fulfilled by the means of object laboratory of radiation monitoring. Radiation situation monitoring in CSFSF site area is carried out on gamma-radiation exposure dose by hardware of radiation in-process measurements subsystem, located along the perimeter of CSFSF site. Activity monitoring of liquid discharge from the domestic sewage is fulfilled by means of sampling with the further laboratory analysis by object laboratory of radiation monitoring.

To monitor the leakage of radioactive liquids into the soil and prevent their penetration into groundwater, underground water activity monitoring is foreseen from test holes, located along the CSFSF perimeter. The monitoring is carried out by sampling with the further laboratory analysis by object laboratory of radiation monitoring.

3.5.6 Communication System

The external and internal communication systems ate arranged to provide CSFSF with dispatch and process control.

To arrange CSFSF external telephone communication with Ukrainian NPP, State nuclear committee of Ukraine and other departments, providing safety functioning of the facility, going out to national communication network, information transmission (including video information) to the upper levels of control, fiber communication line laying is provided with digital multiplexing of transmission systems from CSFSF to communication center of the town of Chernobyl. Further digital communication paths are arranged according to the existing cable lines through the nearest network communication center «Ukrtelecom».

To arrange communication in the process of SF transportation, a continuous mobile communication shall be arranged between sender, recipient, transport means with SF, accompanying groups along the movement route. This will be performed by creation of isolated radio net Mintoenergo based on the digital system of trunking communication "Tetra" ("Dimetra"). Basic stations of this system will be also at ChNPP, "Vector" sites.

There are the following kinds of internal communication :

- Automatic telephone communication of CSFSF users;
- System of in-plant radio communication;
- Broadcasting network with loudspeakers installed in places of constant presence of the personnel as well as announcing circuit and command and searching communication in all amenity, service and working rooms, escape routes and along the CSFSF area. Announcing communication is used for local broadcasting, if necessary.

The more detailed description of CSFSF communication system is given in the volume 1 part 3 FS.

3.5.7 Electric Power Supply System

This system is intended to supply all consumers of CSFSF under normal operation conditions, failure of normal conditions and design accidents.

Power supply system includes equipment to support functioning of all systems, providing working operations with SF, SF storage, technological process monitoring, physical protection, lighting, communication, radiation monitoring, ventilation.

This system provides the modern switch to the system of backup or emergency power supply in case of main power supply loss.

Total power consumption of CSFSF consumers is 4073 kW.

To provide CSFSF consumers with power supply the main switchgear of 0,4/0,23 kV, which is installed in the electrical building and in the receiving building. Sections of switchgear 0,4kV are connected in pairs with the help of normally switched off automatic circuit breakers; in case of failure of one two transformers a sectionalizing circuit breaker is on automatically.

All transformers are operating (implicit standby circuit). Transformers are connected to high-voltage side to two sections of 10 kV switchgear of 110/10 kV «Buryakovka»substation, located at the distance of approx. 1 km from CSFSF.

Power supply of «Buryakovka»substation on side 110 kV is realized by two 110 kV high-voltage lines, one of which is a branch from high-voltage line 110 kV ChNPP – Pripyat, the other is a branch from high-voltage line 110 kV Polevaya - Lubyanka.

Considering the fact that when complex “Vector” achieves an advanced stage of development, its power will be 11200 kV·A, to supply consumers of CSFSF WWER the replacement of the existing transformers of 6300 kV·A power of 110/10 kV «Buryakovka» substation by new transformers 110/10 kV of single-unit power of 16 MV·A.

To connect transformers 10/0,4-0,23 kV CSFSF at the existing «Buryakovka» substation, six new cubicles of 10 kV switchgear shall be installed by three on each section.

«Buryakovka»substation connection with CSFSF, 10 kV voltage, is realized by six cables of 10 kV voltage, aluminum conductor section of 95 mm^2 each.

Diesel-generators are provided for power supply of CSFSF main consumers, requiring uninterruptable power supply in the conditions of loss of all auxiliary transformers of 10/0,4-

0,23 kV voltage. For this purpose together with six sections of the mentioned above main switchgear 10/0,4-0,23 kV two sections of reliable supply of the main consumers are created.

Power supply of each section of the reliable power is carried out from two sources:

- from section of main switchgear 10/0,4-0,23 kV;
- from diesel-generator (the second source).

Directly to reliable power section it is supposed to connect the following consumers requiring uninterruptible power supply but allowing short-time power interruption for the time of the diesel switching on:

- radiation monitoring;
- guard lighting;
- one of two fire pumps.

Power of every diesel is suggested to take 160 kW.

Power supply of automatic fire alarm equipment is provided due to the proper uninterruptible power supply (UPS), having an accumulator battery. Power supply of the physical protection hardware, communication, CCTV and computer communication is foreseen from the other proper uninterruptible power supply. Uninterruptible power supply is realized both from sections of switchgear 0,4/0,23 кkV of normal operations and from sections of reliable power supply of the main consumers. Two DC installations of 48 V, having an accumulator battery and charging device are foreseen to feed control and automatics circuits DC.

The more detailed description of CSFSF power supply system is given in volume 1 part 3 FS.

3.5.8 Water Supply and Sewage System

3.5.8.1 Water supply systems

CSFSF water supply systems are intended for:

- supply of drinking water for the personnel domestic and industrial needs;
- water supply to fill fire reservoirs.

The following is foreseen on CSFSF site:

- utility and drinking water pipeline;
- fire line;
- watering pipeline.

Utility and drinking water pipeline is provided for the personnel and process needs. Water pipeline is foreseen in the following buildings and facilities:

- administrative building;
- receiving building;
- maintenance building with multi-purpose canister storage;
- garage for 4 vehicles;
- cars maintenance building;
- ACP-1;
- ACP-2;
- Guard building;
- Concrete factory.

The source of utility and drinking water supply of ISF WWER site is the existing system of utility and drinking water supply IC «Vector». Water supply source of this system is artesian well of 8 m^3/hr flow, from which water is coming into the water-tower (50m^3 capacity , bore hole is 24m) and further for utility needs, for industrial needs (mostly for concrete tempering) and filling of fire reservoirs of IC «Vector».

Within FS CSFSF construction of additional standby artesian well with the supposed 8 m^3/hr flow is foreseen on water intake facilities IC “Vector” site.

To prepare hot water an installation of capacitive electric water heater installation is provided.

Fire line is provided to ensure external and internal fire-fighting of buildings and structures of CSFSF site. A circular fire line of high pressure is designed on site. Fire line networks are supplied to the buildings, equipped with the internal fire water pipe. Hydrants are foreseen For external fire-fighting. The calculated water flow is 129,6 m^3/hr. It is defined by the required water flow for external and internal fire-fighting of the most fire risk building, which is a garage block for a transporter and four vehicles.

Water supply for fire-fighting is stored in two fire reservoirs of 200m^3 each. Reservoirs filling is provided by utility and drinking water pipeline IC "Vector".

The source of watering supply are rainwater retaining tanks. For watering clarified rainwater is taken from the retaining tank medium part.

3.5.8.2 Sewage systems

CSFSF sewage systems are intended for:

- receiving and sending domestic sewage effluents for sewage treatment works of Vector complex;
- collection, control and sending rainfall sewage effluents for sewage treatment works of Vector complex of CSFSF site;
- collection, purification and sending diesel-generators effluents to rain water collection system;
- Receiving and sending for sewage disposal plants of Vector complex the effluents from the canteen and cafe .

The following is foreseen at CSFSF:

- Domestic sewage;
- Storm water drainage;
- Sewage of effluents, contaminated with oil products.
- Sewage of effluents from canteen and cafe.

To collect and discharge of domestic effluents, including effluents from canteen and cafe, an underground sewage pump station is foreseen beyond the site limits. From pump station waste water by a discharge header is pumped over to the sewage disposal plant for full biological treatment of IC «Vector» site.

Storm water drainage is intended for collection and removal of atmospheric precipitation from the surfaces of on-site roads and CSFSF container storage area and building roofs. On-site water supply network is designed as gravity water supply. A device of 8-accumulating capacities of 6x6 m, blocked in pairs is provided to collect rain-water. Contaminated rainwater in pressure mode are supplied to storm water sewage treatment works of IC «Vector» site. Not used for watering of the area non-contaminated rainwater in pressure mode are supplied to the collector of clarified rainwater after sewage treatment works IC «Vector».

On-site water supply network is designed as gravity water supply for removal of drainage waste water, contaminated with oil products, from diesel-generators installation in electrical building. Discharge from the building is provided in oil catcher from which the waste water are discharged to storm sewage.

3.5.9 Heating and Ventilation

Heating, ventilation and air conditioning is designed for creation in CSFSF of normal labor conditions for the personnel, heat sink, ventilation and negative pressure in rooms where operations with multi-purpose canister and RAW take place.

The following main provisions are put into the ventilation design:

- Exhaust air, released into the ventilation stack , is undergone radiation monitoring;
- The method of separated ventilation is observed for restricted access area and free access area;

- In rooms of restricted access area the directed air flow and negative pressure are created according to the room purpose;
- Exhaust systems from rooms of restricted access area are supplied with aerosol filters;
- The set air temperatures and relative humidity are maintained in rooms;
- Air exchange in rooms of the constant presence of the personnel are defined considering the normalized outdoor air flow rate under sanitary norm;
- Ventilation of rooms is performed considering room fire category .

In case of fire the centralized disconnection of ventilation installations is provided, which serve the rooms with fire and explosion risk production.

To ensure the reliable work the ventilation systems of restricted access area are provided with 100 % equipment reserve, supplied with automated interlocking and remote control. Power supply of ventilation system consumers is taken under category 3 according PUE [68].

Heating in CSFSF buildings is provided with use of industrial and office fan heaters.

Ventilation systems are provided in the following buildings and structures on CSFSF site:

- Receiving building;
- Administrative building;
- Maintenance building with multi-purpose canister (except for the storage);
- Electric building;
- Guard building;
- Sewage pump station ;
- Fire water supply pump station;
- Garage for transporter;
- Garage for 4 vehicles.

Further in the section ventilation systems of the receiving building are considered in more details. This is due to the fact that main operations with SF are fulfilled in the receiving building, that's why the ventilation systems of the receiving building contribute to CSFSF aerosol release. The rest ventilation systems are given in more details in volume 1 part 3 FS

Ventilation system of the receiving building consists of the following subsystems:

- The first subsystem consists of plenum WW01 and exhaust WW11 ventilation systems for transport and process corridor room;
- The second subsystem consists of plenum WW02 and exhaust WW12, WW13, WW14, WW16 ventilation systems (separate for each room category) rooms of restricted access area;
- The third subsystem consists of plenum WW03 and exhaust WW34 ventilation systems for changing facility rooms and amenity rooms of free access area;
- The fourth subsystem consists of plenum WW03 and exhaust WW34 systems for free access area.

Cooling of indoor air by split-systems is foreseen for administrative room, central control rooms and ventilation room, service block.

3.5.9.1 Ventilation system of transport and process corridor - WW01, WW11

A basic diagram of the system is given in the figure 3.5.6.

Plenum-exhaust ventilation system of transport and process corridor works continuously. The plenum installation provides clean and warm air in a cold period of a year, to the transport and process corridor to maintain temperature conditions of reliable equipment work. Efficiency of plenum installation is 20000 m^3/hr, exhaust is 25000 m^3/h. Heat consumption to warm up the plenum air up to 10^0C is 215 kW. Negative pressure in transport and process corridor is maintained due to exceeding of exhaust air flow rate over the plenum one.

Equipment of plenum and exhaust subsystems is provided with 100% reserve. Standby equipment is switched off automatically, if air flow rate reaches the limit values or the operating equipment fails.

3.5.9.2 Ventilation of restricted access area – WW02, WW12, WW13, WW14, WW16

Basic diagram of the system is given on the figure 3.5.7.

Plenum and exhaust ventilation subsystems of restricted access area works continuously. The plenum installation provides clean and warm air to serviced rooms of restricted access area of the receiving building to maintain temperature conditions of reliable work of the equipment and required temperature conditions of the personnel presence considering the regulated outdoor air flow rate under the sanitary norms

Efficiency of plenum installation is 5450 m^3/h, Efficiency of exhaust systems:

- WW12 - 1000 m^3/h (considering changing facility rooms);
- WW13 – 5000 m^3/h(considering changing facility rooms);
- WW14 – 1000 m^3/h
- WW16 – 1100 m^3/h.

Heat consumption to warm up of plenum air is up to 18^0C is 78 kW.

Negative pressure in semi-serviced and not-serviced rooms of restricted access area is kept due to overpressure valves. Equipment of plenum and exhaust subsystems is provided with 100% reserve. Standby equipment is switched off automatically, if air flow rate reaches the limit values or the working equipment fails.

3.5.9.3 Ventilation system for changing facility rooms – WW03, WW34

Basic diagram is given in picture 3.5.8.

Plenum-exhaust ventilation works continuously. The plenum installation provides clean and considering the regulated outdoor air flow rate under the sanitary norms

Efficiency of plenum installation is 6100 m^3/h, exhaust – 4500m^3/h.

Heat consumption to warm up plenum air up to 18^0C is 82 kW.

Equipment of plenum and exhaust subsystems is provided with 100% reserve. Standby equipment is switched off automatically, if air flow rate reaches the limit values or the working equipment fails.

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3.5.9.4 Ventilation system of free access area – WW21, WW22, WW23, WW24, WW31, WW32, WW33, WW34

Plenum-exhaust systems with mechanical (WW24, WW31, WW32, WW33, WW34) and natural inducement (WW21, WW22, WW23) are foreseen for free access area.

The equipment of plenum (WW24) and exhaust (WW34) subsystems of general ventilation is provided with 100% reserve. Standby equipment is switched off automatically, if air flow rate reaches the limit values or the working equipment fails. Fans of heat point, electrical and compressor rooms are switched on and off automatically depending on indoor air temperature.

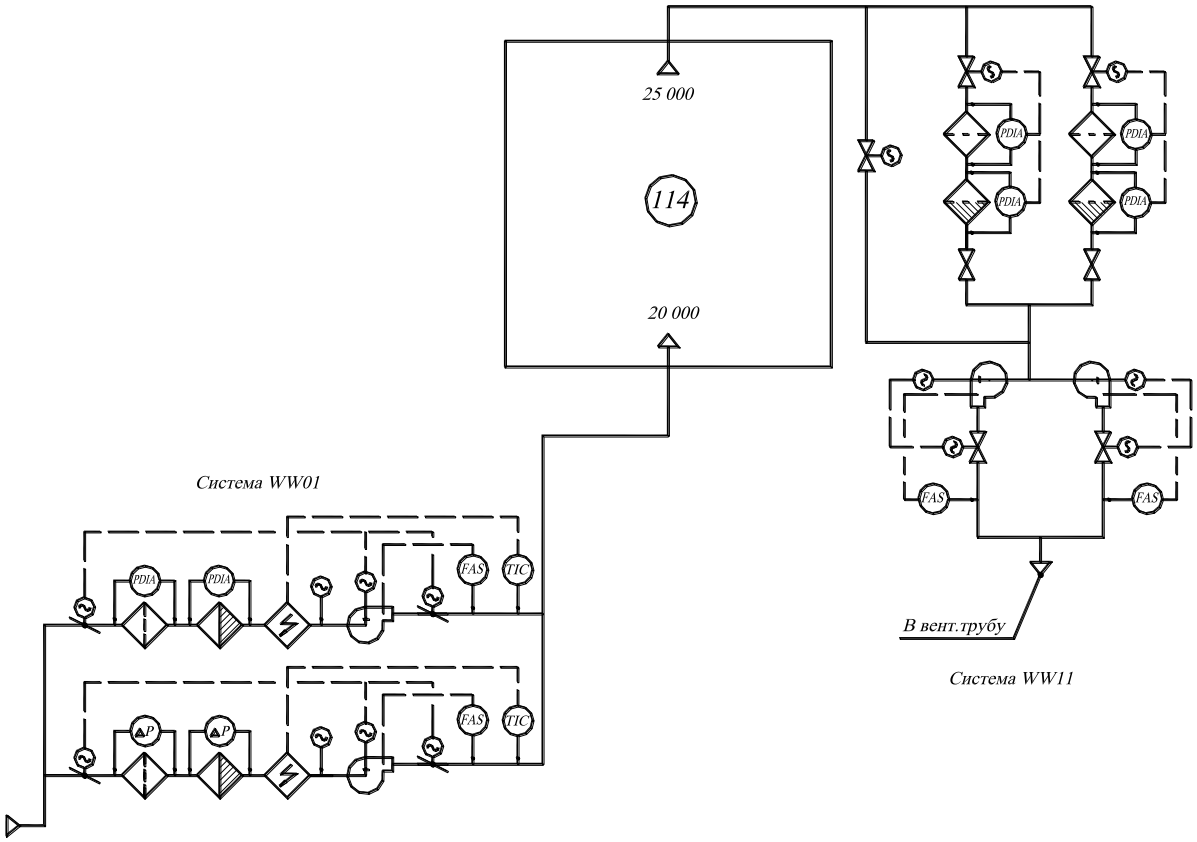

Figure 3.5.6 – Basic diagram of transport and process corridor ventilation system

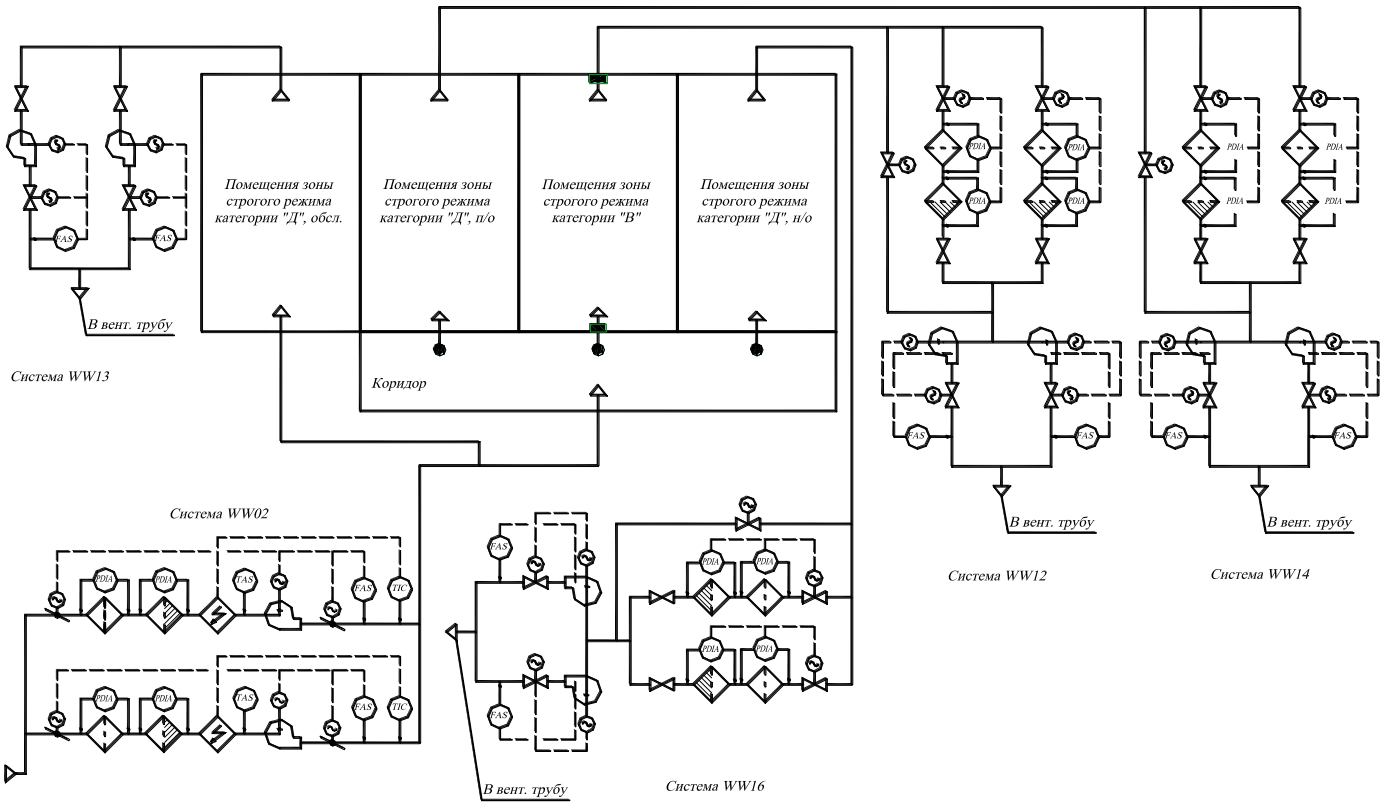

Figure 3.5.7 – Basic diagram of restricted access area ventilation systems

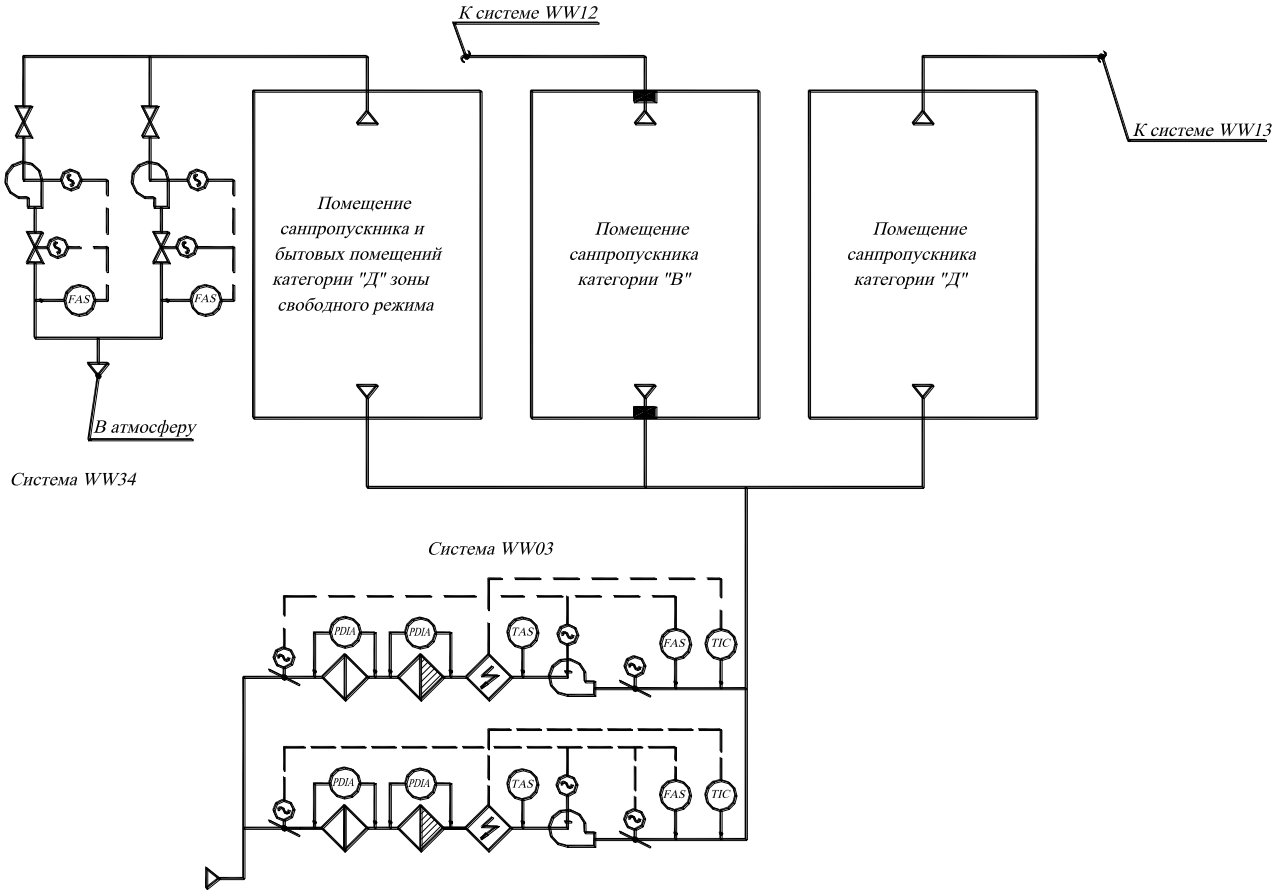

Figure 3.5.8 – Basic diagram of changing facility rooms ventilation system

3.5.10 Fire Safety

3.5.10.1 Basic principles

CSFSF is considered as the object, in which fire can result in release of radioactive agents that will entail the risk of population and personnel irradiation.

In accordance with the requirements of GOST 12.1.004-91[55], CSFSF shall be provided with such fire safety systems as:

- fire prevention system;
- fire protection system;
- organisational and technical measures.

Fire prevention is achieved preventing formation of combustible medium and preventing generation of inflammation source in the combustible medium (or introduction into it).

Preventing combustible medium formation is provided with the help of the following methods combination:

- maximum possible application of non-combustible and poorly combustible agents and materials;
- limitation of mass of combustible agents and materials compactly disposed, placing them by the safest method;
- isolation of combustible medium (availability of fire compartments and sections);
- installation of fire hazardous equipment in isolated rooms (fire compartments and sections);
- installation of chopping off, disconnecting and other devices (including on air ducts of ventilation system).

Prevention of inflammation sources generation in combustible medium is achieved with the help of the following methods combination:

- application of the electrical equipment, which to PUE [68] meets requirements of the equipment type to be used in fire and explosion hazardous areas;
- application of fast-acting means for protective disconnection of inflammation possible sources;
- meeting requirements to electrostatic safety;
- the observance of electrostatic safety requirements;
- arrangement of lighting protection for buildings and facilities.

Limitation of mass of combustible agents and materials, and also the safest method of their placing is achieved by the following methods combination:

- reducing mass of combustible agents being simultaneously in rooms;
- maximum possible replacement of combustible liquids in equipment by non-combustible ones.

Fire protection is achieved by means of the following methods combination:

- application of fire-fighting means and proper types of fire technique;
- application of automatic fire alarm and fire-fighting systems;
- application of non-combustible civil structures and materials with fire danger ratings;
- application of three-dimensional planning solutions and arrangements, limiting fire propagation: dividing building into fire compartments and sections, arrangement of fire barriers, fire-resistant elements in equipment, emergency disconnection of equipment and other;
- providing a timely notification and evacuation of personnel by means of three-dimensional planning solutions and technical means;
- application of people individual and collective protection equipment (personnel, fire departments) from dangerous factors of fire and radiation influence;
- application of technical means of smoke protection (if necessary).

Organisation and technical measures to assure CSFSF fire safety on design stage includes the following:

- verification of arrangement of fire safety system compliance with requirements of construction norms;

- application of the products of fire prevention function with available technical documentation and certified in the order set in Ukraine;
- regulation of personnel quantity on the object based on safety conditions in case of fire taking into account nuclear and radiation safety.

3.5.10.2 Fire prevention solutions on general layout

Standardised distances between CSFSF buildings and facilities depending on their fire-resistance degree and category of fire-and-explosion hazard and fire hazard, and also at design of vehicles access routes were observed.

At design of access routes to buildings and facilities an access for fire engines is provided, as well as the requirements to setting distance from border stone of motor roads to buildings and facilities are observed. Distances from site railways to main building and area of modules are accepted taking into account requirements of item 3.52, SNiP II-89-80 [56]. Firehouse for two vehicles is available on the territory of complex "Vector" at 1-km distance from CSFSF site.

3.5.10.3 Fire safety of electric installations

All CSFSF cables are foreseen to be of fire non-propagating type.

At design of cable routes and cables placing on one cable structure (shelf, tray, bottom of a cable duct, etc.) the recommendations as for non-admission the situation when a total volume of polymeric combustible mass being a part of insulation and cable sheathing exceeds 7,0 l per running meter of the route.

If at CSFSF design preparation based on reasons of arrangement and structural solutions the total volume of polymeric combustible mass of cables placed on one cable structure will be 7,0 l per running meter of the cable route and more, it will be necessary to foresee a fireproof cover for these cables.

3.5.10.4 Power supply of fire protection system

Total power consumed with mechanisms of automatic fire alarm system and fire automatics is 5,5 kW, and fire water supply pump station is 55 kW.

Power supply of consumers of fire protection systems is foreseen in accordance with categories to PUE [68]:

- to category 1 (fire water pump station, mechanisms of automatic fire alarm and fire automatics of automatic fire fighting system and system of rooms notification);
- to a special group of category 1 (mechanisms of automatic fire alarm for transport and process corridor of receiving building, CSFSF central control room and other rooms, where systems and equipment that influence CSFSF nuclear and radiation risk to be placed).

Electrical consumers of category 1 shall be feed from two independent mutually reserving sources of power supply, and pause of their power supply at mains interruption from one source of supply can be assumed only for the time of automatic renewal of power supply.

Among electrical consumers of category 1 a special group of electrical consumers stands out of the other electrical consumers, their uninterruptible operation shall be provided in case of loss of both independent mutually reserving sources; additional feed from the third independent source shall be provided for power supply of this special group.

Power supply of every section of reliable feed shall be performed from two sources:

- from section of 10/0,4-0,23 kW main switch-gear;
- from diesel-generator (the second source).

3.5.10.5 Evacuation lighting

Emergency (evacuation) lighting is foreseen in CSFSF. The networks of evacuation lighting are foreseen along main passages, corridors, and staircases. Also light pointers "Exit" shall be set in all main process rooms, cable rooms. Evacuation lighting shall be performed by means of lamps

with built-in accumulator batteries. Possibility for switch-on of evacuation lighting and pointers "Exit" shall be provided during all the time when working lighting is switched-on.

3.5.10.6 Lighting protection. Grounding

In accordance with RD 34.21.122-87 [69] it is necessary to foresee the complex of measures and arrangements intended to provide safety of people, protection of buildings and facilities from possible explosions, fires and destructions caused with lightning. For protection from the direct shots of lighting the mesh lighting conductors are foreseen on buildings using steel roof and framework.

Separately standing lighting rods are foreseen for outdoor installation of gasoline station for vehicles. Quantity and height of separately standing lighting conductors on containers storage area shall be determined during detail design preparation.

It is necessary to perform external grounding loop with a maximum 4-ohm resistance of earthing device all the year around. Around buildings along the perimeters at a depth of 0,7 m from a ground surface the loop of 40x4-mm steel stripes and vertical electrodes of 12-mm diameter and 5-m length shall be provided. The loops shall be connected with each other minimum in two directions.

3.5.10.7 Ventilation systems

In case of fire a centralised disconnection of ventilation installations servicing the rooms with fire and explosion hazard productions is foreseen. A signal for the ventilation systems disconnection is formed at actuation of automatic fire alarm.

On boundary of the rooms with category B of fire risk the fire retarding valves with remote and manual (in places of their setting) control shall be installed on air ducts of ventilation system.

Removal of gaseous products of combustion after fire suppression in receiving building is foreseen to be realised by means of stationary exhaust ventilation systems with radiation control of removed air. Air release shall be performed into a steel ventilation stack located on the building roof.

3.5.10.8 External fire water pipeline

It is foreseen to provide CSFSF with a fire water pipeline of high pressure that ensures external and internal fire fighting for buildings and facilities, as well as operation of automatic installation for water suppression of fire. The system of fire water pipeline of the area is autonomous.

Design number of fires in accordance with ND shall be one, as the site area is considerably less than 150 ha.

Autonomous system of water fire suppression comprises the following:

- Vessels of fire water reserve;
- Fire pimp house;
- Networks of fire pipeline on the territory with fire hydrants installation;
- Internal fire pipeline.

Two reinforced concrete reservoirs of firewater, capacity of each reservoir is 200 m^3 that shall be a source of fire water supply.

Necessary water flow rates and water heads for demands of internal and external fire fighting, including automatic systems of water fire suppression shall be provided by means of fire pumps installed in separately standing fire pump house. Two pumps (operation one and standby one) with 130 m^3/s capacity and 0,64 MPa head shall be installed in the pump house.

Fire pumps control is foreseen from:

- starting devices of fire cocks;
- starting devices in room of fire pump house;
- automatically from fire alarm in the system of automatic water fire suppression (cable shafts).

External networks of firewater pipeline shall be a circuled ones with dead-end branches towards the buildings where arrangement of internal firewater pipeline is necessary.

Maximum water flow rate for fire fighting is ***36 l/s***, including:

- flow rates (q) for fire fighting in the largest cable shaft of receiving building (sprinkler water fire fighting) q = 16 l/s (at 0,2 l/s per 1 m^2 sprinkler intensity);
- flow rates (q) for fire fighting from internal fire cocks (garage for transporter) q = 5 l/s (2 streams with 2,5 l/s) + 5 l/s = 10 l/s;
- flow rates (q) for fire fighting from fire hydrants q = 10 l/s.

Design water flow rates and water heads for fire fighting of buildings and facilities at CSFSF site are given in Table 3.5.3.

Table 3.5.3 - Design water flow rates and water heads for fire fighting

Name	Water flow rate, l/s		Design time for fire fighting, hour	Volume of water to design time for fire fighting, m^3	Required head, m
	For internal fire fighting	For external fire fighting			
Garage for transporter, fire cocks	5,0 (2 x 2,5) + 5,0 =10,0	10,0	3,0	216	30,0
Garage for 4 vehicles, fire cocks	5,0 (2 x 2,5)	10,0	3,0	162	30
Cable shafts of receiving building	16,0	-	0,16 (10 minutes)	9,6	40÷50
Administration building, fire cocks	2,5	10,0	3,0	135	30

More complete information about providing CSFSF fire safety provision is given in Volume 1 Part 3 of this Feasibility Study.

3.5.11 RAW Management System

Liquid and solid radioactive waste can appear at CSFSF operation. The following two periods of CSFSF operation shall be considered at evaluation of generated RAW amount:

- The first period by duration 45-50 years is a period of active operation, it is assumed to fill a design capacity of the storage;
- The second period by duration 50-55 years is a period of passive operation, only storage of Spent Fuel, observation and control of the storage shall be performed.

Basic principles at design of RAW management systems in CSFSF are as follows: Processing Liquid RAW and Solid RAW in CSFSF is not performed;

- Long term storage of short and medium Level Radwaste in CSFSF is not foreseen;
- Short and medium Level Radwaste shall be transferred for processing and further disposal in ChNPP exclusion zone at existing enterprises on RAW management;
- Means of transport of complex “Vector” and RAW receiving organisation shall be used for RAW removal from CSFSF;
- Containers used in CSFSF are compatible with RAW receiving systems.

3.5.11.1 Sources of RAW generation

Liquid radioactive waste (LRAW)

Potential sources of LRAW generation in CSFSF at a normal operation in the first period can be the water from:

- Areas for decontamination of the equipment contaminated with radioactive agents;
- Decontamination of containers before their transfer to NPP;

- Decontamination of container-car and other transport means;
- Decontamination of controlled access area rooms;
- Control tanks of showers contaminated with radioactive agents, which concentration is higher than admissible of admissible concentration for potable water.

Expected volume of generated low level LRAW is 530 m^3/year.

Potential sources of LRAW generation in CSFSF at a normal operation in the second period are control tanks of showers. Expected volume of low level LRAW is not more than 30 m^3/year.

Solid radioactive waste (SRAW)

Generation of solid radwaste is possible during CSFSF operation in the first period at performing regulated activities on control of radiation environment and also during decontamination and repair of equipment.

The forecast composition of generated SRAW is the following:

- Used materials, spent filters of special ventilation;
- Disabled (used) and non-repairable equipment;
- Used overall, individual protection gears;
- Rags, cleaning material, tampons;
- Construction waste.

The forecast amount of waste at normal operation of the storage will not exceed 64,1-65,1 m^3/year of low level SRAW. Generation of high level SRAW at CSFSF normal operation is not foreseen.

At CSFSF operation in the second period the forecast amount of SRAW connected with stuff presence in ChNPP exclusion zone is 7,2 m^3/year. To such waste belong spent individual protection gears.

3.5.11.2 RAW management

LRAW management

LRAW management in CSFSFD foresees collection, control and transfer for processing facilities in ChNPP exclusion zone. It is assumed to realise transfer of LRAW for processing by means of complex “Vector” rented tank-truck.

LRAW collection shall be performed with special sewage system and control tanks system of showers.

All the rooms of controlled access area with located equipment, which can be contaminated with radioactive agents, are equipped with traps of special sewage system. The traps of special sewage system are united in one pipeline connected with wastewater sump. The sumps of special sewage system were arranged in rooms of controlled access area at 0,000 level, and drain pumps were installed in these sumps.

Wastewater sump with 10-m^3 capacity is located in transport and process corridor of receiving building. The sump is lined with corrosion resistant steel, and it is foreseen to control LRAW radioactivity in waste water sump prior to transfer it for processing, the control is performed by means of sampling and laboratory analysis in receiving building’s laboratory.

In addition to wastewater, it is foreseen to provide entry-point into the sump for pipeline outgoing from control tanks of shower water, this pipeline shall be used if activity concentration of shower water exceeds admissible concentration.

It is foreseen to install two control tanks with 10 m^3 capacity each. The capacity of every tank is determined with discharges made into domestic sewage system during one working shift. Water discharge from shower water control tanks into sewage pump station (SPS) is foreseen if their activity concentration does not exceed admissible concentration. Discharge into SPS shall be performed in head pressure mode by means of control tanks pump.

SRAW management

Low and medium level solid radwaste management is a complex of process operations, which comprise the following:

- Collection in places of its generation, dosimetry control and primary packaging (plastic sacks);
- Delivery of SRAW primary packages to SRAW area in receiving building (place of installation of HI-Star transport container for SRAW) and loading into the transport container;
- Dosimetry control of container's external surfaces;
- Decontamination of external surfaces (laying of fixing coverage) if necessary;
- Temporary storage of SRAW containers at the area of SRAW;
- Loading on means of transport and transportation to the place of its subsequent management.

Area for location of the transport containers is in receiving building in transport and process corridor. The area is designated with marking on the floor and equipped with a sensor of gamma irradiation dose rate. A container before its transfer is subjected to RMS (dose rate, surface contamination). At availability of contamination that exceed regulated values, such container is subjected to decontamination.

3.5.12 Physical Protection System

Physical protection of CSFSF WWER is aimed to prevent and cease the act of nuclear terrorism, theft or any other illegal withdrawal of spent nuclear fuel and radwaste.

3.5.12.1 Purpose of protection

3.5.12.2 Principles of protective measures

3.5.13 Data on Consumed Resources

3.5.13.1 Occupied area

Main feasibility indices of CSFSF general layout are as follows:

- Area of site territory within hoarding is 11,72 ha;
- Dimensions of site is 644x182 m;
- Dimensions of site batching plant is 105x105m;
- Area of motor road passages and hard standings covering is 40133m^2;
- Area of exclusion zone covering is 23880 m^2;
- Length of site rail ways is 1550 m;
- Building density is 40%.

3.5.13.2 Water consumption

At normal operation a consumption of potable water will be 30,36 m^3/day (19,9 m^3/hour) including:

- 16,86 m^3/day (13,16 m^3/hour) for drinking and domestic water consumption;
- 13,5 m^3/day (6,75 m^3/hour) for process water consumption.

One-time filling of firewater reservoirs shall be performed from the system of fire water supply pipeline IC «Vector» with 15,9 m^3/hour flow rate during 24 hours. Refilling of water reserve will be required after its use for fire fighting.

Rated flow rates of water consumption at active and passive modes of operation are given in table 3.5.4

Table 3.5.4 - Rated flow rates of water consumption

№	Name	Flow rate			Line pressure at CSFSF boundary, m	Note
		m/year	m^3/day	m^3/hour		
Active period of operation						
1	Potable water	4350	30,36	19,9	22,0	
2	Water of non-potable quality (filling of fire reservoirs)	-	382	15,9	10,0	Primary filling and renewal after fire fighting
Passive period of operation						
1	Potable water	2083	8,33	6,75	22,0	
2	Water of non-potable quality (filling of fire reservoirs)	-	382	15,9	10,0	Primary filling and renewal after fire fighting

3.5.13.3 Consumption of electricity

A total consumption of electricity for active period of CSFSF operation is 4073 kW, including consumption for the following demands:

- Technological process to be 730 kW;
- Heating, ventilation and air conditioning to be 2833 kW;
- Lighting to be 190 kW;
- Communication, industrial television, physical protection, radiation monitoring to be 64,5 kW;
- Auxiliary facilities to be 255 kW.

In passive period of operation it is necessary to provide power supply of practically all electrical consumers listed above, except for properly technological process consumers, batching plant and equipment related to containers preparation. Besides, in passive period the amount of attending personnel will be less, therefore, it is possible not to heat a part of rooms and facilities or to heat partially. Hence, forecasted power consumption in passive period of operation will not exceed 55 % of consumption in active period and will be 2253 kW.

3.5.14 Data on Discharges and Releases

3.5.14.1 Waste water discharge

Wastewater discharge into environment at a normal operation in active and passive period is not foreseen.

Discharge of domestic wastewater, industrial wastewater and rainwater sewage system is assumed to carry out towards treatment facilities of complex “Vector”.

It is assumed to carry out LRAW removal by means of tank-trucks towards treatment facilities in exclusion zone as LRAW relates to low level short living RAW. The treatment facilities are located in ChNPP exclusion zone to which also relates ChNPP territory. Finally the point of LRAW receival will be defined after project elaboration and its approval by means of receiving technical specifications. The following processing facilities are available in exclusion zone: at ChNPP, SP “Complex”. Radionuclide composition CSFSF wastewater will be almost the same as the radionuclide composition of contamination in exclusion zone. Rated flow rates of water drain at active and passive modes of operation are given in table 3.5.5.

Table 3.5.5 - Rated flow rates of water drain

№	Name	Flow rate			Line pressure at the ISF boundary, m	Note
		m^3/year	m^3/day	m^3/hour		
Active period of operation						
1	Domestic waste water	3675	14,7	11,06	20,0	
2	Contaminated rain water and washing water	9354	74	10	20,0	
3	Non-contaminated rain water	87606	936	30	20,0	
4	LRAW	530	1,8	-	-	Removal in tank-truck
Passive period of operation						
1	Domestic waste water	1543	6,17	4,65	20,0	
2	Contaminated rain water and washing water	9354	74	10	20,0	
3	Non-contaminated rain water	87606	936	30	20,0	
4	LRAW	30	-	-	-	Removal in tank-truck

3.5.14.2 Releases into atmosphere

It is assumed to realise CSFSF controlled releases from a high-altitude ventilation stack of receiving building.

Total volume of released air at a normal operation in active period is 33300 m^3/hour. Air of ventilation systems of the transport and process corridor and the air of restricted access area rooms of receiving building shall be released through the ventilation stack.

Taking into account that in conditions of the storage normal operation a radioactive emission directly from container is impossible, it means that radioactive agents release into environment is expected only when dust from MPC contaminated external surface will rise into the air. Dust can rise into the air in the following events:

- at MPC transfer from HI-STAR transportation overpack into HI-STORM storage overpack and subsequent radioactive release through the ventilation stack (21-m height) of storage receiving building;
- directly in the process of MPC storage in HI-STORM storage overpack at the area for storage (releases through upper ventilation apertures of HI-STORM storage overpack).

Furthermore, at evaluation of release an additional surface contamination of railway car with HI-STAR, caused by passage through a contaminated territory of exclusion and mandatory resettlement zone was considered.

Release from receiving building

At calculations of release during normal operation it was accepted that surface of MPC delivered for storage in CSFSF contains a maximum permissible contamination, which fully penetrates into environment. A maximum permissible residual radioactive contamination of external surface of the MPC prepared to be transferred for storage shall not exceed $3,7 \bullet 10^6$ Bq/cm^2 for β-emitters and $3,7 \bullet 10^5$ Bq/cm^2 for ά-emitters.

The most likely that a radionuclide composition of MPC surface contamination will consist of SFA structural elements' corrosion products, namely: ^{51}Cr, ^{54}Mn, ^{55,59}Fe, ^{58,60}Co and ^{65}Zn situated in aquatic environment of fuel cooling pool located near reactor. At calculation of individual effective equivalent radiation dose caused with releases during CSFSF normal operation it was conservatively assumed that a radionuclide composition of MPC surface contamination includes solely ^{60}Co, which has the highest dose coefficient and half-life (5,27 years).

At the calculation of CSFSF radiation influences on environment at normal operation, the following input data were taken:

- quantity of railway cars with HI-STAR, received during year is 15 pcs.;
- total surface ^{137}Cs contamination of all the railway cars after their passage through the territory of Exclusion and mandatory resettlement zone, conservatively is 190 Bq;
- a maximum permissible ^{60}Co contamination of MPC-31 surface is 1,13 MBq;
- a maximum permissible ^{60}Co contamination of MPC-85 surface is 0,86 MBq;
- dose coefficient of ^{60}Co radionuclide is $1{,}02 \cdot 10^{-8}$ Sv/Bq;
- height of release point (ventilation stack of receiving building) is 21 m;
- velocity of release is 6,95 m^3/s;
- category of atmospheric stability (to Pascal), conservatively is D;
- average wind velocity is 2,1 m/s;
- duration of the release is a short-term.

At consideration of additional surface contamination of the railway car with HI-STAR, caused by passage through contaminated territory of Exclusion and mandatory resettlement zone, it was a conservative assumption that all ^{137}Cs (main dose-generating radionuclide) surface contamination of railway car is released into environment through ventilation stack of receiving building in CSFSF WWER. At calculations of railway car contamination it was accepted the following:

- area of external surface of the railway car with HI-STAR is 90 m^2;
- time of movement at the territory of Exclusion and mandatory resettlement zone is 1 hour;
- maximum intensity of ^{137}Cs precipitation form atmosphere (in the most contaminated places of pathway) is 3,4 Bq/(m^2•day).

To evaluation of release during year and acceptance that all MPCs entering during year do not contain a surface contamination that exceeds the admissible one, than taking into account a maximum possible amount of SF annually entering into storage, in active period of CSFSF operation (filling), radioactive aerosols release into environment will not exceed 16,1 MBq/year of ^{60}Co or 44 kBq/day of ^{60}Co and 190 Bq/year of ^{137}Cs.

Release from containers' storage area

Radioactive particles release from HI-STORM is possible due to contamination of MPC external surface, what will result in radioactive aerosols generation and penetration into environment.

At evaluation of release during CSFSF normal operation it was conservatively assumed that MPC containers entering for storage contain a maximum admissible level of contamination of external surface and that after HI-STORM placing in storage area all surface contamination of MPC penetrates into environment during one year.

At evaluation of release into environment during SF storage in HI-STORM the following input data were taken:

- maximum admissible ^{60}Co contamination of MPC-31 surface with is equal to 1,13 MBq;
- maximum admissible ^{60}Co contamination of MPC-85 surface with is equal to 0,86 MBq;
- quantity of HI-STORM 100 with MPC-31, placed during one year is 12 pcs.;
- quantity of HI-STORM 100 with MPC-85, placed during one year is 3 pcs.;
- height of release point (height of HI-STORM 100) is 6 m;
- atmospheric stability (to Pascal) is category D;
- wind of a constant direction, average velocity is 2,1 m/s;
- dose coefficient of ^{60}Co radionuclide is $1{,}02 \cdot 10^{-8}$ Sv/Bq;
- duration of release is 1 year.

At evaluation of release during year and acceptance that all MPCs entering during one year do not contain a surface contamination, which exceeds the admissible one, then taking into account

a maximum admissible amount of SF annually entering the storage in CSFSF active period of operation (filling), radioactive aerosols' release into environment will not exceed 16,1 MBq/year of ^{60}Co or 44 kBq/day of ^{60}Co.

3.5.14.3 RAW transfer

At normal operation of CSFSF in active period it is assumed to transfer:

- 65,1 m^3 of low level SRAW per year for processing and further disposal with intensity not less than 25 trips per year;
- 4,08 m^3 of IPE for decontamination into a special washing house shall be 1 time per seven working days (36 trips per year to a special washing house and back).

SRAW removal to be performed with the car equipped with 3-m^3 capacity transportation overpack. A special car shall be rented either at Complex "Vector" or ChNPP.

At normal operation of CSFSF in a passive period it is assumed to transfer:

- 7,2 m^3/year of low level SRAW for processing and further disposal with intensity not less than 3 trips per year;
- 1,72 m^3 of IPE for decontamination into a special washing house shall be 1 time per seven working days (36 trips per year to a special washing house and back).

3.5.15 Data on Levels of Non-Radiation Influence

Among factors of CSFSF non-radiation influence on environment the following influences were considered:

- chemical influence;
- ultrasound;
- noise;
- vibration;
- electromagnetic waves.

Available data on technology, used equipment of auxiliary and supporting systems enable to make the following preliminary conclusions:

- chemical influences at CSFSF normal operation is not available as harmful chemical and toxic agents are used in operation process;
- at this stage the data on levels of ultrasound, vibration and electromagnetic waves is not available. At the following design stages the data on above mentioned sources will be specified;
- levels of noise, source of which are ventilation, compressor and pump equipment in accordance with ND requirements to industrial safety shall meet the requirements to conditions of personnel work. It allows making preliminary conclusions that if noise levels meet requirements to conditions of personnel work, the noise levels will not exceed normative levels for personnel and population beyond the site.

Aiming noise localisation in source of its generation, the following technical measures are foreseen:

- centrifugal blowers shall be set on vibroisolating bases;
- flexible insertions shall be installed before and after fans;
- fans shall be installed in separate isolated rooms;
- plenum air-ventilation chamber shall be supplied with noise-suppressing sections;
- use of compressor equipment in noiseless mode.

3.6 Arrangement of CSFSF Construction

CSFSF complex comprises the following objects and facilities for construction:

- Administration building;
- Receiving building;
- Technical maintenance building with MPC storage;

- Garage for transporter;
- Garage for four vehicles;
- Pump station of fire water supply;
- Reservoirs of fire water reserve;
- Sewage pump station;
- Collecting tanks of rain waste water;
- Containers storage area;
- Vans service building;
- ACP-1;
- ACP-2;
- Holding and manoeuvring tracks of railway transport;
- Building of electric devices;
- Guard building;
- Gasoline station for vehicles;
- Site networks of water-supply pipeline and sewage system;
- Site networks of water-supply pipeline and sewage system beyond the site;
- Artesian well near water intake of complex "Vector";
- Power supply networks;
- Reconstruction of 110/10 kV "Buriakovka" substation;
- Site motor roads and hard standings;
- Access motor road;
- Access railway branch of 6,7 km length from Shepelichi station to CSFSF site and passing track;
- Site fence equipped with engineering and technical means of physical protection.

Duration of start-up complex construction will be 3 years. Consecutive construction of three stages is foreseen in future, it is assumed to start their construction one-year before completion of the previous stage.

3.6.1 Brief Characteristic of Construction Conditions

Detailed characteristics of CSFSF site is given in Section 2.

Construction site is located in a considerable distance from large towns, in ChNPP exclusion zone near complex "Vector". Area of the territory intended for CSFSF location is 11,72 ha, in western direction it borders with "Vector" site, in eastern directions borders with 110 kV HVL, from the south it is limited with access motor road to "Vector" site. The site territory is almost fully occupied with a pine forest. Relief of the territory is quite with minimum scopes of planning works. Absolute levels of the relief are 137,00 –142,00 m. The site is remoted from large waterways of Ukraine. Water table fully eliminates possibility of the territory underflooding. Seismisity of the site is 6 points (maximum design earthquake). Average expose dose rate is taken based on SSE "Technocentr" data defined during design of complex "Vector" and is equal to 62 μR/hour (at 1,0-m height above ground surface). The construction site is practically undeveloped. Construction area has a developed network of motor roads with a hard pavement.

To provide the construction site with transport communications, it will be necessary to build two sections of access motor road to the construction site with a total length equal to 895 m from existing motor road to the object "Vector" and from the motor road that leads to Chistogalovka village.

Provision of construction site with water is foreseen from water supply networks of complex "Vector". It is foreseen to use treatment facilities of complex "Vector" to discharge waste water out of the site.

During operation period the external power supply of CSFSF object shall be realised from 10,5 kV switch-gear of the existing 110/10 kV substation "Buriakovka" located at 1-km distance from the designed site in south-east direction. During construction period it is foreseen to realise

power supply using one of six designed cable lines intended for CSFSF power supply during operation period. At the same time 10/0,4-0,23 kV Complete transformer substation with one 1600 kV*A power transformer to be installed on the construction site.

As construction site is located in 30-km exclusion zone inappropriate for people permanent stay, the construction to be performed by means of shift teams with their secondment to Chernobyl, as well as involving inhabitants of Slavutich. Duration of one shift is 15 days. Delivery of workers to the site and back shall be performed by means of two rented buses along such two routes as:

- Chernobyl - CSFSF site;
- station Semikhody - CSFSF site.

It is assumed to provide personal services for civil engineers and operating personal to change clothes into overalls. It is foreseen to provide medical service in a first-aid post located within complex "Vector" territory.

Nutrition of workers shall be provided in canteen located in administration and domestic building of complex "Vector".

To arrange construction works, it was foreseen to build the area of temporary civil structures (construction base), which shall be located from south-east side of the site fence near Main building.

Area of the construction base is 2,31 ha.

As batching plant of complex "Vector" can not satisfy concrete demands for CSFSF construction, it will be necessary to build batching plant on two sections of 30 m^3/hour capacity, which will be located within construction base territory.

Prior to start construction it will be necessary to prepare territory of construction site and construction base of a total area equal to 14,03 ha (11,72 ha+2,31 ha) which includes the following:

- forest cutting - 18,2 ha (taking into account access roads and vehicles parking places);
- skidding;
- stumping;
- planning works;
- territory fencing with ACP arrangement.

Cut forest and soil removed from the site territory during preparation of the territory can be treated as RAW. Forecast quantity of contaminated soil will be 91,0 thous. m^3.

A part of designed access railway runs on the territory of "western" direction radioactive releases. At its construction arises necessity to dispose RAW, generated at change of "contaminated" soil. It as assumed that RAW will amount up to 50,0 thous. m^3.

To store contaminated soil it will be necessary to provide some territories, which area shall be defined at design stage.

Possibility of crossing for traffics connected with works and construction of another objects during construction is minimised.

3.6.2 The Scope of Main Construction-Assembly Works

The main physical volumes of construction-assembly works are defined by similar projects. The results of calculations on projects are given in summary list of the main construction-assembly works (Appendix B, Volume 1, Part 7).

As far as CSFSF construction is intended to be performed in some stages, a start-up complex is picked out in given scope of works.

The start-up complex includes the site to be constructed for containers storage for three foundation plates for HI-STORM as well as all buildings and structures of CSFSF complex in compliance with the title list.

The bulk of concrete for all complex of storage will make-up 31 thous. m^3.

The bulk of concrete for start-up complex will make-up 17,71 thous. m^3, including 8,71 thous. m^3 for Receiving building.

The total weight of steel structures (for all volume of storage) will make-up 186,72 t in the Construction part.

Physical scopes of construction-assembly works are characterized by the main indices given in the table 3.6.1.

Table 3.6.1 - The scopes of main construction-assembly works

	Name of main scopes of work	Total	Including start-up complex
1	Cutting off useless ground, thous. m^3	91,0	91,0
2	Ground excavation, thous. m^3	159,06	125,72
3	Embankment and back filling up, thous. m^3	112,37	111,76
4	Cast-in-place concrete and reinforced concrete structures, m^3	18217,0	10297,0
5	Prefabricated concrete and steel structures, m^3	4526,0	4526,0
6	Building steel structures, t	176,72	176,72
7	Railway laying, km	8,55	8,55
8	Arrangement of roads and areas, thous. m^2	64,01	41,34

3.6.3 Construction Need for Main Structures, Articles and Materials

Construction need for main structures, articles and materials are defined based on physical volumes of works and data given above in table 3.6.2.

Table 3.6.2 - Construction need for main structures, articles and materials

	Name of main structures and materials	Total	Including start-up complex
1	Prefabricated concrete and reinforced concrete structures, m^3	4526,0	4526,0
2	Ready mixed concrete, thous. m^3	31,06	17,71
3	Building steel structures, t	186,72	186,72
4	Cement, thous. t	10,9	6,3
5	Broken brick, thous. m^3	50,9	30,7
6	Sand, thous. m^3	23,5	14,6
7	Reinforcement, thous. t	2,3	1,3

Summary list of needs for the main building structures, articles and materials especially for object construction are given in Appendix C of Volume 1, Part 7.

It is planned to deliver main building materials from the following places listed below:

- Crushed stone - from Korosten, the distance is 110 km;
- Sand - from Chernobyl;
- Prefabricated reinforced concrete will be supplied from building-industry plants;
- Steel structures, rolled steel, reinforcement - from Kyiv, KZEK plant and metal base;
- Cement - from Kamenets-Podolsk plant, Zdolbunov CSHZ.

Concrete plant construction is envisaged for receiving ready mixed concrete of required quality in amount 30 m^3 per hour.

3.6.4 Decisions on Organisation of Construction for Preparatory Period

Works of preparatory period of construction are divided into three stages. The first stage is provided for executing the following work:

- construction to be provided with transport connections. For this purpose the temporary roads would be installed to provide access to construction site on the "spot" of design roads (covered with broken brick) of general extent equal to 895 m.

The second stage is provided for executing the following work:

- preparation of site for CSFSF and construction base providing for:
  - forest cutting down, stumps uprooting with taking out for appropriate disposal;
  - levelling works on 14,03 hectares territory;
- providing with power resources and water at construction site, i. e.;
  - laying and connection of design power network from 10,5 kV switch-gear of the existing substation 110/10 kV "Buriakovra" located in 1,0-km distance from construction site to south-east direction;

- laying and connection of design permanent water lines and sewerage from Complex "Vector" to construction site;

- installation of reservoirs for water store with view to use for fire suppression, that is foreseen in CSFSF constructions. The primary installation of reservoirs for water store to be used in case of fire (for fire suppression) as well as fire pump station to cover all needs for water to be used on construction site.

The third stage provides for the following works:

- arrangement of external fencing of 2,5 m height made of reinforced concrete structures and ACP;
- arrangement of temporary on-site roads to be made in compliance with diagram of permanent roads covered with broken brick;
- laying and connection of temporary engineering services to permanent design networks;
- creation of site for temporary buildings and structures (construction base).

The site for placing structures required for construction base of 2,31 hectares area joins to the site of main CSFSF structures from the of CDF "Vector" side. The following buildings and structures are supposed to be located on this site:

- batching plant of 2 sections, 30 m^3/hour output with storehouse of cement, inert materials and auxiliary structures;
- reinforcement shop with 800 t/year output;
- construction laboratory;
- block of work shops (electrical, chemical and mechanical);
- stock-room of equipment;
- outdoor storage of equipment and materials;
- central material storehouse;
- department of chief mechanic;
- platform of heavy mechanisms and building equipment;
- office;
- foremen rooms;
- every day rooms for construction-assembly staff.

External fencing of construction base territory made of reinforce concrete structure of full filling and 2,5-m height.

On-site roads of construction base are performed with covering of precast reinforced concrete road slabs. Two exits (entrances) are provided for construction base.

For a period of preparatory works carrying out it is possible to obtain ready mixed concrete on the main site and on area of temporary structures from "Vector" concrete plant installed for construction.

Inventory buildings and structures will be used as temporary structures on the site. Expected location of temporary buildings and structures is shown on drawing of general layout (Appendix D, Volume 1, Part 7).

Works of preparatory period are supposed to be carried out by two streams:

- the first stream includes, as follows:
  - arrangement of access road with coating of broken brick;
  - forest cutting down, stump uprooting;
  - replacement of unsuitable ground;
  - construction site fencing;
  - construction of fire water storing reservoirs;
  - laying of temporary on-site roads;
  - arrangement of construction base;
  - laying of temporary on-site water supply lines as well as sewerage, power supply lines and connection to design off-site existing services.

The second stream includes laying of permanent design off-site water main, sewerage, power supply and connection to existing services.

All works are performed by means of mobile cranes, which will be used while creating the objects of the main period.

It is accepted that duration of preparatory period will make up 6 months without taking into account construction of access railway branch of 6,7-km length.

Construction of access railway branch may be started considerably earlier of preparatory works. Actual terms of its construction may be defined on the following design stages. In any case its construction should be completed up to spent nuclear wastes receiving in CFSF.

3.6.5 Decisions on Organisation of Start up Complex Construction

Works of the main period will be start after completion of preparatory period works.

The complex construction is supposed to be carried out by six parallel streams:

- the first stream provides for consequent construction of the following buildings and structures:

  - receiving building by means of tower crane КВ-503 А.1 and crawler (mounted) crane DEK-251;
  - maintenance building with multipurpose canister (MSC) store by means of crawler crane DEK-251;
  - ACP building by means of mobile crane of appropriate load carrying capacity available on site;

- the second stream provides for consequent construction of the following buildings and structures:

  - administration building with Civil Defence (CD) by means of tower crane КБ-306. This building is particular, because the shelter situated under administration building should be constructed at - 4,950 m level. CD construction will be performed by means of crawler cranes of DEK-50 type;
  - electrical buildings will be constructed by means of crane with pneumatic wheels, type КС-5363А;

- the third stream provides for:

  - arrange cast-in-place reinforced concrete foundation plates of start-up complex and railways for conveyer by means of concrete pump of "SANY" NVT 60 C-1413D type;
  - perform fencing of the first stage with physical protection;

- the fourth stream provides for construction of tracks for standing railway transport and building for vans service, ACP-2 during all main period;

- the fifth stream provides for construction of the rest buildings and structures of SFSF, WWER:

  - sewage pump station;
  - garage for transporter;
  - garage for 4 motor cars;
  - building for guard;
  - reservoirs for rain water;
  - gasoline station;
  - internal fencing of the site equipped with the features of physical protection.

The fifth stream works will be carried out by means of mobile cranes with load carrying capacity equal to 10,0-25,0 t. Besides, the works on arrangement of on-site services and motor roads as well as completion of access motor roads construction (arrangement of asphalt – concrete pavement) will be performed.

- the sixth stream provides for construction of 6,4-km length access railway from Shepelichi station to Centralized Spent Fuel Storage Facility and 300-m length passing track on the territory of Shepelichi station. Works will be performed from Shepelichi

station in direction to construction site. Laying of railway elements will be performed by means of KDE-161 type crane. Works may be begun simultaneously with preliminary period works and shall be completed by the start of start-up complex commissioning. The sequence of construction may be changes during development of design for organisation of construction to be performed at stage of design. The site opportunities permit to realise any sequence of construction depending on available of technical means and labour resources of Contractor.

3.6.6 Decisions on Organisation of Construction on Subsequent Stages

After start-up complex commissioning the temporary structures of construction base will be partially dismantled.

Commissioning of subsequent stages (three stages of expansion, i.e. 4 foundations) is supposed to be performed one year prior the previous stage completion.

Works of every stage include the following:

- construction of 4 foundations with arrangement of roads around them for transporter movement;
- expansion of mesh fence for modules area;
- laying and connection of design utility lines.
- Preparatory works provide for:
- installation of temporary buildings;
- arrangement of temporary utility lines with connection to existing lines of start-up complex;
- arrangement of temporary roads and areas for storing with broken brick fill.

Maximum need for concrete will make up 80 m^3/day (during uninterrupted concreting of foundation plate). Concrete will be supplied with the batching plant discussed in the present Feasibility Study. Reinforcement and steel structures are supposed to be supplied by analogy with supply for a period of start-up complex construction.

3.6.7 Duration of Construction. Need for Construction-Assembly Staff

The overall period of start-up complex construction consists of duration of preparatory and main periods.

It is assessed that duration of preparatory period works execution will be 6,0 months, out of which 4,5 months will be a period of carrying out the most labour-intensive area of work (laying of off-site utility lines of 5-km length) considering the factor minus 1,3 for performing of special works on preparing construction territory (forest management)

Duration of carrying out works for main period of CSFSF start-up complex will make up 30 months. Duration is defined based on the sum of the period for construction of the most labour-intensive buildings and structures to be performed subsequently and which relate to the first construction stream (receiving building, maintenance building with MPC storage, ACP-1).

The overall duration of CSFSF start-up complex construction will make up 36 months or 3 years.

To determine required quantity of construction-assembly staff, the output for one worker out of construction-assembly personnel at the stage of Feasibility Study was taken in current prices, i.e., 150,0 thousand of UAH per year. Thus, labour-expenditures for construction of start-up complex will make up 228740 man-days.

If a period of construction is 3 years, an average annual need for workers of construction personnel will make up 212 persons. Priority of construction-assembly works carrying out and costs-distribution of construction-assembly works is shown in work progress schedule (Appendix A, Volume 1, Part 7). Maximum quantity of construction-assembly staff is determined based on work progress schedule for the third peak quarter of the second year of construction and made up 246 persons.

Quantity of required temporary amenity rooms will make up 22 pieces, dimensions 3,0×12 m.

Since construction site is in 30-km exclusion zone, which is unsuitable for permanent stay of people, construction will be carried out by shift method with secondment of people to Chernobyl and everyday workers delivery to work places and back by transport means (2 buses LAZ699N).

Duration of one shift makes up 15 days.

Labour expenditures for construction of the following stage will make up:

- for the 1-st stage - 43200 man-days;
- for the 2-nd stage - 43200 man-days;
- for the 3-d stage - 38218 man-days.

As for the subsequent stages of design, duration of construction may be specified (reduced) according to agreement with Contractor at the expense of increase of construction-assembly staff on construction site.

3.6.8 Method of Construction and Assembly Works Performance

Erection of buildings and structures foreseen by FS will be carried out by means of usual, traditional well-known methods.

Methods of construction and assembly works performance listed below will be specified in course of Work Execution Plan realisation at design stage.

For materials delivery it is supposed to use:

- dump-trucks KAMAZ-5511 (load carrying capacity is 10 t), ZIL MMZ-555 (load carrying capacity is 4,5 t);
- vehicles borne KAMAZ-4310 (load carrying capacity is 4,5 t), KRAZ-257 (load carrying capacity is 12 t);
- truck tractor KRAZ-258 (load carrying capacity is 30 t) and trailer ChMZAP-5523 (load carrying capacity is 20,250 t);
- truck tractor KZKT-537L and trailer ChMZAP-8397-010 (load carrying capacity is 125,0 t);
- mixer trucks SB-92 (volume of ready batch is 4,0 m^3).
- Warehousing and assembly of equipment is foreseen on erection decks of construction base.

In order to perform wiring and I & C works, wiring shop, warehouses, yards are provided for the construction base.

3.6.8.1 Arrangement of roads and areas

Arrangement of trench in earth under roads is performed by means of autograder DZ-143, DZ-122A and DZ-180. Subgrade support compacting to the density of set value will be realised by means of ground rolling with many-times passing of bulldozer DZ-34S and in addition with vibrating rammers. Receiving of broken brick with levelling is performed by means of bulldozer and final levelling will be carried out with autograder. Broken brick base compacting as well as asphalt-concrete pavement is produced first with light rollers and then with heavy rollers and when arranging side-walks the roller BV-76 will be used. Works will be executed from edges to middle with multiple passing along one trace with overlapping of the trace by 1/3 of roll's width. The base treatment with bitumen is performed by means of paver. Placement of asphalt-concrete mixture is produced by means of asphalt pavers DS-143 and DS-195. Methods of executing cement concrete and reinforced concrete pavement of roads are presented in Section 3.6.8.4.

3.6.8.2 Arrangement of railway track

Levelling of sub-grade for route of railway branch is performed by means of autograder DZ-122A. Ground cutting off or filling shall be produced, if necessary.

Density of sub-grade of set value will be reached by means of ground rolling with multiple passing of bulldozer DZ-42 and in addition with vibrating tampers.

By means of locomotive crane KDE-161 of load-carrying capacity 16 t the placement of track elements is produced along the route with consecutive assembly of sleeper and rail grid over a length of the route.

Delivery of crushed stone to fill railway will be carried out by means of hopperbatcher. Delivery of crushed stone to the place of loading is produced with dump-trucks KAMAZ-5511.

After fill with crushed stone the railway track is subjected to ballasting, alignment to set levels and rolling by means of manoeuvre diesel locomotive in some transits.

Prior to the track commissioning, it will be necessary to cover track with crushed stone and to finish the track (adjusting of transverse section of track strictly to set geometric dimensions).

Conditions for hardening of placed concrete and its protection from shrinkage shall be provided by means of its covering or watering not later than 10-12 hours after completion of the concreting.

3.6.8.3 Earth excavation work

Stumpers shall be used to clean the territory from forest, bushes and stumps.

The site levelling and earth excavation works are foreseen to be executed by means of bulldozers of traction class 30-250 kN, buck scrapers with buckets of 7,0 m^3 capacity, excavators with bucket of 0,25 m^3 - 1,0 m^3 capacity, trailed rollers of 12,5t - 20 t mass, hung up compactors of 1,3 t mass or other analogous machines and mechanisms available to Contractor.

Earth excavation under foundations of buildings, structures and trenches is foreseen to be executed by means of excavator with loading on motor-cars and useless clean earth transportation to dump. Polluted earth will be delivered to special areas. Back fill of pits will be produced with sandy sole delivered from the open pit. Trailed rollers of 25 t mass and vibrating tampers shall be applied to back fill foundations cavities and earth compaction.

3.6.8.4 Concrete and reinforced concrete work

Meeting the needs for ready mixed concrete is provided with batching plant foreseen in this FS. The output of this plant is 30 m^3/hour. It is situated on construction base. Delivery of mixed concrete to points of its placement is provided by transport means of construction.

Concrete delivery for concrete bed is intended to be provided with unloading of mixed concrete from dumptrucks body or concrete mixer truck.

Concrete delivery and its placement will be executed by means of buckets of 0,5-2,0 m^3 capacity, crawler and tower cranes as well as mixer truck pumps of "SANY" HBT60 C-1413D type, output 40-65 m^3/hour.

Packing of concrete mixture will be produced by means of vibrator of appropriate type. Reinforced cages and meshes are produced in reinforcement shop located on construction base. Delivery to the place of work performance is carried out by transport means.

3.6.8.5 Assembly of reinforced concrete and steel structures

Reinforced concrete and steel structures of buildings and structures will be delivered to construction site from plants of civil engineering industry by transport means.

Its warehousing may be carried out on open areas of construction base, if necessary. Transport means will deliver the structures to place of assembly. The assembly will be executed by means of mobile cranes of appropriate load-carrying capacity. Some reinforced concrete elements and reinforced structures will be arranged in assembly zones of cranes.

3.6.9 Power Resources and Water Provision for Construction Demand

Summary demand for electrical power for construction site will make up 705 kW. Temporary site electric power supply will be provided from design stationary power network from 10,5 kV switch-gear of existing 110/10 kV substation "Buriakovka" located in 1,0-km distance from the construction site in South-Eastern direction. For a period of construction one line out of

6 design cable lines is intended to be used for CSFSF power supply for a period of operation. In this case, 10/04-023 kV CTS with one 1600 kV·A transformer shall be installed on the construction site. Demand for electric power supply of consequent construction stages will make up 130 kW.

Demand for water (table 3.6.3) on construction site includes, as follows:

- water flow rate for production needs;
- water flow rate for sanitary needs;
- water flow rate for external fire suppression.

Table 3.6.3 - Demand for water at construction

Kind of user	Water flow rate, l	Quantity of water consumers	Water flow rate per day
1 Excavators	15 l per/h	4 pieces	540
2 Bulldozers	300 l/day	3 pieces	900
3 Trucks	300 l/day	8 pieces	2400
4 Compressors	7 l/ day	3 pieces	190
5 Concrete preparation in concrete mixer	225 l/m^3	150 m^3	33750
6 Watering of concrete and reinforced concrete	200 l/m^3	150 m^3	30000
7 Ground watering at packing and other needs	-	-	5840
TOTAL:	-	-	73620

Summary calculated consumption of water for construction site will make up 23,74 l/s, including:

- production needs - 3,41 l/s;
- sanitary needs - 0,33 l/s;
- external fire suppression - 20 l/s proceeding from the total area of construction site.

Demand for potable water is covered at the expense of water delivery in sealed plastic container (coolers of 18,9 l capacity with disposable glasses) to be installed in inventory amenity rooms for workers.

Construction demand for water for production and every day needs (3,74 l/s) is covered at the expense of connection to permanent water main built in preparatory period to, it is connected to existing main of "Vector" complex in compliance with the design.

Prior to completion of design main construction it is well to make use of fire reservoirs of water store located on CSFSF site. Water supply for on site main will be provided by pumps of fire pump house. Demand for water to be used for external fire suppression will be covered from water store of design fire reservoirs installed in preparatory period.

Water demand for production and every day needs on the next stages of construction will make up 1,0 l/s.

3.6.10 Occupational Health Safety Measures

3.6.10.1 Fire safety

For the purpose of exception of the reasons of a fire occurrence on the construction site it is necessary to observe the specified fire-prevention mode. The fire-prevention mode on territory of construction site is provided with implementation of the following measures:

- normative fire breaks between temporary buildings and structures shall be envisaged at the construction site and construction base areas depending on their fire resistance degree;
- motorways and fire entrances will be routed to all temporary buildings and structures by the moment of their commissioning ;
- smoking will be permitted only in specially allocated place with signatures "Smoking area" which will be equipped with urns for stubs and drums with water;
- at entrance to construction territory, as well as inside of the territory where smoking is prohibited, posters with precautionary inscriptions “Smoke is forbidden” will be installed;
- after a completion of works on the daily basis all the construction waste (scraps of forest products, chips, bark, shavings, sawdust) will be removed from territory of construction site to the places specified as agreed with fire department;
- fire water supply of construction site will be provided taking into account requirements of normative-legal acts;
- all the works related to application of open fire, for example, welding of steel, etc. will be performed only under the written permission of the person responsible for fire safety of given area of construction which is obliged to provide the work places with fire extinguishing means;
- the wires connected to welding devices and welded structures will have reliable isolation, and in necessary places shall be protected against the impact of high temperature and mechanical damages;
- cables with index "NG" will be used for power supply of welding devices and lighting of workplaces;
- the power and lighting wiring, as well as temporary electrical installations for construction will meet the requirements to permanent installations.

The construction site will be equipped with the fire boards containing primary fire extinguishing means. Fire boards will be completed according to the requirements of ND. Work areas will be equipped with powder fire extinguishers.

Constructed buildings, temporary facilities, as well as utility rooms will be provided with primary fire extinguishing means according to ND requirements.

The paint and varnish substances emitting explosive or harmful components will be stored in special non-fragile container or packing. On a workplace paint and varnish substances will be supplied in the volumes which do not exceed need per a shift.

Normative distances up to combustible and inflammable materials (not less than 5,0 m), up to explosive materials and installations – 10,0 m, and up to the welding transformer – not less than 10,0 m will be observed during electrical welding performance.

Requirements to the fire safety, which are not included in the given section, are being developed in the design in details.

3.6.10.2 Measures on maintenance of general industrial safety

The personnel staying at the construction site will be provided with protective helmets and overalls according to the requirements of valid ND.

Operation of cranes and other load-lifting mechanisms, electrical safety of work performance, works with electrical tool, electrical welding shall be carried out according to the requirements of valid ND.

The persons having group 1 on electrical safety are permitted to work with electric tool. Installation and movement of construction machinery and vehicles within the limits of sliding prism of soil is forbidden. Bridges with width not less than 0,7 m having handrail shall be arranged pass to through ditches and trenches. All walkways, railings and precautionary inscriptions will be highlighted at night. Ladders with width not less than 0,75 m with handrail shall be installed for descent of workers in foundation pits and wide trenches.

Excavation of foundation pits and trenches without arrangement of fastenings is supposed to be carried out with slopes. Large quantity of materials or soil is authorised only outside the sliding prism. Regular observation will be carried out over condition of edge. If cracks, shifts or landslips are revealed, any work on given area will be suspended.

In the area of erection, performance of other works and staying of extraneous persons is not foreseen.

All load-handling tools will be preliminary examined, tested by means of load, the results of survey shall be registered in a log-book.

Road-building machines are supposed to be refuelled on horizontal areas at artificial and natural lighting. Smoking, use matches and other sources of open fire is forbidden at refuelling. Maintenance of machines shall be carried out only after their full stop (with switched off engine), thus possibility of their start-up should be excluded.

At bulldozer-levelling and compacting works the staying of the personnel in the area of work performance is forbidden.

At simultaneous or joint operation of several self-propelled machines (rollers, asphalt pavers) going one after another, the distance between them will be regulated (not less than 10 m).

3.7 Normal Operation Failures and Accidents at CSFSF

3.7.1 Emergency Conditions During Construction

In order to assess environmental impact during construction, it is planned to evaluate potential accidents, which may lead to maximum negative consequences. It should be done because during accidents related to construction equipment failure or fall of equipment the consequences will relate more to the construction personnel or local dust released. In such cases measures related to dust suppression practically exclude impact of local dust release to the environment.

The only accident, which may result in significant radiation impact is a forest fire at the first stage of preparatory works (prior to natural growth removal).

It is very often that forest fire occurs on the territory of Chernobyl Exclusion Zone. Based on ChernobylLes press release [58] about 60-100 fires are registered annually and the most of them start from the territories, which are not covered with forests (idle fields). Taking into consideration that preparation of the site for CSFSF construction will include a complex of forestry works related to stand removal from the territory of the construction site and access routes the probability of inflammation of ground litter and dead wood during such activities is rather high.

Fires occurred in such conditions are characterised by a lower type when wood bedding, grass and bushes, fallow land and undergrowth burning is typical. During such the fire radionuclides deposited inside of the woods and underwood and released into the atmosphere with smoke and smut will result in additional contamination of the soils and increase of radionuclide concentration in the surface layer. As the result of this process concentration of radionuclides in underwood ash and release of radioactive aerosols of various dispersity into the air will take place.

The quantitative characteristics and progressive dynamics of forest fires, which have taken place in the Exclusion Zone, are presented in Table 3.7.1.

Table 3.7.1 – Fire dynamics in the Exclusion Zone

Year	Number of fires	Square, hectares	Number of fires based on the beginning location		
			Villages	Forests	Fallow land
1993	66	564.5	5	2	59

1994	100	130.9	8	3	89
1995	116	756.7	12	1	103
1996	79	296.3	36	6	37
1997	83	294.29	23	7	53

Available experimental data presented in Tables 3.7.2 and 3.7.3 were used for input data on fractional content and resource of phytomass resources in afforestation at the CSFSF construction site.

Table 3.7.2 – Phytomass resource

Phytocenosis component	**Scope**		**Boughs**	**Leaves, needle**	**Undergrowth**	
	Wood	**Bark**			**AoL**	**AoF+AoH**
Phytomass resource, t/hectares	111	22	23	4	7	11

Table 3.7.2 presents fractional content and phytomass recourse in 30-40 year old forests growing on the territory of CSFSF construction site (calculated in tones of absolutely dry substance per 1 hectare) [59].

Specific activity value per ^{137}Cs for wood phytocenosis components were identified based on transmission coefficient values presented in [60].

Table 3.7.3 presents content of ^{137}Cs in Scotch pine phytomass components (Bq/kg) given that the density of soil contamination is 160 kBq/m^2, which shall be considered during environmental impact assessment.

Table 3.7.3 – Content of ^{137}Cs in Scotch pine phytomass components, Bq/kg

Scope		**Boughs**	**Leaves, needle**	**Undergrowth**		
Wood	**Wood**			**AoL**	**AoF**	**AoH**
56	111	223	270	170	1700	21800

Value for undergrowth contamination density obtained in [65] based on full-scale experiment results was applied in the subsequent environmental impact assessments. As a result of this work it was revealed that the upper (AoL) and enzymatic (AoF) layers of the undergrowth will be burnt in case of ground fire of 30-40 year old pine phytocenosa. The Humus layer (AoH) of the undergrowth (which contains the main radionuclide concentration inside the undergrowth) will not be affected in case of ground fire and correspondingly the radionuclides, which are deposited in it, will not be involved in the process of second transportation.

Numerous surveys of ground fire prove that after the initial stage during which the spontaneous increase of the site area under the fire, a dynamic balance takes place when the area remains stable in time: new areas equivalent to burnt forest zones appear[66].

For calculations of A radionuclide release into the air the following proportion is applied:

$$A=K_v \cdot k \cdot S \qquad (3.7.1)$$

where K_v=0,1 – coefficient of radionuclide release during wood undergrowth burning;

k – density of wood undergrowth contamination with the radionuclide under consideration (Bq/m^2);

S – burnt zone area (m^2).

Most dangerous are the fires during construction of new railway line from Shepelichi to CSFSF. The route passes through the radioactive track (consequences of the 1986 year accident) which is about 300 m in width (in the zone of railway lines) and which surface contamination levels are 750 kBq/m^2 (^{137}Cs), 400 kBq/m^2 (^{90}Sr) and 8 kBq/m^2 (α-active FUE).

Ground fire propagation rate downwind may range from 0,5 to 3 m/min (the rate is 6-10 times less if it is against the wind). Given that the average region wind velocity is 3,3 m/s at the height of 10 m, the ground fire propagation rate shall be about 0,7 m/min based on the calculation data. It is conservatively accepted that the fire propagation rate is 1 m/min, the wind direction is in the direction of ChNPP and the ignition point is at the axis of the track.

In such a case within 4 hours the forest of total area equal to 72 thousand m^2 will be burnt and it will lead to accumulative release of about $5.4 \cdot 10^{10}$ Bq ^{137}Cs, $2{,}9 \cdot 10^{10}$ Bq ^{90}Sr and $5{,}8 \cdot 10^{8}$ Bq of α – active FUE. In such a case the time *t*, during which complete burn of wood undergrowth takes place up to the dynamic balance condition, will be about 1000 s [66], the area of intensive fire will be about 5 thousand m^2, and the release speed will be about $3{,}8 \cdot 10^{6}$ Bq/s ^{137}Cs, $2{,}0 \cdot 10^{6}$ Bq/s ^{90}Sr and $4{,}0 \cdot 10^{4}$ Bq/s of α – active FUE.

During the fire the increase of volume concentration of radioactive elements in the air, the transmission of activity and exposure of ChNPP personnel and other objects located in the fire impact zone is possible. The specific damage may be caused to the environment as well. That is why the level of impact due to such an accident is evaluated in Section 4 (Volume 3 Part 2) of the current document and there are mitigating and/or preventive measures proposed.

3.7.2 Input Data for CSFSF Operation

Completeness justification of the List of Initial events for Design and Beyond the Design Basis Accidents was performed at the stage of Final Safety Analysis for HI-STORM prepared to obtain the License for the HI-STORM system in compliance with the requirements of American Regulatory Body 10CFR72 in the format of the NUREG-1536 Requirements. The Safety Analysis in accordance with the requirements of NP 306.2.105-2004 for CSFSF shall be performed at the CSFSF Design development stage.

Taking into account that Holteck provided data were applied to describe emergency situations and accidents during CSFSF operation, the List of Terms and Definitions defined abnormal events, design accidents and beyond the design basis accidents used in HI-STORM system SARs required for obtaining license in the USA. Definitions of terms are provided in compliance with the American National Standard (ANS) "Design Criteria for individual storage facilities of spent nuclear fuel (dry type)" ANSI/ANS-57.9-1992.

3.7.2.1 Regular operation conditions violation

This subsection describes abnormal events or potential deviations from regular operation conditions, which are considered while getting the License for the HI-STORM system in the USA. The events under consideration can be both single (reloading works) and repeated during the design operation period of CSFSF. Such events will not lead to break of safety operation margin (e.g., to excess of maximum permissible temperature of FR shell).

Abnormal weather conditions

In accordance with the requirements of 10CFR72 HI-STORM storage overpacks are designed for the environmental temperature rates presented in Table 3.7.4. It is supposed that the lower and upper limits of abnormal temperature rates will be kept for no more than 72 hours.

MPC and HI-STORM calculations for abnormal temperature rates at the CSFSF site shall be performed during the design stage.

For comparison Table 3.7.4 presents the environmental characteristics at the CSFSF site.

Table 3.7.4 – Environmental temperature rates

Condition	**HI-STORM Design Temperature, ^{o}C**	**Environmental temperature rates at the CSFSF site area, ^{o}C**
Normal temperature of the air (annual average)	27	6,7
Normal temperature of the	25	-

Condition	HI-STORM Design Temperature, °C	Environmental temperature rates at the CSFSF site area, °C
soil (annual average)		
Abnormal air temperature (average for 3 days)	From -40 to 38	From –35 to 39
Accidental air temperature extreme (average for 3 days)	52	40

Design temperature rates of HI-STORM components for environment air temperature rates presented in Table 3.7.4, are given in Table 3.7.5.

Table 3.7.5- Design temperature rates for HI-STORM components

HI-STORM 100 components	Extreme temperature rates under the long term storage and normal operation conditions (long term events), ° C	Extreme temperature rates under abnormal and emergency conditions(short term events), ° C
MPC Body	260	413
MPC Basket	385	510
MPC Neutron absorber	427	510
MPC lid	288	413
MPC bottom	204	413
FR shell	400	400 or 570 (short term operations)* 570 (abnormal and emergency conditions)
HI-STORM outer shell	177	316
HI-STORM concrete part	149	177
HI-STORM inner shell	177	204
HI-STORM lid	232	288

* - short-term operations include MPC dehydration and transportation within the site, the extreme temperature rate of 570°C shall be applied to MPC which contains all SFA with the average burnout rate. Extreme temperature value of 400°C shall be applied for MPC containing one or more SFA with higher burnout rate.

Thus, at the design stage it is necessary to prove that the temperature of FR shells shall not exceed 350°C under normal outside air temperature, and the temperature of FR shell shall not exceed 450°C within 72 hours under abnormal outside air temperature. For the objectives of this EIA it is accepted that environmental temperature impact in the area of CSFSF including absolute maximum, will not impact the SFA condition and shall not lead to containment limit violation and consequently it is not possible for the radionuclides to be released to the air.

Partial blockage of MPC basket holes

The design of MPC basket presupposes cells for SFA, which are connected by oval ventilation holes. In accordance with the 10CFR72 requirements the case involving blockage of ventilation holes inside MPC is studied.

The source of material, which may block holes, is considered to be fuel spill due to FR destruction or corrosion of deposit on the FR surface. SFA in MPC shall be kept in inert atmosphere with the temperature of the FR shell lower the permissible values. Consequently a potential mechanism which may have caused significant degradation of FR shell during its storage in MPC shall not be presented. That is why possibility and quantity of potential corrosion deposits and their impact on heat sink between the cells with SFA inside MPC will be considered in the future.

MPC design is developed so that it will resist the decrease of sectional area of the air stream due to partial blockage of ventilation holes of MPC basket. The purpose of performed analysis was

to identify maximum possible thickness of corrosion deposits on the bottom of MPC and compare the thickness of deposits with the size of the holes connecting cells inside the MPC basket. The conservative proposal is that the holes between the cells are semicircular with the diameter, which is less then the diameter of the oval, i.e. the real oval form of the holes was neglected.

Experimental data on potential SFA surface contamination of PWR reactors in the USA were used for assessment of maximum possible quantity of deposits. Based on SFA surface contamination and a cell area for SFA, maximum thickness of contamination deposits on the bottom of MPC shall be 9,1 mm. This value in the future can be considered as extreme value for SFA reactors of WWER type.

The received value of deposit thickness is less than the diameter of the oval hole in the MPC basket so blockage of the hole will not take place and heat sink will not be affected. The performed analysis allows to state that in case of partial blockage of MPC holes the MPC containment barrier will not be affected and consequently release of radioactive materials to the environment will not take place.

Partial blockage of HI-STORM ventilation channels

HI-STORM ventilation channels are closed with close-meshed steel grate turned 90° angularly and they shall be controlled in compliance with the container service regulations. Temperature control is provided at the input and at the output from the channels so it is unlikely that they will be blocked with debris, animal bodies, etc. during normal operation and under failure of normal operation.

Conservatively for assessment of consequences it is accepted that two of four ventilation channels will be totally blocked.

During the analysis of this event air stream models were used for calculation of air temperature in the air annular gap. Blockage of two input holes will decrease the total area of inflow face two times which will lead to increase of leakage k/A^2 (k – hydraulic leakage coefficient, A – area of inflow face) for the inflow face area in four times. However the air stream motion system in HI-STORM is designed so that leakage at the input makes a relatively small part of the total pressure fall. That is why increase of the total sum $\Sigma k/A_i^2$ is about 29%. Due to the above the airflow increases to 9%.

Such combination of factors (one of them increases the pressure fall, the other – decreases it) leads to a total fall of pressure due to decrease of air flow by 8%. Decrease of air flow leads to higher value of temperature drop between input and output holes. As the result the temperature drop increases for about by 10% and the outgoing air stream temperature increases from 73 ^oC (164°F) to 78 ^oC (173 °F). As it is seen from SAR for HI-STORM storage overpack, increase of temperature due to such event is not significant (comparing with normal operation conditions).

The performed analysis allows to state that in case of partial blockage of HI-STORM ventilation channels, MPC containment barriers will not be affected and consequently discharge of radioactive materials to the environment will not take place.

Failures during transport-process operations

HI-STORM storage overpack is designed so that it must withstand the fall down from the height of 28 cm. In such case MPC within the container shall remain undamaged.

It is proposed to perform HI-STORM transportation inside of the CSFSF by caterpillar transporter which design allows for non-excess of regulated HI-STORM lift height above the ground.

HI-STAR used in CSFSF is a transportation container, which shall be designed for the fall down from the height of 9 m without damage to the container inside. In the Receiving building maximum height of HI-STAR transportation overpack lifting is 7m.

Load-lifting equipment designed for seismic loads with higher reliability index is planned to be used to exclude failure of load lifting machinery, transportation equipment and the content of SFA.

The preliminary analysis performed allows to state that failure during transportation-process operations will not lead to release of radioactive materials to the environment.

3.7.2.2 Design accidents

Earthquake

The Receiving building and storage site for the HI-STORM storage overpack being facilities of category 1 in respect of nuclear and radiation safety responsibility to PiN AE 5.6 and category 1 in respect of seismic resistance to PNAEG 5-006-87 they are designed to carry Maximum Design Earthquake (hereafter refer to as MDE) loads (once in 10000 years), for this site the earthquake is equal to 6 points. In accordance with the definition buildings of Seismic Resistance Category 1 to PNAEG 5-006-87 means that the building/facility will maintain its protective and localising functions after the earthquake of 6 points. Thus in case of earthquake up to 6 points inclusive, release of radioactive materials outside of the Receiving building and HI-STORM is not expected. In such a case earthquake shall not be considered as initial event for a design accident.

During HI-STORM 100 system licensing in the USA HI-STORM storage overpack stability analysis was conducted applying seismic loads. The performed analysis of storage overpack's stiffness under seismic load shows that under the impact of horizontal acceleration up to 0,1g (7 points) on HI-STORM and consequent vertical acceleration, it remains a quiescent state given that constant of friction is no less than 0,1, i.e. stiffness of the storage overpack is provided.

Tornado

Receiving building and HI-STORM being facilities of category 1 in respect of nuclear and radiation safety responsibility to PiN AE 5.6 shall be designed with consideration of specific impacts due to tornado which is equal to tornado of class 3 for this site conditions. Considering that the stability of walls in the Receiving building will be designed for load resistance which appear in case of design event, i.e. tornado of class 3, the integrity of external walls of the building will be remained. Thus in case of tornado of class 3 there will be no release of radioactive materials outside the building. In such a case the tornado will not be considered as initial event for a design accident.

Design criteria for HI-STORM (see Table 3.7.7) used for the system licensing calculations in the USA are more strict than the input data for the CSFSF site (see Table 3.7.6).

Potential types of HI-STORM analysed damage due to tornado include the disruption of top part of the storage overpack due to wind load, loss of stability and body damage with flying objects.

HI-STORM 100 system shall resist the pressure, wind load and flying objects appeared during tornado. Design parameters for wind loads and tornado for the HI-STORM system are presented in Table 3.7.7. Fall down of pressure will be limited by design external MPC for emergency conditions.

The List and characteristics of postulated flying objects considered during HI-STORM 100 system licensing are presented in Table 3.7.8.

Table 3.7.6 – Tornado characteristics for CSFSF site area

Condition	Parameter
Maximum speed of cone rotation, V_p (m/s)	81
Tornado progressive motion speed, U_p (m/s)	20,3
Pressure fall down between the center and periphery of tornado cone, ΔPp (gPa)	81

Table 3.7.7 – Tornado characteristics considered for HI-STORM licensing in the USA

Condition	Parameter
Horizontal component of tornado cone rotation motion speed, m/s	130
Object movement speed (m/s)	31
Maximum wind speed (m/s)	160
Pressure fall down between the center and periphery of tornado cone (kPa)	20,7

Table 3.7.8 – Flying objects characteristics

Object description	Weight (kg)	Speed (m/s)
Vehicle	1800	56,3
Solid steel cylinder (20,3cm in diameter)	125	56,3
Sphere (2,54cm in diameter)	0,22	56,3

Impacts of hurricane winds and objects lifted to the air with tornado shall be considered separately and combined in compliance with NUREG - 0800. Tornado characteristics for design calculations were chosen in accordance with the Regulatory Guide1.76 requirements.

As the result of the analysis it has been identified that the tornado force will not be enough to overturn or move a storage overpack because tilting moment is less than restoring moment and coefficient of kinetic friction (for steel and concrete) is more than 0,11.

Calculations of storage overpack's body and lids' resistance to armour-piercer penetration show that the thickness of concrete and steel layer is significant to prevent fragmentation, unglue or splitting of various structural elements of storage overpack functioning as enclosure. General reaction of storage overpacks to shock from disassembled gear with great energy has been assessed. These calculations show that after such events the storage overpack remains in vertical position and the loads due to the shock will not damage storage overpack's integrity.

As long as the postulated loads due to tornado will not be able to lead to storage overpack turnover they will not effect MPC.

Thus tornado is not the initial event of a design accident for HI-STORM. More detailed calculations shall be performed for HI-STORM storage overpack during licensing of this technology in Ukraine.

Lightning stroke

Lightning protection system shall be created for all buildings and facilities including HI-STORM storage overpacks in CSFSF. The system is designed to provide full range protection from lightning stroke.

Lightning will not be considered as initial event for a design accident for the buildings and facilities in which lighting protective system is foreseen.

Strong wind and hurricane

Impact of wind will not exceed impact of tornado. Thus if tornado is not an initial event for a design accident it may be considered that a strong wind will not be an initial event for a design accident either.

Flood

Initial events related to potential CSFSF flooding in case of high water in the Uzh, Sakhan and Pripyat rivers have been simulated as initial event.

Maximum spring flood +110,40 m level (Baltic System) was taken into consideration. It can not impact the CSFSF building and HI-STORM because the planning level of the site is not less than +138,50 m Baltic system.

Thus flood will not be considered as an initial event for a design accident.

Heavy snow

For adjacent buildings and facilities of CSFSF maximum snow load is low in comparison with impact from other loads under consideration.

HI-STORM storage overpack is designed with consideration of snow and glaciation impacts. During the system licensing process in the USA, the data for the continental parts of the USA and Alaska were used to calculate the pressure on HI-STORM due to snow accumulation. Design values of snow pressure for heated facilities (heat from nuclear fuel) such as HI-STORM system varies within the limits of 0,34 –0,48 MPa. Taking into account that Ukraine is located further South than Alaska and maximum snow amount in the CSFSF sit area is 75 cm, it is considered that heavy snow as regards of snow pressure on HI-STORM structures shall not be an initial event for a design accident.

Snowfall impact in respect of HI-STORM ventilation channels blockage is considered within the analysis of complete blockage of ventilation channel.

Strong showers

Absolute daily precipitation maximum registered during the entire survey period in the area of CSFSF was in May, 1983 and it equalled 81 mm. Daily maximum may reach or exceed 100mm with frequency of once in 100 years.

Storm water sewage system is provided on the territory of CSFSF and foreseen to discharge water in case of very strong showers. Thus the CSFSF site area including HI-STORM storage area is protected from flood.

Ventilation holes in HI-STORM are located at the ground level, so in case of abnormal strong showers a partial underflooding of ventilation holes is possible. Taking into account that a storm water sewage system of HI-STORM storage area is provided and water will flow down via slope to rainwater drainages of storm water sewage system, the possibility of ventilation holes flooding is excluded. That is why this event is considered as beyond the design basis accident event due to entire blockage of ventilation hole. SFA are located in tight MPC that is why access of water to SFA is excluded.

Soil shifts of various genesis, land slides

Taking into account soil composition of the CSFSF industrial site, the risk of soil shifts or slides for this area does not exist.

Retrogression of river banks, slopes, river beds

The site is located in the significant distance from river beds that is why such initial events shall not be considered for this site.

Settlements and subsidence of the territory including cases of subsurface erosion

The conditions of the site (water table is more than 20 m from ground level) and solutions to be made during CSFSF buildings and facilities construction (measures to consider settlements and tilts of buildings) exclude such initial event for CSFSF.

Explosion, fire outside the site

Taking into consideration that near the CSFSF there is a highway an explosion of a vehicle transporting balloons with acetylene is considered as an initial event.

Receiving building being facilities of category 1 in respect of nuclear and radiation safety responsibility to PiN AE 5.6 is designed with consideration of specific impacts due to external explosion. Its structures shall withstand the impact of air-blast with the pressure in the wave front up to 30 kPa and duration of contraction phase up to 1 sec in horizontal distribution.

An accident with a vehicle transporting balloons with liquefied gas (acetylene, 40 kg) on the highway to Complex "Vector" is considered as an initial event. As the result of a vehicle accident leakage of gas took place and an acetylene-air mix cloud was formed in stoichiometric proportion. The cloud approximately is presented as a hemisphere in the middle of which an explosion is initiated. Overpressure at the air blast front of 10 kPa is reached for 40 kg of acetylene at the distance of 73 m, i.e. design criteria parameter for Receiving building design will not be met and consequently the structures of the building will not be damaged.

Air blast parameters for which HI-STORM system elements are designed are presented in Table 3.7.9. It is seen from the Table that external components of HI-STORM are designed for a maximum external pressure of 69 kPa, which is higher than the potential blast from an acetylene balloon explosion. At the Design stage an explosive danger analysis for the CSFSF site will be performed and specific air blast parameters potentially possible for the site conditions will be identified.

Table 3.7.9 – Design pressure parameters

Pressure	**Condition**	**Pressure**
Outer pressure on HI-STORM	Normal	(0) External
	Extreme	(0) External
	Emergency	69 kPa (fall down of pressure maximum within 1 sec) or 34 kPa (fall down of pressure in static state)

The analysis performed for HI-STORM system licensing in the USA shows that air blast pressure due to the accident with explosion near the HI-STORM storage area will not lead to overturn or displacement of HI-STORM. Thus there will be no release of radioactive materials due to the explosion.

The CSFSF site is located within the boarders of the afforestation. Creation of fire barriers outside the CSFSF industrial site area in compliance with the standard requirements is planned to exclude the impact of forest fire on CSFSF buildings and facilities.

Terror acts and theft of nuclear materials

Accepted technical solutions on SF storage technologies (tight MPC and steel-concrete protective HI-STORM) as well as solutions made on physical protection system allow to exclude

theft of ionizing radiation sources including nuclear materials from the list of initial events for design accidents.

Consequences of terror acts related to HI-STORM storage overpack damages are considered as consequences of an initial event related to external/internal explosion. At this design stage it is accepted that air blast due to a terror act will not create the pressure higher than 69 kPa with the contraction phase up to 1 sec under which the integrity of HI-STORM is provided. To decrease possibility of terror acts in CSFSF it is provided for creation of special importance zones inside the guarded CSFSF perimeter with the storage area inclusive. Consequently at this design stage taking into consideration of physical protection measures it is accepted that terror acts are not initial events for a design accident.

Fire inside CSFSF

The following combustible materials are used in CSFSF: diesel oil, vehicle fuel and oils.

The initial events for fire inside CSFSF under consideration are:

- Fire in Diesel engine room;
- Fire of gasoline tanker with fuel during fuel discharge to the filling station reservoir;
- Fire during HI-STORM transportation by means of caterpillar from Receiving building to the storage area due to ignition of the caterpillar fuel tanker.

The fire in one of the rooms in which diesel oil is used for diesel equipment (diesel generator room) is taken into consideration. The room is located in a separate building for electrical devices in the free access area and has no connection with the rooms where containers with SFA and radioactive materials are stored. The electrical devices building is constructed to meet fire resistance level II requirements. Fire detection system and fire protection system shall assure automatic gas fire fighting of the diesel generator room. Thus applied fire protective measures allow to exclude the impact of this kind of fire on structures at the storage area for storage overpack and Receiving building where storage overpacks with SFA and radioactive waste are located.

Fire of gasoline tanker during discharge of the fuel to the filling station reservoir may occur due to leakage while transmitting or violation of fire safety rules. The filling station is located at the distance no less than 70 m away from storage area for storage overpack and consequently if the fire resistance of HI-STORM on the caterpillar is proved then we may consider that the impact of this fire type will not lead to an accident with release of radioactivity to the environment.

During HI-STORM licensing in the USA, a leakage and ignition of 227,3 l of fuel from the transporter was considered as an initial event for fire. The fire was considered as impact of incident radiation and specific heat flow rate of forced convection on the surface of HI-STORM. The fire temperature is accepted to be 800°C (1475° F).

During analysis of this event the following input data are considered:

- HI-STORM storage overpack is completely enveloped in flames, additional area of heat exchange surface is conservatively transmitted to fire temperature increase;
- Minimum required value of exposure mid-coefficient is no less than 0,9;
- It is accepted that painted outside surface of HI-STORM will remain safe under exposure coefficient of 0,85;
- It was conservatively accepted that exposure coefficient of the flame was equal to 1,0 (critical maximum value) would lead to complete blackening of the source. If we conservatively consider that the flame exposure coefficient is equal to 1,0, and exposure coefficient for painted surfaces is 0,85, and then effective exposure coefficient will be 0,85. Since the minimum required value 0,9 is more than the real value 0,85, application of mid exposure coefficient 0,9 is conservative;
- Average flame temperature is no less than 800°C (1475°F), which is conservative because the flame as a rule covers large air volume that leads to lower flame temperature. Additionally it is conservatively considered that the same temperature values are applicable to the entire storage overpack surface which is impacted with the flame. These values are rather conservative and take into consideration size of HI-STORM storage overpack.

- Fuel source impacts the front of 1m (40 inches) width which is conservative because the flow in reality can be more than the boarders of HI-STORM outer surface, i.e. more than 3m (10 feet). The point is conservative because if apply 1m fire front the time of fire impact will increase given that the amount of burned is equal;
- Based on the HI-STORM surface temperature field measurement results obtained during a large scale fire with consideration of a short fire in time matter the conservative coefficient of forced heat exchange convection of 25,55 W/m^2*^oC was applied.

Taking into account conservative fire conditions and concomitant heat flow from the fire, the sun insolation effect is insignificant and was not considered. Moreover, smog screen, which results from the fire basically, blocks the sun insolation.

Taking into account the volume of the fuel in a tank (227,3 l), the outer diameter of HI-STORM (3,492 m) and the accepted width of inflamed fuel front (1 m), the ring from the inflamed fuel will cover the area of 13,71m^2 and have the depth of 1,37 cm. Based on the depth value and the linear fuel rate of 3,8 mm/min, design fire time will be 3,622 min (217 sec). Linear fuel rate of 3,8 mm/min is the lowest value presented in the Report on temperature tests of simulated fire at the large area of Sandia site. Application of minimum linear rate is conservative as it increases the fire time.

Under given fire characteristics the temperature of FR shells did not exceed the permissible value in accordance with the USA requirements. Fire hazard analysis of the specific CSFSF site for HI-STORM storage overpacks will be performed at the design stage. For the purposes of this EIA it is accepted that fire is not initial event for an accident which leads to release of irradiation to the environment.

Explosion inside CSFSF

Explosive gas will not be used and explosive substances will not be technologically applied for the CSFSF.

Explosion in CSFSF may be provoked only with fuel ignition in a fuel tank at gasoline station located at the distance of 50-70m from the HI-STORM storage area and 70m from the Receiving building.

Impact of explosion and fire at the gasoline station can be analysed only from the viewpoint of impact on the Receiving building structures and HI-STORM storage overpacks.

Receiving building being facility of category 1 in respect of nuclear and radiation safety responsibility to PiN AE 5.6 is deigned with consideration of specific impacts related to external explosion. Its structure shall withstand impact of air blast with the pressure in front up to 30 kPa with the duration of the contraction phase up to 1 sec in case of horizontal distribution.

As it is shown in Table 3.7.9, external HI-STORM surface is designed for pressure of 64 kPa.

At this design stage it is supposed that explosion at the gasoline station shall not lead to generation of the air blast with the pressure in front more than 30 kPa, and consequently for Receiving building and HI-STORM storage overpacks the internal explosion has not been considered as initial event for an accident.

De-energization

Switching to reliable power supply system (diesel generator set) is foreseen in case of interruption of CSFSF external power supply for the object's nuclear and radiation safety related systems.

UPS blocks are foreseen for the period of diesel generators' activation for the systems, which exclude power supply interruption.

For the rest of the safety related systems the full de-enegization time will not exceed 5 min. Installation of two independent sections of diesel generators is provided to exclude impact of diesel generator failure on power supply of safety related systems in case of complete de-energization of CSFSF. Thus in case of one section failure there is a possibility to switch to another section.

Taking into account that SFA direct management in CSFSF is not planned and SFA are located in the MPC inert atmosphere, loss of power supply during transportation-process operations with MPC shall not be an initial event for a design accident.

Emergency high pressure in MPC

During HI-STORM system development Design pressure values inside MPC (Table 3.7.10), which do not allow radioactive release outside MPC were identified. Justification of these calculations shall be presented at MPC certification stage in Ukraine.

Table 3.7.10- Design pressure parameters in MPC

Pressure	Condition	Pressure (MPa)
Internal MPC pressure	Normal	0,7
	Non-standard	0,76
	Emergency	1,4

Under regular operation conditions (ROC) increase of pressure in MPC more than the set pressure during sealing of MPC is possible:

- Due to increase of average gas temperature in MPC;
- Due to permissible leakage of FR shell.

Maximum pressure in MPC due to the first reason is possible only under extreme outside temperature.

Possible increase of pressure in MPC due to the second reason shall be specified by permissible quantity of FR with 1% gas leakage of shell (FA safety operation margin during operation in a reactor according to Item 1.2 of Appendix to PBY RU AS-89). All SFA unloaded from active reactor zone into the fuel cooling pool shall pass leakage control of FR shells in KGO system operated at NPPs. Only sealed SFA will be allowed for loading to MPC-31. If SFA are leaking, special tubes shall be used for their storage and amount of SFA in MPC decreases to 24 (more detailed information about defective SFA management is presented in Volume 1 Part 3). This accident is considered for sealed SFA. As the result, from leaking FR shells the gas penetrates into MPC space and consequently pressure in MPC raises. In CSFSF SAR at the design stage cumulative geometrical volume of gas in FR shells and free MPC space will be identified and consequently the amount of gas penetrating from leaking shells (1%) to MPC helium space brought to atmospheric pressure and average gas temperature as well as creating overpressure will be calculated. It is expected that pressure in MPC will not be higher than the design one (Table 3.7.10). Consequently in case of permissible leakage of FR shells release of radioactive materials to the environment is not expected.

Regarding emergency leakage of all FR shells it is possible to consider such event as beyond the design basis accident. The only reason which may cause leakage of all FR shells placed to MPC may be significant external dynamic impact on SFA during loading to MPC. Even if we consider that such accident will take place it will be identified during the next MPC filling with helium (prior to final sealing) and such MPC surely will be recognised as emergency and it will not be transported to CSFSF. Thus an accident in which all FR shells are leaking in MPC can be described only as beyond the design basis accident.

Leakage of LRAW during transmission to a tank truck

During pumping of collected LRAW from wastewater sump to a tank truck it is planned to use flexible hoses, but it does not exclude leakage of hosepipe and spillage of medium.

LRAW pumping shall be performed in Receiving building, in the restricted access area, in the sump coated with corrosion resistant steel. Thus release of radioactive materials outside will not take place under approved design solutions.

Release of radioactive materials from the external MPC surface

Proposed technical solutions using HI-TRAC transfer casks during SFA loading to MPC in the NPP fuel cooling pool will decrease the possibility of MPC surface contamination with water of the fuel cooling pool.

MPC surface contamination with water of the fuel cooling pool over the permissible norms is considered as an initial event. Radioactive contamination of MPC surface with β-transmitters will conservatively be $8{,}73 \cdot 10^7$ Bq/m^2 ($2{,}36 \cdot 10^5$ β-parts/ cm^2 ·min). Such condition was not revealed during MPC loading to HI-STAR at NPP.

In case the excess of surface contamination is not timely identified prior to MPC transportation for storage from NPP Unit, radioactive parts may release to the environment in the following two cases:

- During MPC unloading from HI-STAR (short term release from the Receiving building tube);
- During MPC storage in HI-STORM at CSFSF storage area (long term release from the storage module within one year).

Given that the area of potential surface contamination of MPC-31 container is 30,54 m^2, release activity will be $2{,}67 \cdot 10^9$ Bq. The release is conservatively presented exclusively with radionuclide Co^{60}.

This initial event is a design accident with maximum consequences.

3.7.2.3 Beyond the design basis accidents

This section describes initial events of beyond the design basis accidents regulated with requirements of PNAEG-14-029-91, IAEA and Department of Energy of the USA.

Initial events leading to beyond the design basis accidents in accordance with the PNAEG - 14-029-91 are the following:

a) extreme natural phenomena with the impact parameters exceeding the design ones;
b) beyond the design basis accidents at the nuclear facilities adjacent to the CSFSF site;
c) a plane crash based on the probability assessment or risk assessment;
d) occurrence of self-sustained chain reaction within the SF management and storage systems.

In accordance with the IAEA requirements a plane crash is considered as an initial event for beyond the design basis accident for the SF storage system. The following was considered as initial events for the HI-STORM storage system in the USA:

- Hypothetical criticality occurrence;
- Obstructions;
- Total blockage of HI-STORM air intake;
- Plane crash.
-

Hypothetical criticality occurrence

Random criticality is assumed to occur only in the process of multi-purpose canister (MPC) loading at the NPP. Taking into consideration the fact that loading of spent fuel assemblies (SFA) into the MPC is similar to that of SFA into transportation overpack –13 (TO-6) such analysis was performed in the SARs for specific power units. This beyond the design basis accident will be considered in the SAR for the MPC loading at the stage of the CSFSF design.

Obstructions

The initial events leading to obstructions can be flooding, strong wind or mudflow. Mudflow, flying objects associated with tornado or fragments coming with flooding can lead to blockage of the channels. Obstruction is an unlikely event, nevertheless, it was analysed in the SAR during HI-STORM licensing in the USA.

During analysis the fragments were considered as material with the maximum heat-insulating properties. In addition, the MPC inside the HI-STORM is subjected to short-term heating under adiabatic conditions. The minimum time required for the fuel shell to reach the short-term design temperature limit depends on the container heat inertia, ambient conditions under which the container is maintained, and heat transfer during decay of spent nuclear fuel.

The difference between maximum design temperature of the FA shell and short-term temperature limit of that is about 149°C. The permissible temperature increase of the FA shell when the HI-STORM is obstructed with the debris is a conservative value 66°C. Considering this value a dependency of MPC heat load on time was developed. The time period within which the FA shell temperature reaches a critical limit was defined by the following formula:

$$\Delta t = \frac{m \times c_p \times \Delta T}{Q}$$

Where:

Δt = permissible time for HI-STORM obstruction with debris (hours)

m = HI-STORM weight (in pounds)

c_p = specific heat (British heat unit/ pound ×°F)

ΔT = permissible increase of FA shell temperature (150°F)

Q = total heat load from heat buildup during decay (British heat unit /hour)

The analysis results shows that even if the HI-STORM stays buried under debris, the FA shell temperature will not reach the permissible limit within the time required for clearance of debris covering the container. In addition, the debris will additionally function as shielding, thus, reducing exposure levels during accident mitigation activities. Therefore, this accident is considered not to lead to release of radioactive matters into the environment.

Total blockage of HI-STORM ventilation channels

Total blockage of HI-STORM ventilation channels can lead to failure of normal air circulation required for cooling the MPC. Some amount of heat will be removed due to local circulation of air through the HI-STORM circle and its ventilation ducts with the MPC emitting the heat into the colder HI-STORM. The increase of the MPC temperature will lead to the HI-STORM temperature rise. Under such conditions the temperature of HI-STORM, MPC and FA contained will be rise proportionally to the time.

Due to significant weight and corresponding heat capacity of the reinforced HI-STORM (weight is more than 77 t), large temperature increase is expected to occur providing the ventilation openings are totally plugged within several days. The intended stationary monitoring of air temperature at the inlet/outlet of ventilation channels and routine daily inspection of containers stored will allow for elimination of this event. Therefore, technical decisions and administrative measures are considered to eliminate release of radioactive matters into the environment in case of total blockage of ventilation ducts.

Plane crash

The HI-STORM is designed as a welded steel structure filled with homogeneous concrete (without re-bars or any other members, which can be reason for cracks). The total radial thickness of steel and concrete affected with a flying object and to be breached for the contact with the MPC is about 76 cm. The design properties of the HI-STORM body are selected as such not to allow for brittle fracture under very low temperatures likely to occur in the northern part of the USA. Therefore, the HI-STORM is designed as resistant to shock and impulse loads even during the coldest weather. The top part of the HI-STORM is designed as a heavy steel welded lid which is fixed to a cylinder body with four big bolts with the permissible combined axial load exceeding 1361 t.

The HI-STORM is a cylinder, capable to withstand much bigger load bearing capacity than a structure with flat edges. An annular cylinder body is capable to withstand much bigger loads than a structure with flat edges, mainly, due to distribution of tensile and/or compressive loads within width, which is different from distribution of a bending moment.

As for the physical shape, the HI-STORM system is separate heavy cylinder (about 150 t when loaded) with a low factor of relative extension (relative to proportions height-diameter). The following planes were considered as initial events for the plane crash as beyond the design basis accident:

- Non-rigid small private or official plane flying at low- or medium speed and containing solid elements of insignificant weight;
- Non-rigid big multi-engine plane flying at medium speed and containing large amount of fuel and heavy engines;
- Non-rigid small high-speed plane carrying multi-purpose solid elements such as an engine and arming;
-

Assessment of explosion made with Holtec showed that a non-rigid small private plane will distribute the most part of its energy through internal plastic deformation, which will insignificantly affect the container. If there is a crash of a big plane or one of its heavy engines at a medium speed or a small plane flying at a high speed and carrying a few hard elements, the crash may lead to the overturn of the container. In addition, if the container is overturned, thus, distributing the energy transferred with a missile to a steel and concrete shell of the HI-STORM and confining shell of the MPC. This assumption is incorrect, since the flying object was designed for breaching the armature due to powerful heat generation and metal cutting (sharp protruding edge).

The analysis performed with Holtec International with using the software LS-DYNA, simulated the impact due to the crash of a plane of 17 t, with one jet of 2t installed in the rear part of the fuselage, with the HI-STORM system freely located. The analysis demonstrated that the cylindrical shell of the HI-STORM was not breached though flying objects affected it with different speed and angle. Moreover, the analysis showed that:

- At the medium speed of the crash against the middle part of the HI-STORM, the container will repulse the shock with tangent, which can affect the nearby container. A shocked area remains unbreached;
- If the speed is bigger, the depth and the area of the dent will grow larger; The collision height will be also increased. The HI-STORM affected will rotate, move and may collide with the nearby containers. Depending on the linear and angular moments occurring as a result of collision, one or both containers may turn and overturn;
- Under the plane crash scenarios considered the HI-STORM lid did not separate from the HI-STORM body, thus, leaving the MPC confining shell integral;
- The vertical blow affecting the top of the HI-STORM during collision with the loaded plane flying at the speed exceeding the medium did not breach the top of the HI-STORM lid.

In addition to the blow effect considered for the plane crash, the impact of fire as a result of combustion of aviation fuel was analysed. Based on the assessments performed, the MPC inside the HI-STORM will remain leak-tight within one hour even if it is surrounded with flames of burning aviation fuel. Since the CSFSF site is plain, the fire from the burning aviation fuel will propagate at the bigger area of the site surface but the burning time will be short.

In conclusion, it can be noted that, the total effect of the plane or plane engine collision with the HI-STORM storage overpacks cannot be the reason for an event with significant radiological impact on the CSFSF locating the HI-STORM storage overpacks.

Damage of all fuel rods with subsequent depressurisation of MPC

Licensing of HI-STORM storage technology in the USA in accordance with NUREG/CR-648 7 required consideration of radionuclide release outside the depressurised MPC. Assessment of accident consequences assumed consideration of spent fuel from the US reactors PWR with the maximum burn 70,000 MW/day/kgU, kept in the fuel cooling pool for 5 years with the initial enrichment 4,8% ^{235}U. Consideration included assessment of pressure increase inside the MPC due to decay heat generated with spent fuel stored inside the MPC versus the MPC leakage value as required with ASME section III, subsection NB, with considering the weld control requirements.

Assessment of accident included consideration of internal pressure increase inside the MPC up to 1,4 MPa, associated leakage outside the MPC and personnel intake at the distance of 100 m from the container. Leakage of $5x10^{-6}$ atm-cm^3/s under internal pressure to 0,69 MPa meeting the requirements of Technical Specification for storage in the USA was considered as a leakage criteria under normal operation. Progression of internal pressure to 1,6 MPa was further analysed with maximum leakage of $3,3x10^{-4}$ cm^3/s being estimated. Permissible release considering the MPC content and release quota is regulated with NUREG-6487 [24] and constitutes the following:

- ^{85}Kr - 0,3;
- ^{60}Co – 1;
- ^{90}Sr, 134Cs, ^{137}Cs, ^{106}Ru – 2,0x10-4;
- ^{241}Pu, ^{144}Ce and other transuranium elements – 3,0x10-5.

The amount of ^{60}Co is predetermined with the maximum surface activity of SFA. In the USA in accordance with NUREG-6487 [24] the surface activity of PWR SFA is $5,18x10^6$Bq/cm^2 for ^{60}Co.

In accordance with NUREG-1536 [25] the release within 720 hours (30 days) was considered. Some individual is assumed to have stayed at the distance of 100 m from the damaged storage overpack for 24 hours within 30 days. All fuel rods inside the MPC are damaged and the leakage to the atmosphere is $3,3x10^{-4}$ cm^3/s. Based on the calculation results the personnel exposure doses at the distance of 100 m from the damaged container are as follows:

- Total effective dose – 0,291mSv;
- Effective dose for the whole body– 0,0276 μmSv;
- Effective dose due to inhalation – 0,291 mSv.

This accident has been considered as hypothetical assuming damage of all fuel rods inside the MPC with the subsequent release of gaseous fission products. It is impossible to define any realistic initial events direct consequences of which could lead to simultaneous damage of MPC and all fuel rods contained. The only impact on the HI-STORM storage module likely to lead to simultaneous damage of MPC and all fuel rods is significant external dynamic impact (for instance, application of special ammunition, etc.). This accident is considered to demonstrate relatively insignificant radiation consequences due to the accidents at the CSFSF even with considering hypothetical initial events.

This accident is considered in this EIA as beyond the design basis accident with the most severe consequences.

3.7.3 Discharges and Releases under Abnormal Operational Conditions and Accidents

3.7.3.1 Discharge into atmosphere

During abnormal operational conditions and input events which are not related to depressurisation or contamination of the MPC the release into atmosphere will correspond to that under normal operation and will go through the high-rise ventilation stack of the Receiving building.

In case of human errors associated with insufficient monitoring over the MPC surface contamination (design accident with the most severe consequences) the air release through the ventilation stack will be 25000 m^3/h, which corresponds to capacity of the exhaust ventilation system of the transportation corridor of the Receiving building.

3.7.3.2 Discharge of waste water

During abnormal operational conditions generation of liquid radwaste is similar to that under normal operation.

During the accident with the most severe radiation consequences (surface contamination of the MPC with the SF fuel cooling pool water) additional generation of liquid radwaste is not expected.

3.7.3.3 Transfer of solid radioactive waste (SRAW)

During abnormal operational conditions generation of solid radioactive waste is similar to that under normal operation.

The amount of solid RAW will not exceed the amount generated under normal operation.

During the accident with the most severe radiation consequences (surface contamination of the MPC with the SF fuel cooling pool water) there might be a slight increase of SRAW amount due to rag. The expected additional amount of low active SRAW will not exceed 0,1 m^3.

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Attachment A Terms of Reference for Development of Feasibility Studies

Attachment B Environmental Conditions of the CSFSF site

Attachment C Diagram of Plot Plant and General Layout for the CSFSF

CENTRALIZED SPENT FUEL STORAGE FACILITY OF UKRAINIAN WWER NPP

FEASIBILITY STUDY

VOLUME 3

Environment Impact Assessment

PART 2

CSFSF Environment Impact Sources.
Assessment of CSFSF Impact on the Environment

Table of Content

Introduction 6
List of the accepted abbreviations 7
List of accepted terms and definitions 10

4 Description of the environment and assessment of impact 12

4.1 List of Sources of Impacts and Justification of Components of Natural Environment Taken into Account 12
4.1.1 List of CSFSF Impact Sources 12
4.1.2 Justification of Considered Components of Natural Environment 13
4.2 Impact Assessment on Geological Environment 13
4.3 Impacts Assessment on the Air Ambient 14
4.3.1 Radioactive Contamination of Surface Air at CSFSF Site 14
4.3.2 Impacts During Normal Operation Conditions 19
4.3.3 Impacts During Design Accident with the Maximum Consequences 21
4.3.4 Impacts During Beyond Design Basis Accident 22
4.3.5 Brief Conclusions of Impact on the Air Ambient During Operation . 27
4.4 Assessment of Impact on Water Media 28
4.4.1 Radioactive Contamination of Water Media at CSFSF Site 28
4.4.2 Impact on Surface Waters 31
4.4.3 Impacts on Ground Waters 32
4.5 Assessment of Impacts on Topsoil 33
4.5.1 Radioactive Topsoil Contamination at CSFSF Site 33
4.5.2 Impacts under Normal Conditions of Operation 40
4.5.3 Impacts under Design Basis Accident with the Maximum Consequences 41
4.5.4 Impacts under Beyond Design Basis Accident (BDBA) 42
4.5.5 Brief Conclusions of Impact on Topsoil During Operation 44
4.6 Impact on Flora and Fauna 45
4.6.1 Normal Operation Conditions 45
4.6.2 Design Basis Accident with the Maximum Consequences 46
4.6.3 Beyond Design Basis Accident 46

5 Description of social environment and assessment of impact on it 47

5.1 Description of Social Environment 47
5.2 Dose Uptakes on the Personnel and the Population Within the Limits of Exclusion Zone 49
5.2.1 Normal Operation Conditions 49
5.2.2 Design Basis Accident with the Maximum Consequences 53
5.2.3 Beyond Design Basis Accident 55
5.3 Impacts on Social Environment Outside of Exclusion Zone 56

6 Assessment of impact of planned activity on man-caused environment 58

7 Measures on minimization of additional impact on the environment 62

7.1 Security Measures 62
7.1.1 Radiation Monitoring System 62
7.1.2 Nuclear Material Monitoring and Registration System 63

7.1.3 Physical Protection System 63
7.1.4 Technological Processes Monitoring and Control System 63
7.2 Security Measures 64
7.3 Reconditioning Measures 65
7.4 Compensation Measures 66
7.5 Resource-saving Measures 66

8 Comprehensive environment impact assessment 67

8.1 Comprehensive Assessment of CSFSF Impact under Normal Operation Condition 67
8.1.1 Assessment of Impact on the Air Medium 67
8.1.2 Assessment of Impact on Water Media 68
8.1.3 Assessment of Impact on Topsoil 68
8.1.4 Assessment of Impact on Flora and Fauna 69
8.1.5 Assessment of Impacts on Man-caused Environment 69
8.1.6 Assessment of Impacts on Social Environment 70
8.2 Comprehensive Assessment of CSFSF Impact under Accident Conditions 70
8.2.1 Considered Accidents 70
8.2.2 Assessment of Impact on the Air Ambient 71
8.2.3 Assessment of Impact on Water Media 71
8.2.4 Assessment of Impact on Topsoil 72
8.2.5 Assessment of Impact on Flora and Fauna 73
8.2.6 Assessment of Impact on Man-caused Environment 73
8.2.7 Assessment of Impacts on Social Environment 74
8.3 Description of Residual Impacts 75
8.4 Control Area and Surveillance Area of CSFSF 82
8.5 Assessment of Ecological Risk 82

9 Environment impact assessment during construction 84

9.1 List of Sources of Impacts 84
9.2 Justification of Considered Environmental Components 84
9.3 Assessment of Influence on Geological Environment 84
9.4 Assessment of Impacts on the Air Ambient 85
9.4.1 Impacts under Normal Conditions 85
9.4.2 Impacts of Accidents During Construction 87
9.4.3 Summary of Impact on the Air Ambient during Construction 90
9.5 Assessment of Impacts on the Water Medium 90
9.5.1 Impact on Surface Waters 90
9.5.2 Impacts on Ground Waters 91
9.6 Assessment of Impacts on Topsoil 91
9.6.1 Impacts under Normal Operation Conditions 91
9.6.2 Impacts of accidents during work performance 94
9.6.3 Brief Conclusions of Impact on Topsoil during Construction 96
9.7 Impact on Flora and Fauna during CSFSF Construction 96
9.7.1 Normal Conditions of Construction 96
9.7.2 Accidents during Construction 97
9.8 Assessment of Impacts on Vital Activity of People 97
9.8.1 Dose Uptakes under Normal Work Performance Conditions 97
9.8.2 Accidents During Construction 99

9.8.3 Impacts on Social Environment During CSFSF Construction Outside Exclusion Zone 100
9.9 Assessment of CSFSF Construction Impact on Man-caused Environment 101
9.10 Measures for Maintenance of Normative Conditions of the Environment During Construction 103
9.10.1 Security Measures 103
9.10.2 Protective measures 104
9.10.3 Reconditioning Measures 106
9.10.4 Compensation Measures 106
9.10.5 Resource-saving Measures 106
9.11 Comprehensive Assessment of the Impact of CSFSF Construction under Normal Conditions 106
9.11.1 Assessment of Impacts on the Air Ambient 107
9.11.2 Assessment of Impact on Water Media 107
9.11.3 Assessment of Impact on Topsoil 108
9.11.4 Assessment of Impact on Flora and Fauna 108
9.11.5 Assessment of Impacts on Man-caused Environment 108
9.11.6 Assessment of Impacts on Social Environment 109
9.12 Comprehensive Assessment of CSFSF Impact During Accidents 109
9.12.1 Considered accidents 109
9.12.2 Assessment of Impact on the Air Ambient 110
9.12.3 Assessment of Impact on Water Media 110
9.12.4 Assessment of Impact on Topsoil 110
9.12.5 Assessment of Impact on Flora and Fauna 110
9.12.6 Assessment of Impact on Man-caused Environment 111
9.12.7 Assessment of Impacts on Social Environment 111
9.13 Description of Residual Impacts 111
10 Impact of CSFSF construction, operation and accidents on territory of the adjacent states 115
10.1 Impact under Normal Construction Conditions 115
10.1.1 Air Pollution 116
10.1.2 Contamination of Surface Topsoil and Additional Exposure of the Population 116
10.2 Impacts During CSFSF Normal Operation 118
10.2.1 Air pollution 118
10.2.2 Contamination of Surface of Topsoil 119
10.2.3 Additional Personnel and Population Exposure 119
10.3 Impact during the MDBA 122
10.3.1 Air Pollution 123
10.3.2 Contamination of Surface of Topsoil 124
10.3.3 Additional Exposure of the Population 124
10.4 Impacts during the BDBA 126
10.4.1 Air Pollution 126
10.5 Conclusions on CSFSF Trans-border Impact 133
List of Reference Normative Documents and Literatures 134
Attachment A – Report on interdepartmental meeting 136
Attachment B –Calculation procedure of impacts of radioactive emissions 137

Introduction

This document is Part 2 of Environment impact assessment (EIA) for CSFSF. EIA is a part (volume 3) of the Feasibility Report (Feasibility Study) performed based on DBN A. 2.2.1-2003 [1].

The Terms of Reference on development of the Feasibility Study including EIA development are given in Attachment A to Vol. 3, Part 1.

Taking into account that normative requirements for scope of representation of issues of EIA in structure of Feasibility Study are unavailable, rough structure and content of the given part were coordinated at interdepartmental meeting. The Protokol of interdepartmental meeting is given in Attachment A.

Part 2 contains:

- CSFSF impact assessment on geological environment;
- CSFSF impact assessment on the ambient air during construction and operation;
- CSFSF impact assessment on surface and ground water during construction and operation;
- CSFSF impact assessment on topsoil during construction and operation;
- CSFSF impact assessment on flora and fauna during construction and operation;
- CSFSF impact assessment on man-caused environment during construction and operation;
- CSFSF impact assessment on social environment outside exclusion zone during construction and operation;
- Measures on minimization of additional influence of CSFSF on the environment are determined;
- Comprehensive assessment CSFSF impact on the environment;
- Assessment of CSFSF impact on the environment in transboundary aspect;
- Residual impacts of CSFSF on the environment during construction and operation are determined;
- Estimated ecological risk, related to CSFSF construction;
- Proposals on control area and CSFSF observation area are provided.

List of the accepted abbreviations

AB	-	Administration building
ACP	-	Access control point
AM	-	Accident mitigation
ARMS	-	Automated monitoring system of radiation conditions
BPS	-	Bank pump station
BSH	-	Baltic system of heights
CA	-	Control area
CCM	-	Capital construction administration
CCP	-	Central control panel
CD	-	Civil defense
CDF	-	Central disposal facility
CIP	-	Construction and industrial personnel
CL	-	Controlled level
CPR	-	Construction and assembly personnel
CSFSF	-	Centralized interim radioactive waste storage facility for spent nuclear fuel
CWTF	-	Centralized waste treatment facility
DADS	-	Defective assemblies detection system
DBE	-	Design basis earthquake
DDA	-	Dnepr-Donetsk avlakogen
DGS	-	Diesel generating station
DISF	-	Dry interim radioactive waste storage facility for the spent nuclear fuel
DL	-	Dose limit
EB	-	Engineering barrier
EGE	-	Engineering-geological element
EIA	-	Environment impact assessment
EIL	-	Easily inflammable liquid, inflammables
ERM	-	Environment radiation monitoring
ERML	-	External radiation monitoring laboratory
EZ and OEA	-	Exclusion zone and obligatory evacuation area;
FR	-	Fuel rod
GEDR	-	Gamma-radiation exposure dose rate
GS	-	Gasoline station
HES	-	Human exposure spectrometer
HI-STAR	-	Hi-Star transportation overpack
HI-STORM	-	Hi-Storm storage overpack
HI-TRAC	-	Hi-Trac transfer cask
HVDS-750	-	High-voltage distributive substation;
HVTL	-	High-voltage (transmission) line
IC	-	Industrial complex
ICSRM	-	Industrial complex for solid radioactive waste management
IDC	-	Individual dosimetry control
IPE	-	Individual protection equipment
IRWSF	-	Interim radioactive waste storage facility
ISF	-	Interim storage facility for spent nuclear fuel
KhNPP	-	Khmelnitskiy nuclear power plant
LCP	-	Local control panel
LILW SL	-	Low and medium radioactive short living waste

LRAW	-	Liquid radwaste
LRTF	-	Liquid radwaste treatment facility
MCS	-	Monitoring and control system
MDA	-	Minimum detectable activity
MDBA	-	Maximum design basis accident
MDE	-	Maximum design earthquake
MIA	-	Ministry of internal affairs
MOE	-	Ministry of emergencies
MOH	-	Ministry of health
MP	-	Meteorological potential
MPC	-	Multi-purpose container
MTE	-	Motor transportation enterprise
NAS	-	National academy of science
NCA	-	Normal confined aquifer
NCRE	-	National energy regulatory commission
ND	-	Normative documents
NF	-	Nuclear fuel
NPP	-	Nuclear power plant
NRBU	-	Codes of radiation safety of Ukraine
NRSC	-	Nuclear regulation state committee
NSC	-	New safe confinement
NTD	-	Normative and technical documentation
OSG	-	Open switch-gear
OSV	-	Overpressure safety valve
OTS	-	On-site transportation system
PA	-	Preserve area
PD	-	Permissible discharge
PP	-	Petroleum products
PP	-	Physical protection
PR	-	Permissible release
PSC	-	Permissible surface contamination
RAW	-	Radwaste
RBMK	-	High capacity channel reactor
RCPP	-	Reinforced concrete plant production
RF	-	Russian Federation
RM	-	Radiation monitoring
RMS	-	Radiation monitoring system
RN	-	Radionuclides
RPM	-	Radiation process monitoring
RR	-	Radiation release
RWDF	-	Radioactive waste disposal facility
SAR	-	Safety analysis report
SCF	-	State control facility
SFA	-	Spent fuel assemblies
SFPSF	-	Facility for spent fuel preparation for storage
SG	-	Switch-gear
SNF	-	Spent nuclear fuel
SO	-	Shelter object
SPS	-	Sewage pump station

SRAW	-	Solid radioactive waste;
SRTF	-	Solid radwaste treatment facility
SSE ChNPP	-	State specialized enterprise Chernobyl NPP
SSPP	-	Steel structures plant production
STE	-	State timber enterprise
SZ	-	Surveillance zone
TC	-	Transport container
TUE		Transuranium elements
UPS	-	Uninterrupted power supply source
WWER	-	Water moderated reactor
WIS	-	Water-intake station
WT	-	Water table

List of accepted terms and definitions

Abnormal event or violation of normal operation conditions	-	design event II by ANS - events which though do not occur on a regular basis but can occur with a moderate frequency or about once a year of operation of storage facility
Biocenose	-	historically developed set of plants and animals which occupy territory with more or less identical conditions of existence
Gas-aerosol emission (emission)	-	release of radioactive substances into the atmosphere from process contours and ventilation systems of the enterprise
Damp area	-	territory with damp and warm climate where amount of precipitation exceeds evaporation
Permissible release (PR)	-	regulated maximum cumulative level of gas-aerosol emission. PR is emission, at which total annual effective dose of the representative of critical group of the population (outside Control area) due to all radionuclides present in the emission is equal to quota of dose limit (NRBU - 97)
Permissible discharge (PD)	-	regulated maximum cumulative level of water discharge. ET - discharge at which total annual effective dose of the representative of critical group of the population, due to all radionuclides is equal to quota of dose limit (NRBU – 97)
Radioactive contamination	-	availability or spreading of radioactive substances over their natural content in the environment and/or in body of person
Beyond design basis accident	-	the text of this document supposes design event IV by ANS - event that is postulated due to the fact that its consequences can result in the maximum possible impact on the environment
Surveillance area over facility	-	territory on which influence of radioactive discharges and emissions from nuclear facility is possible and where monitoring is carried out (NRBU - 97)
Controllable area	-	territory on which strengthened radiation monitoring (NRBU - 97) is envisaged
Exclusion zone	-	territory from which the population (Law of Ukraine) was evacuated in 1986
Area of obligatory evacuation	-	territories undergone to intensive contamination by long-living radionuclides with density of Cesium topsoil isotopes contamination from 15,0 Ci/km^2 and above, or some Strontium from 3,0 Ci/km^2 and above, or Plutonium from 0,1 Ci/km^2 and higher, as well as territories with soils promoting high migration of radionuclides in plants with density of contamination by isotopes of Cesium from 5,0 to 15,0 Ci/km^2, or Strontium from 0,15 to 3,0 Ci/km^2, or Plutonium from 0,01 to 0,1 Ci/km^2, where effective equivalent radiation dose for the person can exceed 5,0 mSv (0,5 bar) per a year over the dose taken during the pre-accident period (Law of Ukraine)
Environment	-	set of natural, man-caused and social conditions of human society
Natural environment	-	set of natural factors and facilities of the environment having natural origin or development
Man-caused environment	-	Artificially created part of the environment consisting of technical and natural elements
Design accident	-	design event III by ANS - infrequent event which could be expected at least once during service life of storage facility

Radioactively contaminated grounds	-	territories which require carrying out measures on radiation protection and other special interventions, directed to restriction of the additional exposure caused by Chernobyl accident, to ensure(allow) normal economic activities
Control area of facility	-	territory around of radiation - nuclear facility where the level of exposure of people under normal operation conditions can exceed quota of dose limit for category B. Residing of the population, restriction of industrial activity which has no the relation to nuclear facility and where the radiation monitoring (NRBU - 97) is carried out is forbidden in Control area
Phytocenosis	-	historically developed set of types of the plants which are existing on territory with more or less similar climatic, soil and other conditions
Faunistic complex (zoocenosis)	-	set of types of the animals being a part of biocenose
Ecotone	-	vegetation of transitive character between the neighboring communities
Ecotope	-	set of natural factors (climatic, soil) which are characterizing determined homogeneous area of surface
Phytocenosis	-	historically developed set of types of plants which are existing on territory with more less same climatic, soil and other conditions
Faunistic complex (zoocenosis)	-	set of types of the animals being a part of biocenose

4 DESCRIPTION OF THE ENVIRONMENT AND ASSESSMENT OF IMPACT

4.1 List of Sources of Impacts and Justification of Components of Natural Environment Taken into Account

4.1.1 List of CSFSF Impact Sources

The description of normal operation conditions, possible infringements of normal operation, consideration of initial events of possible design-basis accidents and beyond design basis accidents, as well as the description of accident sequences and possible impacts at design accident with the maximum consequences and beyond design basis hypothetical accident are given in Volume 3, Part 1, Sections 3.5-3.7. Table 4.1.1 contains the results of analyses given in part 1 of EIA of CSFSF impact sources on the environment at normal operation, infringements of normal operation, at design accident with the maximum consequences and beyond design basis (hypothetical) accident. As a result of the analysis of non-radiation impacts of CSFSF given in the first part of EIA, during CSFSF operation the essential non-radiation impacts on the environment are not assumed. In this connection, main sources of impact on the environment (radiation impact) will render emissions of radioactive substances during operation and possible accidents on CSFSF given in table 4.1.1.

Table 4.1.1 - List and description of radioactive substances emission sources during operation and possible accidents at CSFSF

Source of impacts	Measuring unit	Radionuclide	Activity of emission
Operation in normal conditions			
Normal operation of CSFSF	Bq/year	60Co 137Cs	$1{,}61 \cdot 10^{7}$ 190
The maximum design accident			
Delivery of MPC-31 in CSFSF with surface contamination higher than the maximum permissible	Bq	60Co	$2{,}67 \cdot 10^{9}$
Beyond design basis accident			
Loss of sealing of the MPC-31 with destruction of all spent fuel assemblies by unstated reason	Bq	137Cs 90Sr ά active TRU elements	$4{,}3 \cdot 10^{11}$ $3{,}0 \cdot 10^{11}$ $6{,}5 \cdot 10^{9}$

Calculation of annual permissible release for CSFSF has been made by procedure given in Attachment A to this document. The initial assumptions for calculations is the regulation about non-exceedance of value of quota of dose limit for the population due to all ways of impact from process emissions of radionuclides in the atmosphere by facility specified by NRBU- 97 and making 40 mkSv/year.

According to calculation data given in Section 5 of this document, due to all ways of impact of emissions at normal CSFSF operation , the value of annual individual effective dose will not exceed quota of dose limit for population DL_B = 40 mkSv/year.

So, at the nearest boundary of the occupied territories (EZ and OEA boundary from storage facility – 13 km) the value of annual individual effective dose will not exceed 1,5·10-3 mkSv or 0,004% from the quota of dose limit.

In case of approach of boundaries of residential territories to CSFSF to the distance 2 km (boundary of 10-km zone of ChNPP), the value of annual individual effective dose will not exceed 3,0·10-2 mkSv or 0,08 % from quota of dose limit.

Therefore, the value of quota of dose limit also will not be exceeded and CSFSF operation will not interfere with possible reduction of EZ and OE territory up to boundaries of 10 km zone of ChNPP.

4.1.2 Justification of Considered Components of Natural Environment

Selection of components of the environment for which the assessment of impacts CSFSF is carried out, is performed according to Item 2.8 DBN A. 2.2-1-2003 [1] on the basis of the analysis given in section 3 EIA "General characteristic of facility and economic activities in area of impact".

Item 2.7 DBN A. 2.2-1-2003 allocates the following components of the environment:

- geological environment;
- the air ambient;
- climate and microclimate;
- water medium (surface and ground waters);
- topsoil;
- flora and fauna and reserved objects.

During CSFSF operation the thermal contaminations and evaporations are not assumed. CSFSF operation does not impact on intensity of solar radiation, temperature, wind speed, humidity, atmospheric inversions, duration of fogs and other climatic properties. In this connection an influence on climate and a microclimate of designed CSFSF is not considered.

4.2 Impact Assessment on Geological Environment

The description of geological conditions in CSFSF allocation area is represented in sections 2.1.2-2.1.5 of this EIA (ref. volume 3, part 1).

Various adverse natural and natural-man-caused processes and phenomena are observed In area of CSFSF construction site location . Exogenic processes are related to them:

- plane erosion (plane and site washout);
- aeoline (sand relocation by wind);
- bogging.

As to the endogenic processes mainly caused by internal forces of the ground, they have a weak development at CSFSF site. The analysis of the latest tectonic movements, the structural - tectonic plan of territory and character of occurrence of deposits in the top part of sedimentary cover testifies that the CSFSF site settles down outside zones of the newest explosive infringements.

Potential threat of violation of CSFSF normal operation is represented with process of underflooding by ground water (occurrence of top water) which in detail was considered in subsection 2.1.5 of volume 3, part 1. Potential threat of impact of local underflooding is promoted by positive water balance of territory, insignificant ruggedness of relief and lack of obvious surface effluent. Local underflooding of facility site can be caused by the following natural and natural-man-caused reasons:

- deforestation in the area located above on soil stream that can result in reduction of evaporation of moisture and increased infiltration of atmospheric precipitation up to water table;
- progressing increase in volume of atmospheric precipitation and their fallouts non-uniformity which have been related to modern warming and climate damping.

During CSFSF construction there will be carried out measures on prevention or restriction of impacts on geological environment (influence of man-caused factors on development of adverse natural processes) for the purpose of:

- improvement of geological environment properties for leveling influence of exogenic processes;

- prevention of deterioration of properties of soils (decrease in indexes of compressibility and strength) at the basis of the foundations of structures;
- prevention of local underflooding.

For prevention or restrictions of impacts man-caused factors on geological environment during CSFSF operation, the following measures will be performed during CSFSF construction:

- the territory will be leveled, asphalted and well-equiped that completely will remove erosion and aeoline processes;
- in the area allocations structures in case of backfilling, it will be removed and replaced by soil with layer-by-layer compacting;
- the drainage and discharge of surface effluent will be arranged;

For reduction of impact of factors of geological environment on CSFSF operation, CSFSF structures will be designed taking into account seismic properties of site.

Taking into account the measures to be carried out, development of adverse natural-man-caused processes on CSFSF industrial site is not forecast.

4.3 Impacts Assessment on the Air Ambient

4.3.1 Radioactive Contamination of Surface Air at CSFSF Site

Indexes of radiation condition of surface air of the EZ and OEA – are an extremely dynamical integrated values, whose magnitudes are determined by a plenty of the natural phenomena and anthropogenic factors. Value of contamination of ground layer of the atmosphere is identified by density of surface contamination of territory, physical and chemical and disperses structure of emergency radioactive fallouts, soil properties and condition of their surface, relief and phase of development of the vegetative cover, current weather conditions and intensity of man-caused activity.

The analysis of long-term observations of radiation condition of ground layer of the atmosphere shows that the appreciable air migration of radioaerosols caused, first of all, by significant gradients of surface contamination of territory takes place at EZ and OEA territory.

At the present moment, the greatest radionuclides content in aerosols of ground layer of EZ and OEA atmosphere registered in a nearby ChNPP zone, moreover dynamics of change of their structure is identified by natural processes of "disintegration - accumulation" (table 4.3.1).

Among controlling points of distant zone the greatest values of radionuclides content are registered on those points which are characterized by high surface contamination and where civil work are carried out or intensive movement of motor transport is observed. First of all points of ARMS "Mashevo" ($1{,}1 \cdot 10^{-4}$ Bq/m^3), "Chistogolovka" ($7{,}1 \cdot 10^{-5}$ Bq/m^3) and "Buryakovka" ($7{,}6 \cdot 10^{-5}$ Bq/m^3) (table 4.3.2) are related to those.

The general stabilization process of radiation conditions in EZ and OEA promoted an establishment of determined low variable ranges of radionuclides concentration in ground layer of air in all observation points. Thus, average concentration of radioaerosols during the warm period of a year, as a rule, in 1,5-2 times exceeds its value which is registered in a cold season (table 4.3.2).

Table 4.3.1 - Nuclide composition of radioaerosols of ChNPP industrial site, 2000-2002[2-4]

Radionuclide	**Content, % from total activity**		
	2000	**2001**	**2002**
^{134}Cs	0,53	0,26	0,24
^{137}Cs	67,0	68,0	72,0
^{154}Eu	0,34	-	-

Radionuclide	Content, % from total activity		
	2000	2001	2002
^{155}Eu	0,29	-	-
^{90}Sr	21,0	22,0	19,0
^{238}Pu	0,12	0,11	0,09
$^{239+240}$Pu	0,25	0,24	0,23
^{241}Pu	10,0	9,0	8,0
^{241}Am	0,47	0,39	0,44

Table 4.3.2 - Specific activity of ^{137}Cs in surface air items of radiation monitoring on EZ and OEA territory, 2002[4]

Observation point	Specific activity ^{137}Cs, Bq/m3			Relation of seasonal values of ^{137}Cs (summer / winter)
	minimum	maximum	average	
Distance up to CSFSF site - to 10 km				
Chistogolovka	$4{,}2\cdot10^{-6}$	$4{,}8\cdot10^{-4}$	$7{,}1\cdot10^{-5}$	3,7
Buryakovka	$5{,}4\cdot10^{-6}$	$6{,}7\cdot10^{-4}$	$7{,}6\cdot10^{-5}$	7,5
Distance up to CSFSF site from 10 to 20 km				
HVDS-750	$1{,}1\cdot10^{-4}$	$8{,}5\cdot10^{-3}$	$1{,}5\cdot10^{-3}$	1,2
Tank farm	$1{,}7\cdot10^{-5}$	$1{,}3\cdot10^{-2}$	$6{,}3\cdot10^{-4}$	0,6
CPS	$3{,}8\cdot10^{-5}$	$6{,}6\cdot10^{-3}$	$1{,}1\cdot10^{-3}$	1,5
Pripyat - LZD	$4{,}7\cdot10^{-6}$	$9{,}9\cdot10^{-4}$	$1{,}8\cdot10^{-4}$	1,9
Kopachi	$3{,}2\cdot10^{-6}$	$2{,}4\cdot10^{-4}$	$5{,}0\cdot10^{-5}$	3,2
Zimovishche	$2{,}0\cdot10^{-6}$	$3{,}4\cdot10^{-4}$	$5{,}8\cdot10^{-5}$	3,3
Starolesie	$2{,}5\cdot10^{-6}$	$2{,}1\cdot10^{-4}$	$3{,}7\cdot10^{-5}$	2,0
Benevka	$4{,}1\cdot10^{-6}$	$2{,}2\cdot10^{-4}$	$3{,}1\cdot10^{-5}$	2,5
Distance up to CSFSF site from 20 to 30 km				
Mashevo	$8{,}0\cdot10^{-6}$	$7{,}5\cdot10^{-4}$	$1{,}1\cdot10^{-4}$	3,7
Chernobyl	$2{,}1\cdot10^{-6}$	$1{,}5\cdot10^{-4}$	$3{,}1\cdot10^{-5}$	1,3
Dityatki	$2{,}0\cdot10^{-6}$	$3{,}7\cdot10^{-5}$	$1{,}3\cdot10^{-5}$	1,2

However, in separate years (for example, in 2000), because of specific weather conditions this ratio has considerably extended up to 2,0-5,7 [3].

The analysis of annual dynamics of contamination of ground layer of atmosphere at EZ and OEA shows that the amplitude of vibrations between minimum and maximum values can reach several orders of value (table 4.3.2). Thus, concentration of RN in the air correlates with indexes of humidity of air, amount of precipitation (during sampling) and wind speed. Under normal conditions of dust release, air pollution by RN is determined by condensation phase and under conditions of intensification of deflationary processes it was determined by finely dispersed fuel particles.

Autoradiography investigations of structure of radioaerosols at ChNPP industrial site during intensive relocation of dust (May, 2000) show that on the average in 1000 m^3 of air 105 "hot" particles with total activity 22 Bq are available. Thus, the range of activities of these particles varies from 0,0003 up to 76 Bq. On the contrary, during long fogs (November, 2000), on the same observation point it was

observed the significant reduction of their amount - 0,74 particles in 1000 m^3 with total activity 0,063 Bq, and a range of activities particles varied from 0,01 to 0,91 Bq [3].

Data on the analysis of cases of exceedance of controlled levels during one year (table 4.3.3) which were caused, mainly, by strong winds and man-caused reasons can be a vivid example of dynamism of radioactive contamination of ground layer of EZ and OEA atmosphere.

Table 4.3.3 - Cases of exceedance of controlled levels (CL) radionuclides contents in surface air of EZ and OEA in 2002[4,5]

ARMS	Number of cases	Concentration of ^{137}Cs, Bq/m^3	CL by ^{137}Cs, Bq/m^3	Exceedance of CL by ^{137}Cs, times	CL by RN sum, Bq/m^3	Exceedance of CL by RN sum, times
Tank farm	1	$1,3\cdot10^{-2}$	$1,0\cdot10^{-2}$	1,3	$1,5\cdot10^{-2}$	1,3
Chernobyl	5	$(0,81\text{-}3,1)\cdot10^{-4}$	$0,8\cdot10^{-4}$	1,0-3,8	$1,5\cdot10^{-4}$	0,8-3,0
Benevka	1	$2,2\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,0	$3,7\cdot10^{-4}$	0,9
Mashevo	5	$(2,1\text{-}7,3)\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,0-3,5	$3,7\cdot10^{-4}$	0,8-2,9
Buryakovka	3	$(2,5\text{-}6,7)\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,2-3,2	$3,7\cdot10^{-4}$	1,0-2,7
Chistogolovka	3	$(2,8\text{-}4,8)\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,3-2,3	$3,7\cdot10^{-4}$	1,1-1,9
Zimovishche	2	$(2,8\text{-}3,4)\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,3-1,6	$3,7\cdot10^{-4}$	1,1-1,4
Starolesie	1	$2,1\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,0	$3,7\cdot10^{-4}$	0,8
Kopachi	1	$2,1\cdot10^{-4}$	$2,1\cdot10^{-4}$	1,0	$3,7\cdot10^{-4}$	0,8

Chernobyl NPP, even after its shutdown continues to impact on radioecological condition of EZ and OEA. Dynamics of annual emissions ^{137}Cs and ^{90}Sr by plant for three last years (before ChNPP shutdown) which are registered by the remote monitoring system of volumetric activity in vent stacks of 1-st and 2-nd turn, is represented in section 3.1.2 of the entire EIA (ref volume 3, part 1).

Intensity of atmospheric fallouts of ^{137}Cs registered in the radiation monitoring points (ARMS) is represented in table 4.3.4, when it is visible that intensity of fallouts has a seasonal nature and considerably weakens in direction from center EZ and OEA to periphery.

Table 4.3.4 - Intensity of fallouts of ^{137}Cs from the atmosphere in the radiation monitoring points in 2002[4]

Observation point	Intensity of fallouts, Bq / m^2•day).			Ratio of seasonal intensity. (summer / winter)
	minimum	average	maximum	
Reference network of Shelter object(distance up to CSFSF site 12-13 km)				
1 km east	0,18	1,9	5,8	1,4
1 km south	0,47	3,4	12	3,3
3 km southeast	0,11	0,83	3,4	1,6
3 km southwest	0,14	2,0	5,9	3,0
Distance up to CSFSF site - up to 5 km				
Chistogolovka	0,082	0,52	2,6	1,3
Buryakovka	0,031	0,50	3,4	1,8
Vektor	0,071	0,31	0,92	2,0

Observation point	Intensity of fallouts, Bq / m^2•day).			Ratio of seasonal intensity. (summer / winter)
	minimum	average	maximum	
Distance up to CSFSF site from 5 up to 15 km				
Tank farm	0,42	8,2	56	0,63
3-n turn ChNPP	0,12	1,0	6,0	0,35
CPS	0,33	1,8	5, 5	1,6
Kopachi	0,040	1,2	4,7	3,3
Benevka	0,047	0,22	0,57	0,70
Distance up to CSFSF site from 15 up to 30 km				
Zimovishche	0,033	0,18	0,94	1,5
Starolesie	0,036	0,19	0,67	1,4
Mashevo	0,061	0,36	1,6	2,6
Chernobyl (ARMS)	0,043	0,89	2,2	2,3
Dityatki	0,043	0,16	0,76	1,4

CSFSF site is characterized by the same laws of origin and distribution of atmospheric contaminations, as EZ and OEA territory.

Specificity of CSFSF site is high frost-covering of adjoining territory (especially, in north and east directions) and advanced mesorelief that interferes with air pollution due to dust release at strong winds. Therefore, man-caused factors play the main role in formation of increased content of radioaerosols in air of CSFSF site measures on processing RAW, movement of motor transport, etc. Thus, prominent feature of man-caused impact is the tendency to increase in the content of 137Cs in radionuclide content of atmospheric fallouts [6].

For example, occurrence of incidental man-caused source of radioaerosols at ChNPP industrial site in 2001 has resulted in sharp 90-fold increase in concentration of ^{137}Cs in the air on the nearest points of ARMS "HVDS-750". During the same time, at points of ARMS "Chistogolovka" and "Buryakovka" (fig. 4.3.1) concentration of ^{137}Cs has increased, accordingly, in 23 and 7 times. Thus, meteorological conditions were characterized by regular settlements and sharp impulses of northwest wind [6].

Also, due to impacts of man-caused sources, concentration of ^{137}Cs in ground layer of air of RWDF "Buryakovka" in 2002 varied in the wide range $8{,}9 \cdot 10^{-5}$ - 1,2 Bq/m^3. If during one year its values there were within the limits of usual range for this point with the maximum value $7{,}6 \cdot 10^{-3}$ Bq/m^3; after open unloading of RAW (soil) radioactive air pollution of RWDF "Buryakovka" (fig. 4.3.1) has considerably increased. In sample of the air which was taken after RAW unloading on territory RWDF, concentration of ^{137}Cs has made 1,2 Bq/m^3 that in 120 times exceeds controlled levels specified for atmospheric air 10-km zone of ChNPP [4,5].

Under some incidental experimental data, in area of complex "Vektor" (fig. 4.3.1), the element structure of background radioactive fallouts includes from 4 up to 9 radionuclides. Thus, researched indexes were characterized by stability during 3 years of investigations, and 95 % of total volumetric activity fell ^{137}Cs and ^{7}Be (natural radionuclide of cosmogeneous origin) (table 4.3.4).

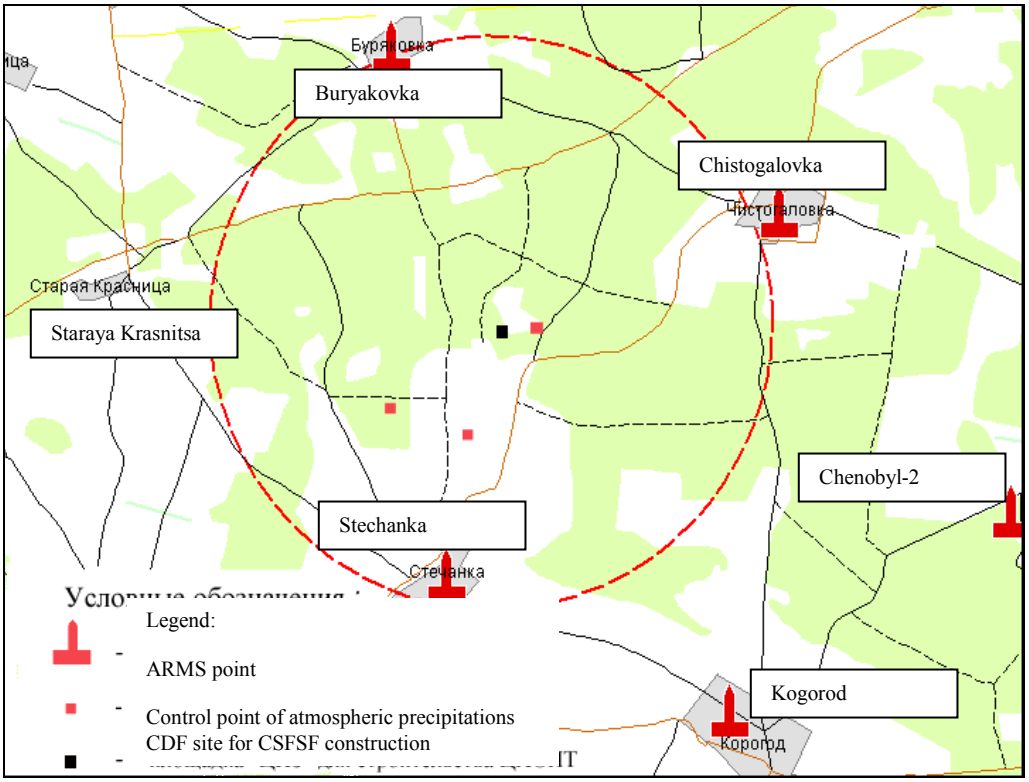

Figure 4.3.1 – Site - layout of observation points of system of the State monitoring of radiation conditions in 5-km area of CSFSF construction site, according to data [6].

Table 4.3.5 - Experimental data characterizing background values for ground layer of the atmosphere on construction site of CDF «Vektor», 2001-2002[7]

Index	**Radionuclide**	
	^{137}Cs	**^{7}Be**
Volumetric concentration (h=1,8 m above surface), Bq/m^3	$2{,}0\cdot10^{-3}$	$5{,}6\cdot10^{-3}$
Density of fallouts of radioaerosols (h=1,0 m above surface), Bq·m^2/sec	$10{,}7\cdot10^{-6}$	$5{,}2\cdot10^{-6}$

Therefore, taking into account close location of man-caused sources of radionuclides for description of ground layer of the atmosphere of CSFSF site it is necessary to take average Values of indexes of points of ARMS "Buryakovka" and "Chistogolovka" (tables 4.3.1, 4.3.2 and 4.3.4), taking place alee of area (table 4.3.6).

Table 4.3.6 - Description of ground layer of the atmosphere of CSFSF site, according to data [4]

Index	**Measuring units**	**Value**
Specific activity ^{137}Cs in air:		
- average	Bq/m^3	$7{,}4\cdot10^{-5}$
- maximum	Bq/m^3	$5{,}6\cdot10^{-4}$
- controlled level (CL) in air by ^{137}Cs	Bq/m^3	$2{,}1\cdot10^{-4}$
- ratio of seasonal values ^{137}Cs (summer / winter)	unit	5,6
The maximum specific activity in air on sum RN	Bq/m^3	$8{,}5\cdot10^{-4}$

Index	Measuring units	Value
Controlled level (CL) in air on sum RN	Bq/m^3	$3,7 \cdot 10^{-4}$
Intensity of fallouts ^{137}Cs from atmosphere:		
- average	$Bq / (m^2 \cdot day)$.	0,51
- maximum	$Bq / (m^2 \cdot day)$.	3,0
- ratio of seasonal values (summer / winter)	unit	1,6

4.3.2 Impacts During Normal Operation Conditions

During CSFSF normal operation, emission of radioactive aerosols is possible in the environment due to contaminations of external surface of multi-purpose canister (MPC).

Conservatively it was accepted that surface contamination is represented exclusively by ^{60}Co.

Taking into account the fact that under normal operation conditions of storage facility release of activity directly from the MPC is impossible, emission of radioactive substances in the environment is expected only during dust release from the contaminated external surface of MPC. The dust release can occur in two cases:

- During overloading the MPC from transport container HI-STAR in HI-STORM and subsequent emission of activity through the stack (height – 21 m) of the reception building of storage facility;
- Directly during storage of MPC in HI-STORM at storage area (emission through top ventilating openings of HI-STORM).

For calculation and modeling of RN spreading in the atmosphere at CSFSF emissions, the modified Gauss procedure recommended by IAEA (Attachment B) is used.

Besides during calculations of additional surface contamination of railway platform with HI-STAR due to travel on contaminated territory EZ and OEA was taken into account. Conservatively it was assumed that all surface contamination of site by ^{137}Cs (main dose generating nuclide) thrown out by in the environment through vent stack of reception building of CSFSF. During calculations of contamination of site it was accepted:

- The area of external surface of railway platform with HI-STAR – 90 m^2;
- Time of movement on territory EZ and OEA - 1 hour;
- The maximum intensity of fallouts ^{137}Cs from the atmosphere (in the most contaminated places along the travel way) - 3,4 $Bq / (m^2 \bullet day)$.

The design quantity of ^{137}Cs which entering CSFSF reception building as surface contamination of railway platform and thrown out in the environment will make no more than 190 Bq per year. It is necessary to note that this volume of released activity practically does not increase CSFSF radiation impact on the environment.

4.3.2.1 Emission of Radioactive Aerosols from Reception Building

The analysis of results of calculations of impacts on the air by emission through the stack of reception building demonstrates that the greatest possible value of volumetric concentration of radionuclide ^{60}Co (6 Bq/m^3) will be observed at a distance of 250 – 300 m from source (fig. 4.3.1) in surface air under normal operation conditions. Thus it is necessary to take into account that the radioactive emission from stack of reception building was accepted during calculations conservatively as instant, therefore the time of such radiation impact on the air will be short.

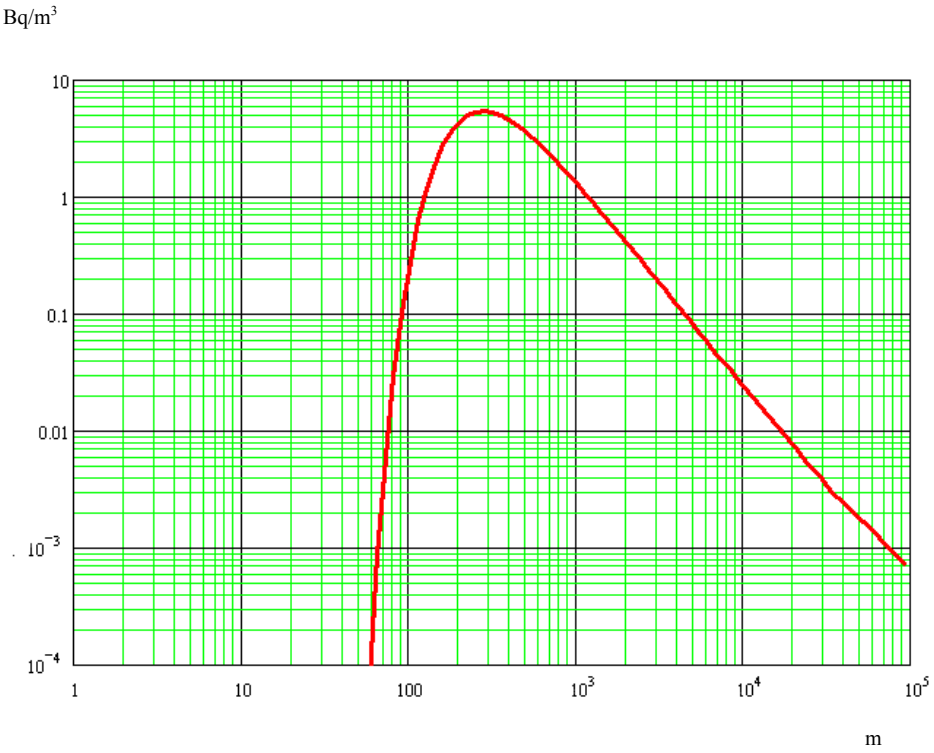

Figure 4.3.1 - Dependence of volumetric concentration of ^{60}Co (Bq/m^3) in the air from distance (m) up to CSFSF under normal operation conditions (emission from stack of reception building)

Under normal operation conditions of storage facility, the value of volumetric concentration of ^{60}Co on the nearest boundary of EZ and OEA (13 km in "south-west" direction) will make – 0,02 Bq/m^3 (fig. 4.3.1).

Taking into account the fact that permissible concentration of radionuclide ^{60}Co in air (PC_B^{inhal}) for the population of Ukraine makes 1 Bq/m^3 [NRBU - 97] thus concentration will not be exceeded under condition of normal operation of storage facility on boundary of residential territories.

4.3.2.2 Emission of Radioactive Aerosols from HI-STORM

Emission of radioactive substances from HI-STORM is possible also, as mentioned above, due to contaminations of external surface of MPC that results in generation and release of radioactive aerosols in the environment.

It was assumed that after installation of HI-STORM at storage area, all surface contamination of MPC comes in the environment within one year.

According to forecasting calculations the maximum of volumetric concentration of ^{60}Co in the surface air $6{,}0 \cdot 10^{-5}$ Bq/m^3 will be observed at distance of 50 – 70 m from the source (fig. 4.3.2).

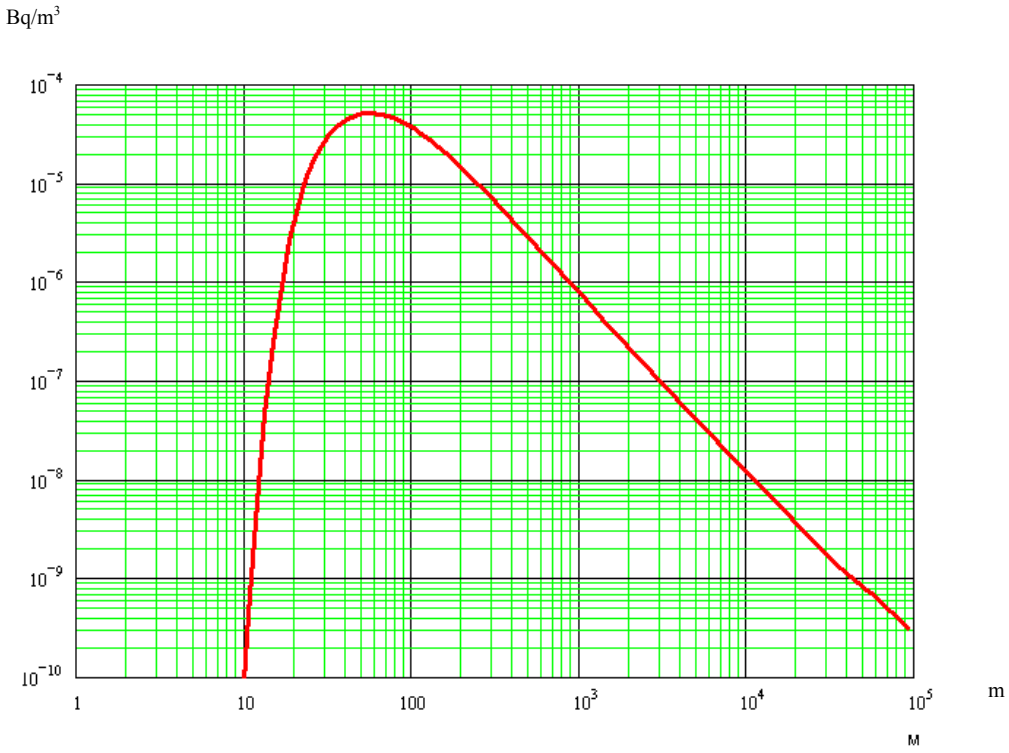

Figure 4.3.2 - Dependence of volumetric concentration of ^{60}Co (Bq/m^3) in the air on distance (m) to CSFSF under normal operation conditions (emission from HI-STORM)

At the distance 13 km from CSFSF the value of volumetric concentration of ^{60}Co will not exceed 8,0●10-9 Bq/m^3 (fig. 4.3.2) which is much less than the specified normative values.

Therefore, at CSFSF normal operation, irrespective of source and character of emission, the extent of radiation impacts on the air of territories where the population lives will not exceed the specified normative values.

4.3.3 Impacts During Design Accident with the Maximum Consequences

The most representative design accident is delivery of the MPC-31, having surface radioactive contamination which exceeds the specified permissible limits, to storage facility and its loading in HI-STORM. Thus it is necessary to note that the probability of this event is extremely small.

As well as in case of CSFSF normal operation (Subsection 4.3.2), it is conservatively assumed that emission is represented exclusively by radionuclide Co^{60}.

During assessment of impact on environmental air medium only emission from HI-STORM during storage at the storage site, as well as emission from reception building of storage facility is considered. Duration of emission for storage area makes 1 year; emission from reception building is momentary.

Calculation results of volumetric activity of ground layer of atmosphere due to spreading of emergency emission are represented in Figure 4.3.3.

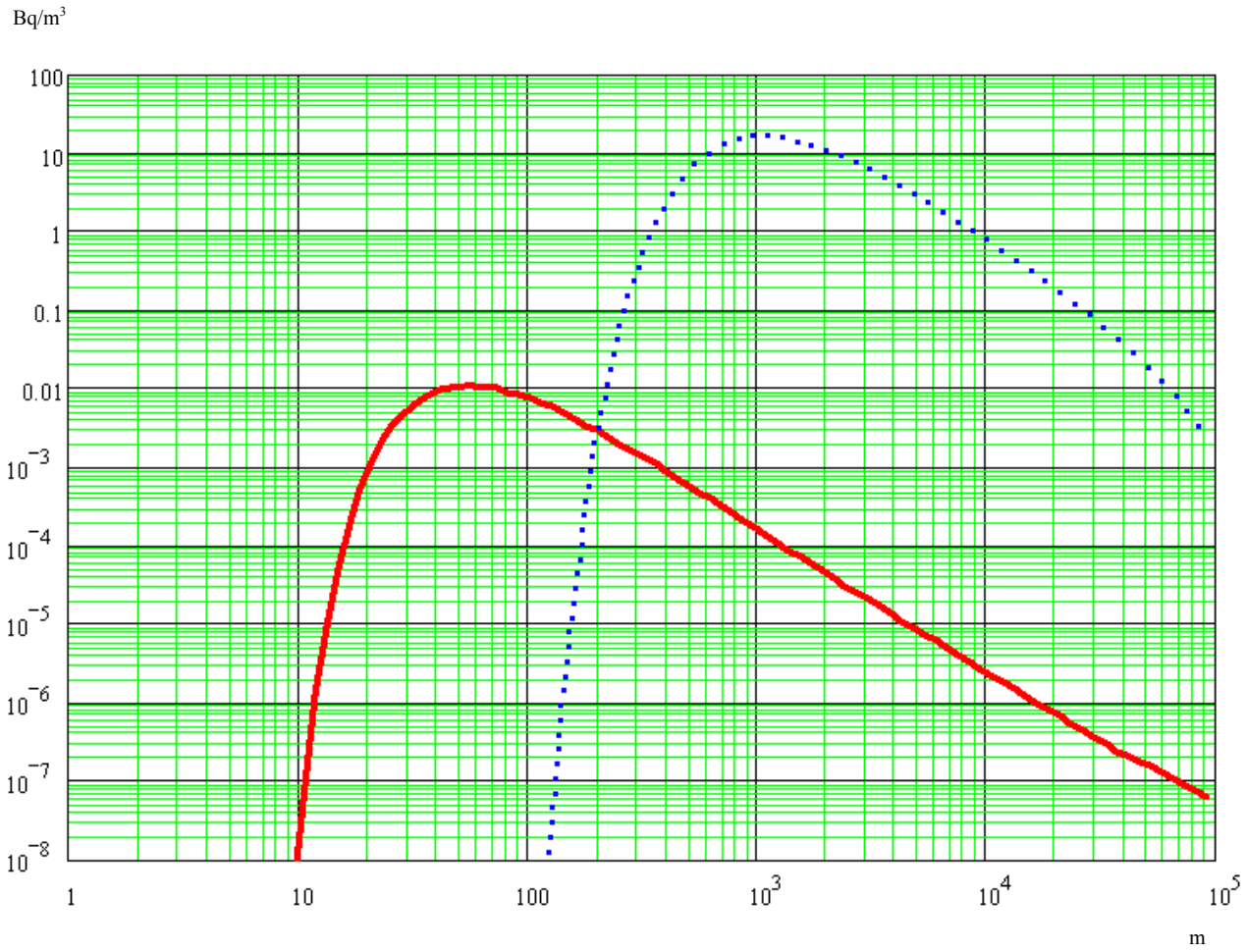

Figure 4.3.3 - Dependence of volumetric activity ^{60}Co (Bq/m^3) in the air from distance (m) up to CSFSF in case of MDBA. Red continuous line - emission from HI-STORM during 1 year, dark blue (dot) line - the volumetric activity average for 5 hours at instant emission from reception building.

The maximum value of volumetric concentration of ^{60}Co in air (16 Bq/m$^{3)}$ will be observed at a distance of 1,1 km from emission source. At the distance 13 km, values of volumetric activity ^{60}Co in air, due to possible MDBA will not exceed – 0,5 Bq/m^3 (fig. 4.3.3).

4.3.4 Impacts During Beyond Design Basis Accident

During licensing of technology of storage HI-STORM in USA, emission of radionuclides from depressurized MPC is considered according to NUREG/CR-6487 [31]. For assessment of consequences of accident, the spent nuclear fuel of USA reactors PWR with the maximum burning out 70,000 MWt-day/kgU was considered. The spent fuel was storied in fuel pool during 5 years with initial enrichment 4,8% of ^{235}U. Within the framework of accident consideration there was performed assessment of the influence of increase of pressure inside the MPC due to decay heat generated by spent nuclear fuel stored in MPC on value of leakage from MPC according to the requirements of ASME section III, subsection NB, taking into account performance of welds according to the regulation.

During accident assessment an increase of internal pressure in MPC up to 1,4 MPa, the leakage related to such pressure from MPC was considered. As the criterion of leakage at normal operation it is accepted leakage in $5x10^{-6}$ atm - cm^3/sec at internal pressure up to 0,69MPa which met the requirements of Data sheet of storage facility in the USA. Further increase of internal pressure up to 1,6 MPa was considered and the greatest possible leakage in $3,3x10^{-4}$ cm^3 / sec was assessed. Possible emission in the environment in view of contents of MPC and fractions of emission is regulated by NUREG-6487 [31] and is provided below:

- ^{85}Kr - 0,3;
- ^{60}Co – 1;
- ^{90}Sr, 134Cs, ^{137}Cs, ^{106}Ru – 2,0x10-4;
- ^{241}Pu, ^{144}Ce and other transuranium elements – $3,0x10^{-5}$.

The quantity of ^{60}Co is caused by the maximum surface activity of spent fuel assemblies. For spent fuel assemblies of reactors PWR in the USA according to NUREG-6487 [31] surface contamination of spent fuel assemblies by ^{60}Co makes $5,18x10^6 Bq/cm^2$.

According to NUREG-1536 [32] emission within 720 hours (30 days) is considered. It was assumed that a person will stay during 24 hours during 30 days at the distance 100 m from the emergency container. In this case all fuel assemblies in MPC will collapse and leakage in the environment makes $3,3x10^{-4}$ cm^3/sec.

Dependence of volumetric total activity of radionuclides in the air (during 30 days from the beginning of emergency emission) on distance up to emergency HI-STORM is represented in figure 4.3.4, and separate, most radiologicaly significant radionuclides, in figures 4.3.5-4.3.7.

Such accident is designed as absolutely hypothetical case of damage of all fuel rods in MPC with the subsequent release of gaseous fission products. It is impossible to determine any actual initial events which direct consequences would entail simultaneous damage of MPC and all fuel assemblies, taking place in it. Unique type of impacts on the module of storage HI-STORM which can result in simultaneous damage of the MPC and all fuel assemblies, is significant external dynamic impact (for example, as a result of application of special ammunition, etc.). The given accident is considered for demonstration of relatively insignificant radiation consequences of accidents in CSFSF even taking into account hypothetical initial events.

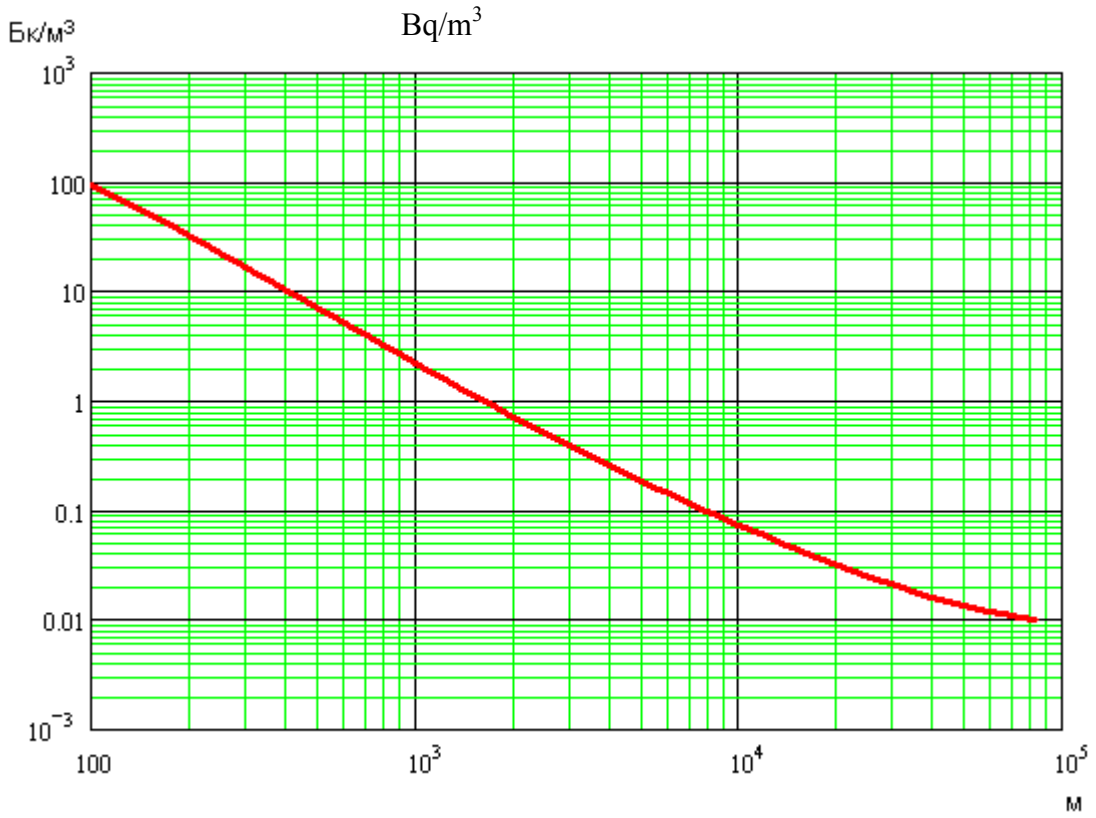

Figure 4.3.4 - Dependence of volumetric total activity of radionuclides in air (Bq/m^3) from distance (m) up to CSFSF in case of possible Beyond-Design-Basis Accident.

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

In case of occurrence of beyond design basis accident, the maximum value of total volumetric activity of radionuclides in the air at the distance 100 m from emergency HI-STORM will not exceed 100 Bq/m^3. Thus, at the distance 13 km (boundary of exclusion zone) this index will be characterized, accordingly, with much smaller values and will not exceed 0,05 Bq/m^3 (fig. 4.3.4).

Therefore, on the nearest boundary of residential territories (at the distance 13 km), volumetric activity of most radiologicaly significant radionuclides will not exceed the permissible limits specified by normative document NRBU - 97 (table 4.3.4).

Table 4.3.4 - Assessment of radiation impact on the air of residential territories due to Beyond-Design-Basis Accident in CSFSF

Radionuclide	Allowable concentration in air (NRBU - 97), Bq/m^3	Volumetric activity in air on the nearest boundary of EZ and OEA
^{137}Cs	0,8	$6{,}0\cdot10^{-4}$
^{90}Sr	0,2	$4{,}0\cdot10^{-4}$
TUE*	$4\cdot10^{-4}$	$1{,}4\cdot10^{-6}$

Note: * - conservatively assumed that all emission of TUE is represented by the most dangerous radionuclide ^{238}Pu.

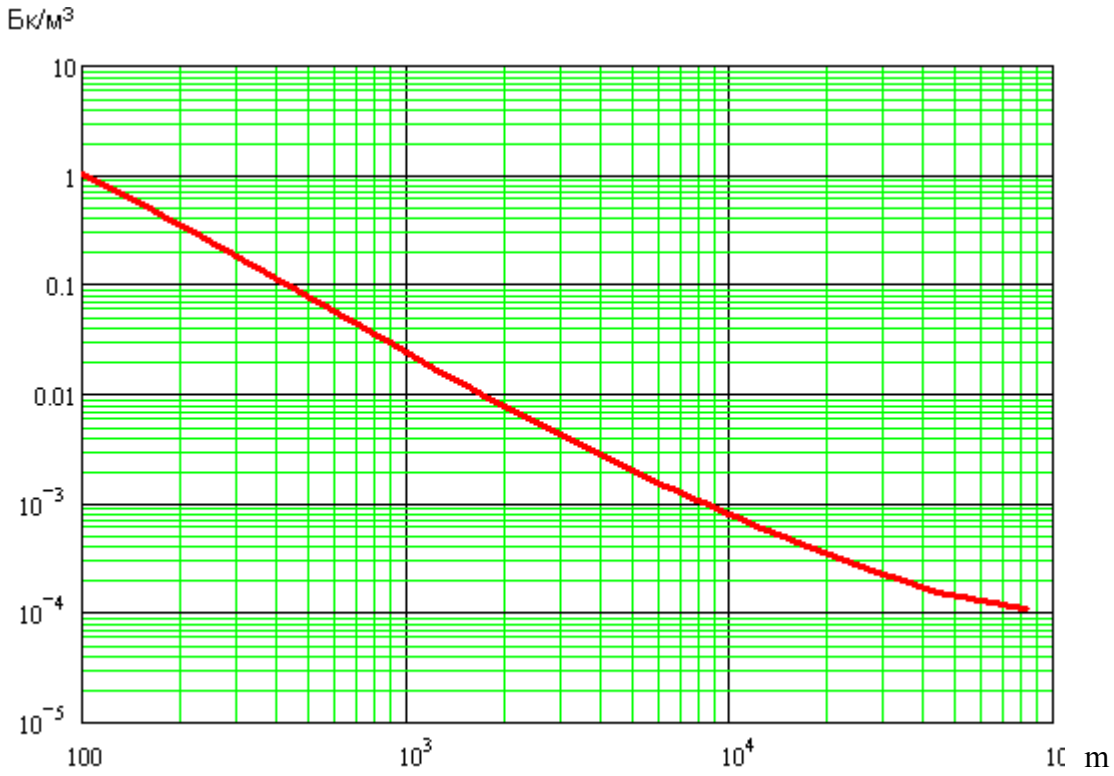

Figure 4.3.5 - Dependence of volumetric activity ^{137}Cs in air (Bq/m^3) generated due to Beyond-Design-Basis Accident from distance (m) up to CSFSF

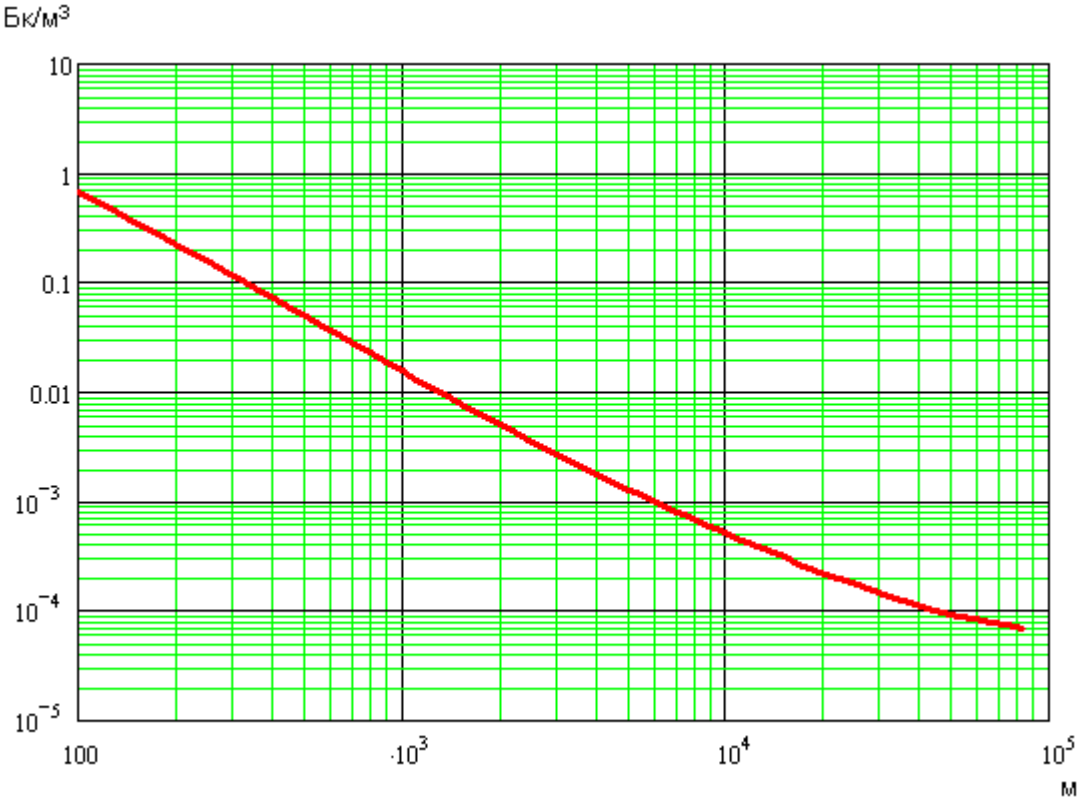

Figure 4.3.6 - Dependence of volumetric activity ^{90}Sr in air (Bq/m^3), generated due to Beyond-Design-Basis Accident, from distance (m) up to CSFSF

Legend: X-coordinate – m; Y-coordinate – Bq/m^3

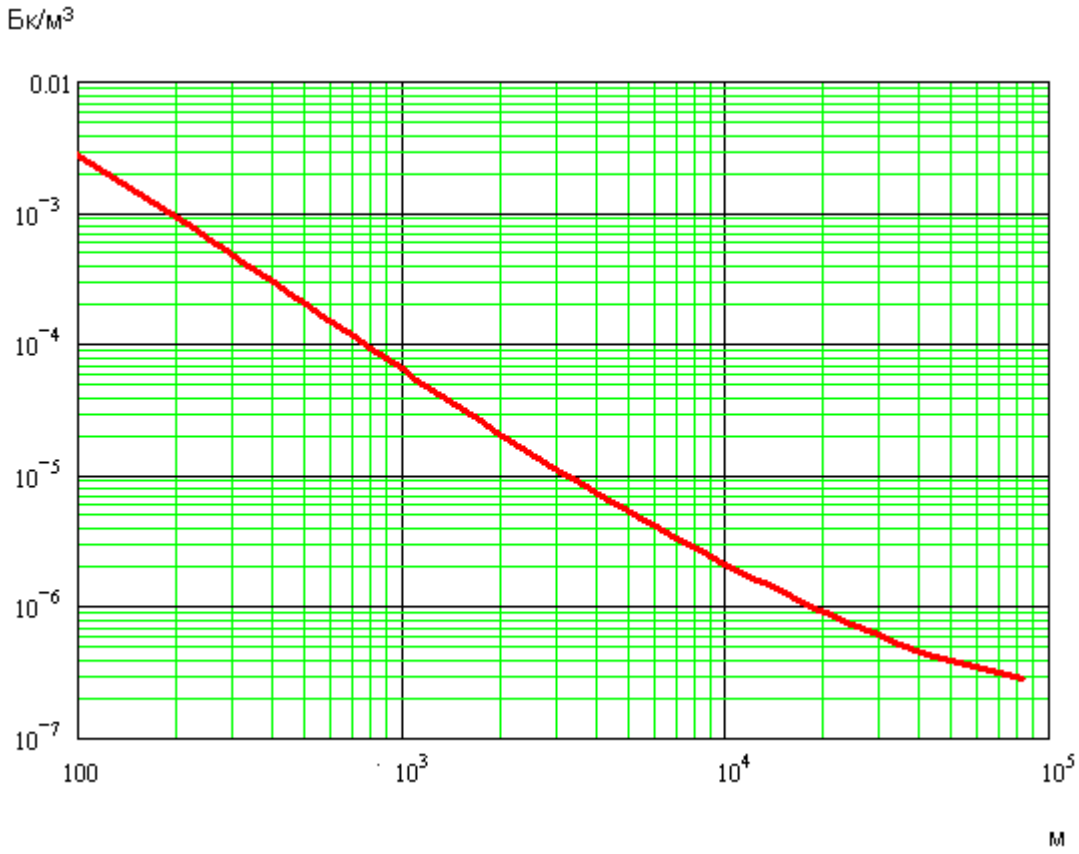

Figure 4.3.7 - Dependence of volumetric activity of transuranium elements in air (Bq/m^3), generated due to Beyond-Design-Basis Accident, from distance (m) up to CSFSF

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

Therefore, taking into account small probability of similar accident and relatively small value of volumetric total activity of radionuclides in the air, radiation impacts of emergency emission due to Beyond-Design-Basis Accident shall be considered as accepted.

4.3.5 Brief Conclusions of Impact on the Air Ambient During Operation

Normal operation conditions. Under normal operation conditions of storage facility, the maximum radiation impact on the air ambient is possible at short-term emission from stack of reception building at the moment of extraction of MPC from HI-STAR. Thus, value of volumetric air pollution by ^{60}Co will reach 6 Bq/m^3 at distance of 250 - 300 m from reception building. On the nearest boundary of EZ and OEA (13 km in "south-west" direction) volumetric activity of ^{60}Co will not exceed 0,02 Bq/m^3.

In case of long emission of activity from HI-STORM at storage area (more probable scenario), the maximum concentration of ^{60}Co will not exceed $6{,}0 \cdot 10^{-5}$ Bq/m^3 at distance of 50 – 70 m from CSFSF. Thus, on the nearest boundary of EZ and OEA (13 km in "south-west" direction) volumetric activity of ^{60}Co will not exceed $8 \cdot 10^{-9}$ Bq/m^3.

Taking into account that permissible concentration of radionuclide ^{60}Co in air (PC_B^{inhal}) for the population of Ukraine is equal to 1 Bq/m^3 [NRBU - 97], under normal operation conditions of storage facility, it will not be exceeded on boundary of residential territories.

The design quantity of ^{137}Cs which gets in CSFSF reception building as surface contamination of railway platform and thrown out in the environment does not exceed 190 Bq in one year that practically will not affect change of radiation conditions in adjoining territories.

Therefore, at CSFSF normal operation, irrespective of source and character of emission, the extent of radiation impacts on the air of territories where the population lives will not exceed the specified normative values.

Design Basis Accident with the maximum consequences. At the most representative design accident (instant emission of activity from reception building, due to above permitted standard contamination of surface of multi-purpose container), the maximum values of volumetric concentration of ^{60}Co in air (average for 5 hours) will reach 16 Bq/m^3 and will be observed at distance of 1,1 km. Therefore, on the nearest boundary of EZ and OEA (13 km in "south-west" direction), values of volumetric concentration of ^{60}Co will not exceed 0,5 Bq/m^3.

Therefore, radiation impact on surface air at the maximum design accident in CSFSF will not result in exceedance of permissible concentration of 60Co (1 Bq/m^3) in air on boundary of EZ and OEA.

Beyond Design Basis (hypothetical) Accident. Due to accidents, the maximum value of volumetric total activity of radionuclides in air, at distance of 100 m from emergency HI-STORM, will not exceed 100 Bq/m^3. Thus, on the nearest boundary of EZ and OEA (removal - 13 km), this index will be characterized much by smaller values – 0,05 Bq/m^3 of total activity.

Taking into account small probability of similar accident and relatively small value of volumetric total activity of radionuclides in air of residential territories, due to Beyond-Design-Basis Accident, it is necessary to consider radiation impacts of emergency emission acceptable.

4.4 Assessment of Impact on Water Media

4.4.1 Radioactive Contamination of Water Media at CSFSF Site

4.4.1.1 Radioactive contamination of surface waters

As a result of Chernobyl accident, practically all water objects near 10-km zone of ChNPP were contaminated and still being contaminated with emergency fallouts.

At the present moment, water objects (rivers, streams, lakes, artificial ponds, backwaters, channels and waterways) play the main role in redistribution of radionuclides in environmental natural environment on territory EZ and OEA. Radioactive substances, dissolve thawed, rain or freshet waters migrate with an intrasoil effluent in ground waters, are washed off by surface streams in the rivers and lakes. Thus, ^{137}Cs and ^{90}Sr bring the main contribution to formation of radiation contamination of surface waters. Since 1988, the fraction ^{90}Sr in river waters constantly grows, and last years, it makes 60-75 % of their total activity [4]. Dynamics of removal of ^{90}Sr is represented by main waterways of EZ and OEA in table 4.4.1.

Table 4.4.1 - Removal of ^{90}Sr main waterways EZ and OEA and other sources in 1998-2002[4]

Facility - range	Removal of 90Sr, (n 10^{12}) Bq				
	1998	1999	2000	2001	2002
river Pripyat (input in 30-km area)	2,58	3,21	1,71	1,29	0,51
river Sakhan	0,06	0,04	0,02	0,05	0,01
Effluent from a left-bank polder	1,50	1,39	0,35	0,57	0,17
Filtration streams cooling pond	0,17	0,10	0,09	0,10	0,07
river Glinitsa	0,24	0,28	0,21	0,21	0,15
Filtration from ChNPP cooling pond	0,40	0,40	0,40	0,40	0,40

Facility - range	Removal of 90Sr, (n 10^{12}) Bq				
	1998	1999	2000	2001	2002
Filtration from backwaters, intake of ground water, intake from flood-plain	1,42	4,78	0,58	0,52	0,34
river Pripyat - Chernobyl	6,37	10,2	3,36	3,14	1,65
Intake 90Sr in river Pripyat in boundaries 30-km zone, (n 10^{12}) Bq / contribution of 30-km zone, %	3,79/59	7,0/69	1,65/49	1,85/59	1,14/69
River Uzh	0,49	0,27	0,14	0,20	0,04
river Braginka	0,51	0,28	0,13	0,22	0,08
Total outtake in the Kiev reservoir: river Pripyat + river Uzh + river Braginka	7,37	10,80	3,63	3,56	1,77

Reservoirs of the exclusion zone are not used for the household purposes. However they are located inside places of residing and work of the personnel of exclusion zone and consequently the permanent control of their sanitary, chemical and bacteriological condition is carried out. Concentration of 137Cs and 90Sr in water of waterways and reservoirs EZ and OEA are represented in table 4.4.2.

Table 4.4.2 - Concentration of 137Cs and 90Sr in water of waterways and reservoirs EZ and OEA in 2001[6]

Facility and observation point	^{137}Cs, kBq/m^3			^{90}Sr, kBq/m^3		
	minimum	maximum	average	minimum	maximum	average
river Pripyat (Dovlyadi)	0,04	0,20	0,10	0,02	0,27	0,09
river Pripyat (Chernobyl)	0,03	0,38	0,12	0,10	0,53	0,23
River Uzh (Cherevach)	0,03	0,22	0,09	0,06	0,53	0,18
river Braginka (a dam №39)	0,21	2,90	1,30	0,73	3,10	1,7
river Sakhan It (Novo-Shchepelichi)	0,11	0,65	0,22	0,45	7,40	1,50
Reservoir - cooler (ChNPP)	0,23	7,6	2,10	0,28	3,50	1,50
river Glinitsa	0,15	0,57	0,31	1,60	7,70	4,60
Semikhody backwater	0,50	1,80	1,30	10	23	16
Pripyat backwater	1050	4,00	2,70	17	37	26
Azbuchin lake	6,10	12	9,90	100	120	110
Discharge channel of 3-turn ChNPP	150	240	190	12	48	38
Polder near Zimovishche	1,40	7,20	3,90	1,50	43	16
Lake Glubokoe	2,40	11	7,10	59	96	79

In southwest sector distant 10-30-km zone of CSFSF site the largest waterway is river Uzh with inflows - river Ilya and river Veresnya.

CSFSF site is located in area of raised water-separate plateau of river Pripyat and its inflows - river Sakhanand and river Uzh. Practically, in 10-km zone of area there are unavailable large waterways from which inundated areas washout of radionuclides is possible during high water (ref. table 4.4.2).

By set of the landscape factors determining carrying out of substances by water, surface effluent represents the greatest danger in 10-km zone of CSFSF site. However, lack of sharp differences of heights in relief, domination in topsoil sandy soils and high percentage of forest land area considerably weaken development of surface effluent. Therefore, the main form of migration of radionuclides in this

area is the intrasoil effluent and wind erosion which is possible in thinly populated southern sector 10-km zone of CSFSF site. Besides 10-km zone of the site from southwest and northwest is bordered by areas of bogs which regional areas are accumulative areas of local landscapes and biogeochemical barriers on the way of further migration of radionuclides.

Brief radioecological description of main waterways of east, southern and western sectors of 30-km zone of CSFSF site is represented in tables 4.4.3 and 4.4.4. Based on data of tables it is visible that values of removal of 90Sr are determined by complex interaction of various factors and frequently do not depend on value of annual river effluent.

Table 4.4.3 - Description of removal of 90Sr by river effluent in CSFSF site in years of various water content [13]

The river and line(range) of observation	**Removal of ^{90}Sr on 1 km^2 reservoir, GBq/year**		
	shallow year (1995)	**year of average water content (1996)**	**year of high water content (1999)**
river Ilya (Rudnya-Ilienetskaya)	0,08	0,22	0,08
Rive Uzh (Cherevach)	0,02	0,04	0,03
river Sakhan (Novo-Shchepelichi)	0,50	0,08	0,21

Table 4.4.4 - Value of effluent and removal of ^{90}Sr by waterways in CSFSF site in a year of increased water content, 1999 [13]

River and range of observations	**Drainage area, km^2**	**Initial stock ^{90}Sr on reservoir, TBq**	**Effluent, mln.m^3/year**	**Removal of ^{90S}r, TBq**
river Ilya (Rudnya-Ilienetskaya)	381	13	40,6	32
River Uzh (Cherevach)	8080	290	1011	236
river Sakhan (Novo-Shchepelichi)	200	328	19,4	41

4.4.1.2 Radiation contamination of ground waters

Processes of migration of radionuclides within the limits of aeration zone and the water-saturated thickness of topsoil (as against their behavior in the air and surface waters) are characterized by slowness and inertness. Speed of vertical migration through aeration zone does not exceed several m one year, and horizontal speed on stream groundwater – up to 30-40 m a year.

Contamination of ground waters of aquifers of eocene and senoman lower cretaceous deposits by radionuclides of emergency emission ChNPP authentically is not registered.

The first from surface of CSFSF site aquifers of quaternary deposits is combined by sand of different granulometric composition with "island" layers of sandy loam and loams of small capacity. The level of unconfined groundwater is available on depth from 11 to 20 m. Direction of movement of stream groundwater - northwest, towards river Pripyat with the slope angle 0,002 [12].

Water confining stratum for quaternary aquifers are represented the Kiev clays with average with the thickness of 6,9 m and filtration ratio 10-2-10-4 m/day [12].

Main laws of formation of radioactive contamination of ground waters with radionuclides in CSFSF site are the same, as for ChNPP site. The area nearest to RWDF "Buryakovka" carrying out monitoring of ground waters contamination is available at the distance 1,1 km (fig. 4.4.1).

Groundwater contamination of this area can characterize their contamination in area of CSFSF site (table 4.4.5), however it is necessary to take into account influence on level of contamination of waters of radionuclides from RWDF and possible contaminations at drilling a borehole.

Table 4.4.5 - Seasonal vibrations and average values of radionuclides content in groundwaters quaternary aquifer RWDF "Buryakovka" 2001 [6]

No of borehole	^{137}Cs, kBq/m^3			^{90}Sr, kBq/m^3		
	minimum	maximum	average	minimum	maximum	average
RWDF "Buryakovka"						
5	0,04	0,06	0,05	0,18	0,72	0,43
14	0,03	0,07	0,05	0,16	0,31	0,24
22	0,04	0,18	0,08	0,17	0,32	0,24
35	0,02	0,08	0,04	0,09	0,44	0,24
53	0,02	0,06	0,04	0,08	0,33	0,18
Average by boreholes	0,03	0,09	0,05	0,14	0,42	0,27
Sampling in 1993						
Average by boreholes	-	-	0,18	-	-	0,33

By design data [12,14], forecasting radioactive contamination of ground waters at the site does not render adverse impact on contamination of water of the rivers Pripyat and Uzh which are available at distance 12 and 11 km during 300 years.

4.4.2 Impact on Surface Waters

4.4.2.1 Impacts under normal operation conditions

The analysis of spreading of radioactive emissions in the air has shown that under normal conditions of CSFSF operation surface contamination of territories (on distances more than 1 km) will make 100 fractions of percent from the existing contamination caused by emergency emission from ChNPP. Based on these results and taking into account that surface reservoirs are located at great distance from CSFSF (river Uzh – 6-8 km, river Sakhan about 7 km, river Pripyat – 12 km), volumetric concentration of radioactive substances in water of the specified reservoirs caused by CSFSF will be lower than levels of authentic detecting.

It is also necessary to take into account that water collecting territories of the nearest to the CSFSF rivers Uzh and Sakhan mainly are relatively leveled, forest-covered territories which have no surface effluent which is the main source of intake of radioactive substances from water collecting territories. A significant part of water collecting territories is boggy, and, as a matter of fact, they are natural biogeochemical barriers on the way of spreading of radioactive substances.

Being based on this fact it is possible to conclude that at intake of radioactive substances on water collecting territories under normal conditions of CSFSF operation, their direct transport in the rivers will be considerably limited by the existing biogeochemical barriers.

Taking into account all these factors it is possible to draw a conclusion that main impact on surface reservoirs will appear, mainly, due to the direct intake of radioactive substances on surface of reservoirs.

Taking into account the aforesaid it is possible to conclude that under normal conditions of CSFSF operation it will not be impact on surface waters.

4.4.2.2 Impacts under accidents

Maximum design basis accident (MDBA). During assessment of MDBA impacts on surface waters it was conservatively assumed that a part of the activity thrown out in the air which are taking place after accident above the nearest area of river Pripyat (distance 13 km) will settle on its surface and will be drifted outside the limits of EZ and OEA. At that, value of the greatest possible sedimentation of ^{60}Co on surface of river Pripyat will not exceed $5{,}6 \cdot 10^6$ Bq. This is a negligibly small value in comparison with total annual of removed activity with effluent of river Pripyat (up to 10^{13} Bq on the sum of radionuclides).

Therefore, radiation impacts on water media in case of possible MDBA will be insignificant.

Beyond design basis (hypothetical) accident (BDBA)**.** It is assumed that the maximum radiation impact on surface waters due to BDBA is possible at sedimentation of radioactive substances on top area of delta river Pripyat. This area has width of water surface mirror (flooded flood-plain), approximately, 1000 m and located at distance 20 km from CSFSF (southeast direction). On design data, along axis of emission sedimentation plume it is expected $4{,}3 \cdot 10^5$ Bq of total activity that is insignificant impact in comparison with value of annual total activity with effluent river Pripyat (up to 10^{13} Bq). Taking into account that current concentration of radioactive substances in river Pripyat does not exceed the value of permissible concentration for potable water, radiation impacts on surface waters at possible BDBA in CSFSF are also will not result in essential increase of their concentration in water of river Pripyat. Therefore, radiation impacts due to BDBA on surface waters should be considered as permissible.

4.4.3 Impacts on Ground Waters

4.4.3.1 Normal operation condition

Radioactive contamination of ground waters during CSFSF operation is possible only due to vertical migration of the radionuclides which have dropped out on topsoil surface. Results of calculations show that at active operation (annual loading with spent nuclear fuel) of facility during 50 years, the maximum additional surface topsoil contamination by ^{60}Co will not exceed 600 Bq/m^2 (without taking into account a half-life period of ^{60}Co – 5,27 years). Levels of groundwater occurrence in area of construction site are at the depth 18 - 21 m (see section 2.1.5). At average speed of vertical migration of radionuclides in soils EZ and OEA - 0,1-1,5 cm / year, intake ^{60}Co in ground waters at CSFSF normal operation can be neglected.

4.4.3.2 Maximum Design Basis Accident

Intake of ^{60}Co in ground waters, due to surface contamination of soils at MDBA, is excluded due to low speed of vertical migration and relatively small half-life period (5,27 years) of this radionuclide.

4.4.3.3 Beyond Design Basis (hypothetical) Accident (BDBA)

In case of BDBA intensity of processes of contamination of ground waters will be determined as level of groundwater occurrence, and level of the additional surface contamination dependent on distance up to point of emission.

CSFSF site is located on the leveled plateau with deep groundwater occurrence (above 18 m), and where the large closed downturn of relief whose surface contamination eventually can result in their essential contamination are unavailable in radius 2 - 3 km.

Taking into account that the greatest (comparable with background) surface contamination of soils due to BDBA will be observed in radius only up to 300 m from CSFSF industrial site (see section 4.5) at possible BDBA in CSFSF essential additional contamination of ground waters will not take place.

4.5 Assessment of Impacts on Topsoil

4.5.1 Radioactive Topsoil Contamination at CSFSF Site

Man-caused radioactive contamination of soils in EZ and OEA is represented by mix of radionuclides (RN) ^{90}Sr, ^{137}Cs, ^{154}Eu, $^{238-241}Pu$ and ^{241}Am taking place in various physical and chemical forms and ratio.

General content of RN in soils of EZ and OEA for 01.01.2000 (except for RN in disposals RAW, and ChNPP cooling pond) makes territories of industrial site [15]:

^{90}Sr – $7{,}7 \cdot 10^{14}$ Bq;
^{137}Cs – $2{,}8 \cdot 10^{15}$ Bq;
^{154}Eu – $1{,}4 \cdot 10^{13}$ Bq;
^{238}Pu – $7{,}2 \cdot 10^{12}$ Bq;
$^{239+240}Pu$ – $1{,}5 \cdot 10^{13}$ Bq;
^{241}Am – $1{,}8 \cdot 10^{13}$ Bq.

Spatial distribution of density of contamination of EZ and OE topsoil by various RN is represented in figures 4.5.1-4.5.3 Prominent feature of distribution of density of radioactive contamination are its high values on territory near 5-km areas ChNPP and extended areas, so-called, "traces" of the emergency fallouts extended in western, southwest and northern directions.

Essential distinctions between fields of contamination of EZ and OE territory by ^{137}Cs and ^{90}Sr are visible. For example, availability of wide soft contrast of "northern" fallout trace of ^{90}Sr as against well defined "northern" trace ^{137}Cs (fig. 4.5.1, 4.5.2). On the contrary, between distribution of density of contamination of territory ^{90}Sr and transuranium elements (TUE) full qualitative correlation (fig. 4.5.3 and 4.5.4) is observed. Last circumstance is explained by the fact that more than 90 % of total activity of ^{90}Sr and TUE was thrown out from emergency reactor in structure of fuel particles [16].

In case of increase of the distance from emergency power unit of ChNPP, the average density of contamination of surface gradually decreases. The range of variation of density of contamination for 10-km zone makes - 0,4-40 MBq$^{137}Cs/m^2$ and 0,09-16 MBq $90Sr/m^2$. For 30-km ChNPP zone values of contamination density are in interval 20-260 kBq of $^{137}Cs/m^2$ and 2-190 kBq of $90Sr/m^2$.

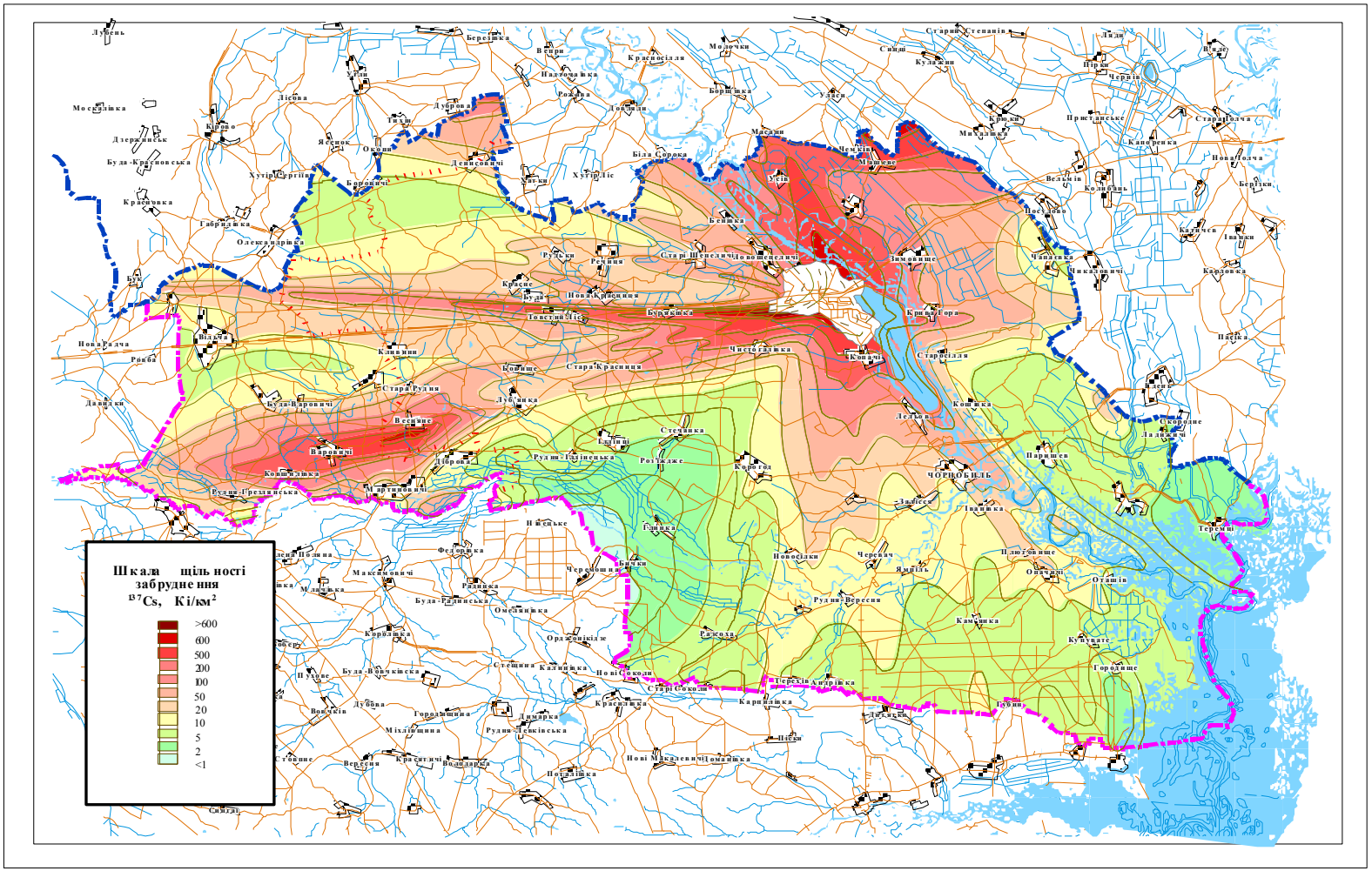

Figure 4.5.1 - Diagram of contamination of EZ and OE territory by ^{137}Cs (as of 01.01.2000), according to data [17]

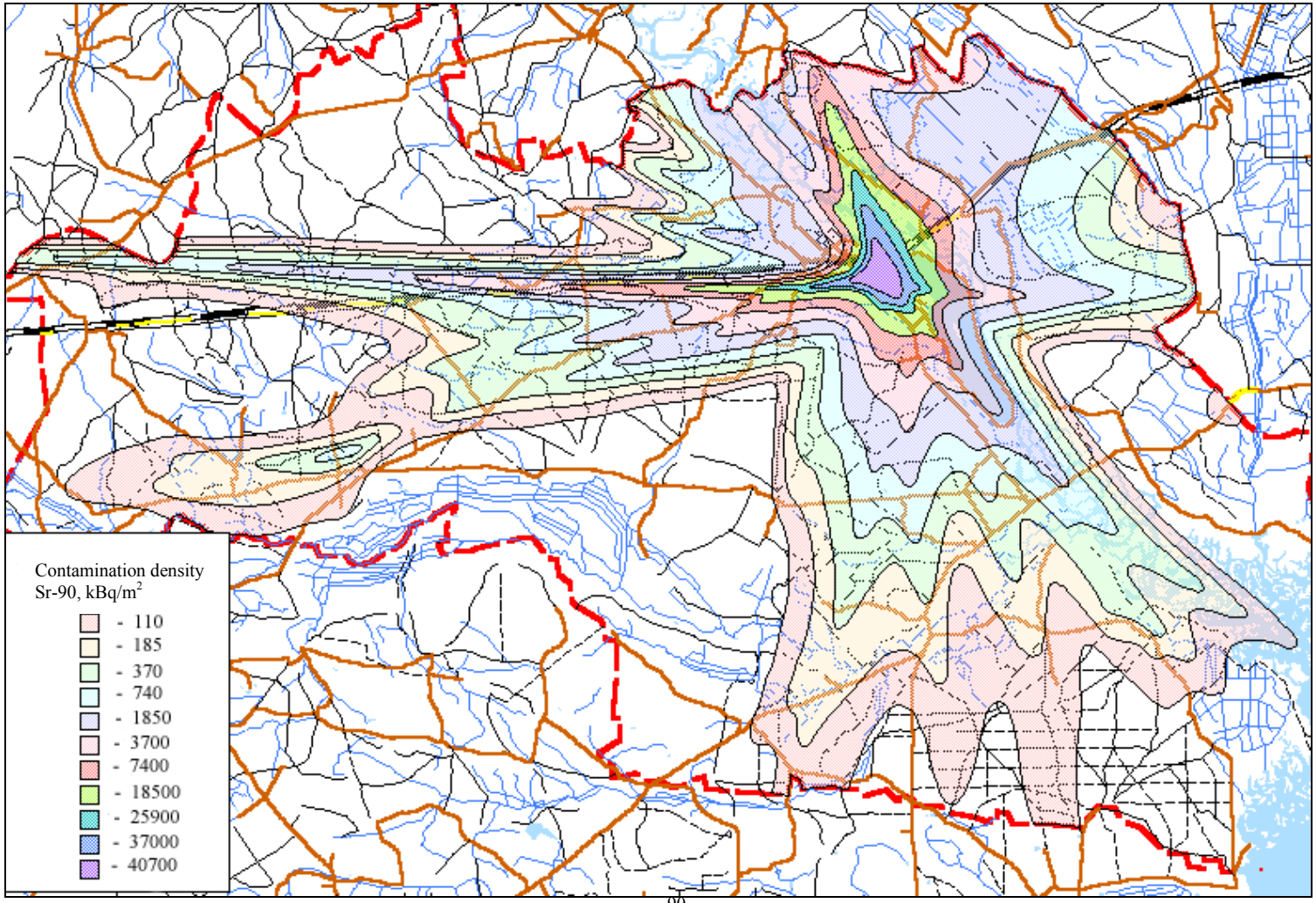

Figure 4.5.2 - Diagram of contamination of EZ and OE territory by ^{90}Sr (as of 01.01.2000), according to data [17]

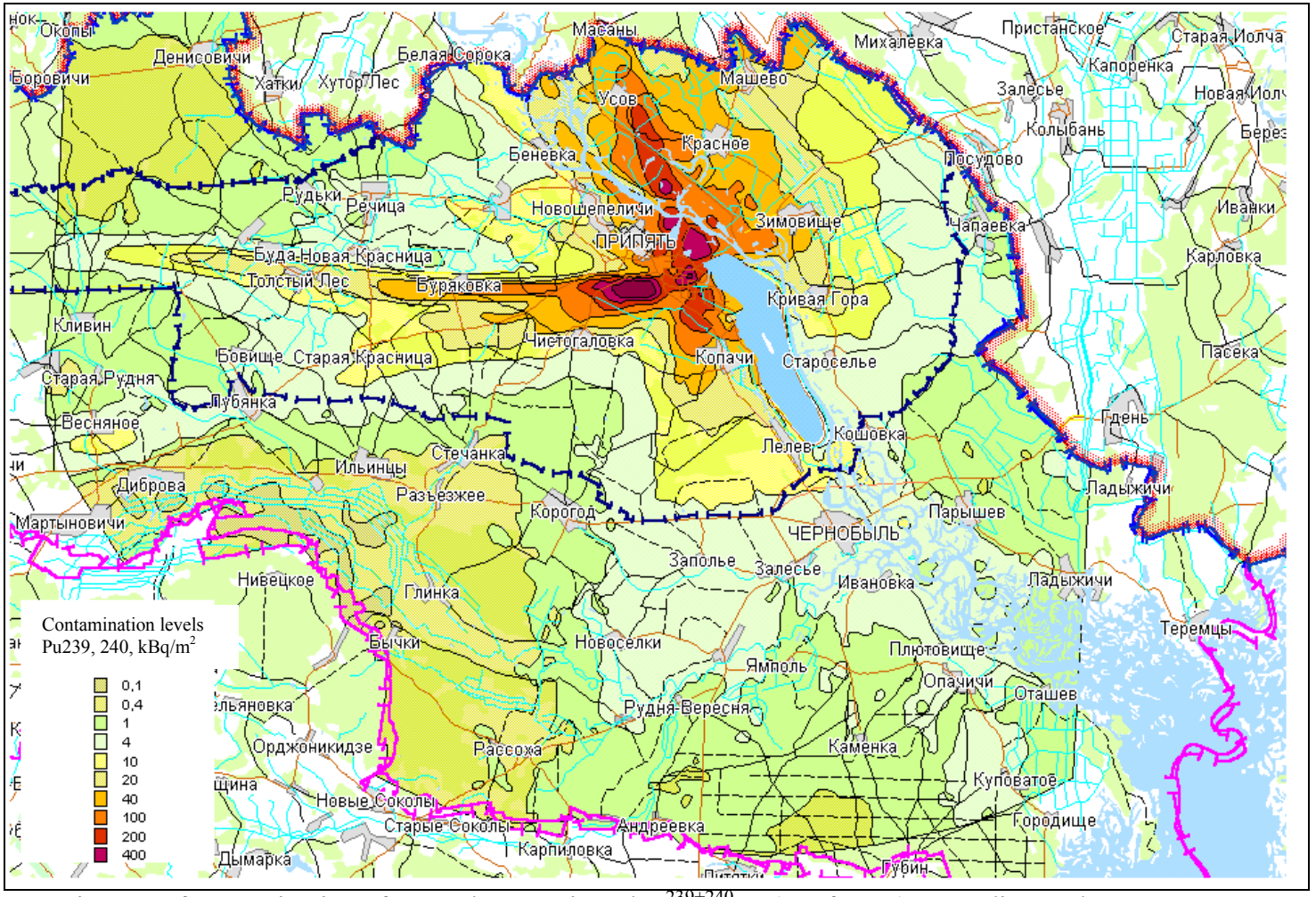

Figure 4.5.3 - Diagram of contamination of EZ and OE territory by $^{239+240}$Pu (as of 2000), according to data [17]

According to numerous data, 90-95 % of emergency contaminations total activity (geometrical center of reserve) is concentrated at a distance 5-10 cm from topsoil surface (including forest underlayer) [16, 18-23].

Vertical migration of RN occurs due to processes of diffusion, lessivage (mechanical displacement with current of water) and biogenic migration. Thus, ^{90}Sr is more active geochemical migrant in comparison with ^{137}Cs. The main part of ^{90}Sr is available in cationic exchange form and related to organic matter of soils. Therefore, the expressed maximum of the content in top humid soil horizon with the subsequent sharp fall of concentration in mineral horizons is typical for ^{90}Sr. On the contrary, the main part of ^{137}Cs is represented by non-exchange forms and the curve of its distribution on the vertical structure of soils comes nearer to exponential law.

Transuranium elements have the least migratory ability in landscapes EZ and OEA and, as a rule, they are lumped only in top 0-10-cm layer of topsoil. Thus, 85-97 % of their stock TUE are available in top (0-5 cm) layer. Migratory ability of TUE is identified by extent of development of the lessivage phenomenon of "hot" particles, intensity of biogenic relocation, quantity and quality of organic matter of soils.

Initial radioactive environmental contamination occurred by air relocation and sedimentation of RN on topsoil, vegetative cover, water objects and etc. In their main bulk the RN were released into the air in structure of disperse fuel materials (fuel fragments) and their mix with inactive carriers.

Fuel containing component of emission consist of particles of dispersed fuel (UO_2, UO_3, U_3O_8 and another stoichiometric content) and particles of composite structure with impurity of inactive carriers (graphite, constructional materials of destroyed reactor, concrete of protection, materials of emergency backfilling, etc.).

In steam and gas phase of emergency emission, except for short live gaseous radionuclides, partially there occurred isotopes of cesium and ruthenium which also were deposited on underlying surface in structure of radioactive particles mononuclide composition. Formation of radioactive cesium particles occurred at condensation of cesium vapors on atmospheric nucleus of condensation (dust, particles of smoke, etc.).

Fuel containing materials have generated contamination mainly nearby ChNPP zone, and steam and gas phase (with impurity of fine disperse fractions of fuel fragments) - distant zone. Average value of ratio fuel and condensation components of fallouts nearby ChNPP zone varies in the range of values 5-8 units [18].

The most important value for development of radiation conditions in CSFSF site has stability of "hot particles" in the environment. Three types of particles are allocated by extent of stability [24]:

- U-Zr-O - very stable, insoluble particles in natural conditions (20±10 % of activity, constant value of transformation k=0 year $^{-1}$);
- UO_2 - particles dispersed nuclear fuel (60±10 % of activity, constant value of transformation k=0,029 year $^{-1}$);
- UO_{2+X} - the least stable particles (20±10 % of activity, constant value of transformation k=0,43 year $^{-1}$).

Distribution of permanent transformation of "hot particles" on EZ and OE territory shows that the steadiest physical and chemical forms of fallouts are lumped on its periphery, in areas of the "west" and "southwest" traces of emergency fallouts (fig. 4.5.1-4.5.3).

Under influence of natural processes and phenomena, there is a continuous autopurification of landscapes and redistribution in them activity due to radioactive decay, lateral and descending vertical migration of RN, deposited in the top layer soils. For example, for the first 10 years after accident, activity of 137Cs in top 10-cm layer of topsoil has decreased on 20-50 % from initial value [16].

In result lateral migration which is shown on 5-10 % of EZ and OEA territory, the secondary accumulation of RN occurs in lowered areas of relief. Secondary accumulation occurs due to material which is washed off during spring snow melting or during storm rains from

environmental slopes and eminences. Border parts of marshes, microbowls and internal-drainage basins, bottoms and cones of hollows and other similar landforms are the areas of secondary accumulation in EZ and OEA landscapes in landscapes. Since the initial moment of accident, the density of surface contamination in similar places could increase from 2 up to 5 times by various assessments [16,21].

In general, radiation conditions on EZ and OE territory is stable enough. The steady tendency to autopurification of surface layer soils with a speed at level of 2-5 % by 137Cs and 4-8 % by 90Sr per one year [16] is observed.

CSFSF site is characterized in full scope by the parameters of described above radioecological conditions on territory EZ and OEA. However the area has a number of the specific differences caused by its arrangement in southwest sector of zone of special radiation danger.

The CSFSF site adjoins to peripheral territory of "southwest" trace of emergency radioactive fallouts and characterized by significant gradients of density of contamination soils in northern and northeast directions (fig. 4.5.1-4.5.3). According to data of SSE "Technocenter" [12], at CSFSF site on extent ~ 0,5 km change of density of soils contamination by 137Cs makes over 10 times, and by 90Sr – over 8 times (fig. 4.5.4, 4.5.5).

As, specificity of radioactive contamination of CSFSF site is availability, in structure of emergency fallouts, of significant amount of "hot" particles with high extent of stability in environment.

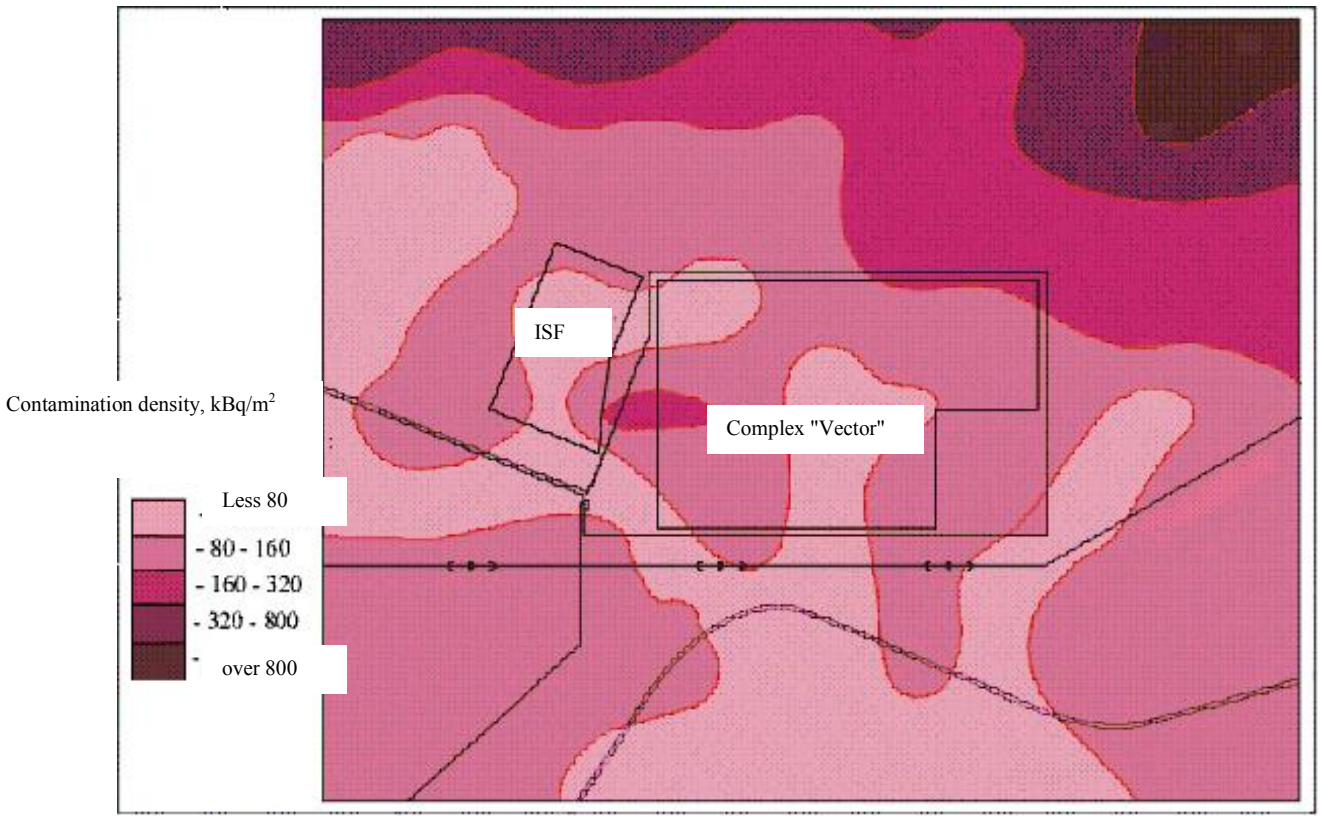

Figure 4.5.4 - Density of 137Cs contamination at territory of CSFSF site [12], the forecast for date of presumable construction (01.07.2006)

The constant value of transformation of "hot" particles (k) is typical for the "western" trace of emergency fallouts and makes, approximately, 0,1-0,2 year^{-1}. Relatively low speed of destruction specifies possibility of presence at topsoil of not destroyed fuel particles till now.

A particular feature of CSFSF site contamination is the lowered speed of RN vertical migration that has resulted in localization of their main stock in top 0-5 cm layer of topsoil [12]. This fact is explained by a large fraction of steady "hot" particles in structure of emergency fallouts and ephemeral water mode of sandy soils which are in relatively dry condition during the significant part of the warm period of a year.

The analysis of distribution of TUE contamination density in CSFSF site (fig. 4.5.3) shows that it is available in one area of contamination density with ARMS point "Chistogolovka", namely - 0,4 kBq $^{239+240}$Pu/m^2. However, according to data given in tables 4.5.1 and 4.5.2 it is visible that contamination of area of ARMS point "Chistogolovka" in tens times is higher that is related to its arrangement directly on territory of the western "trace" of fallouts.

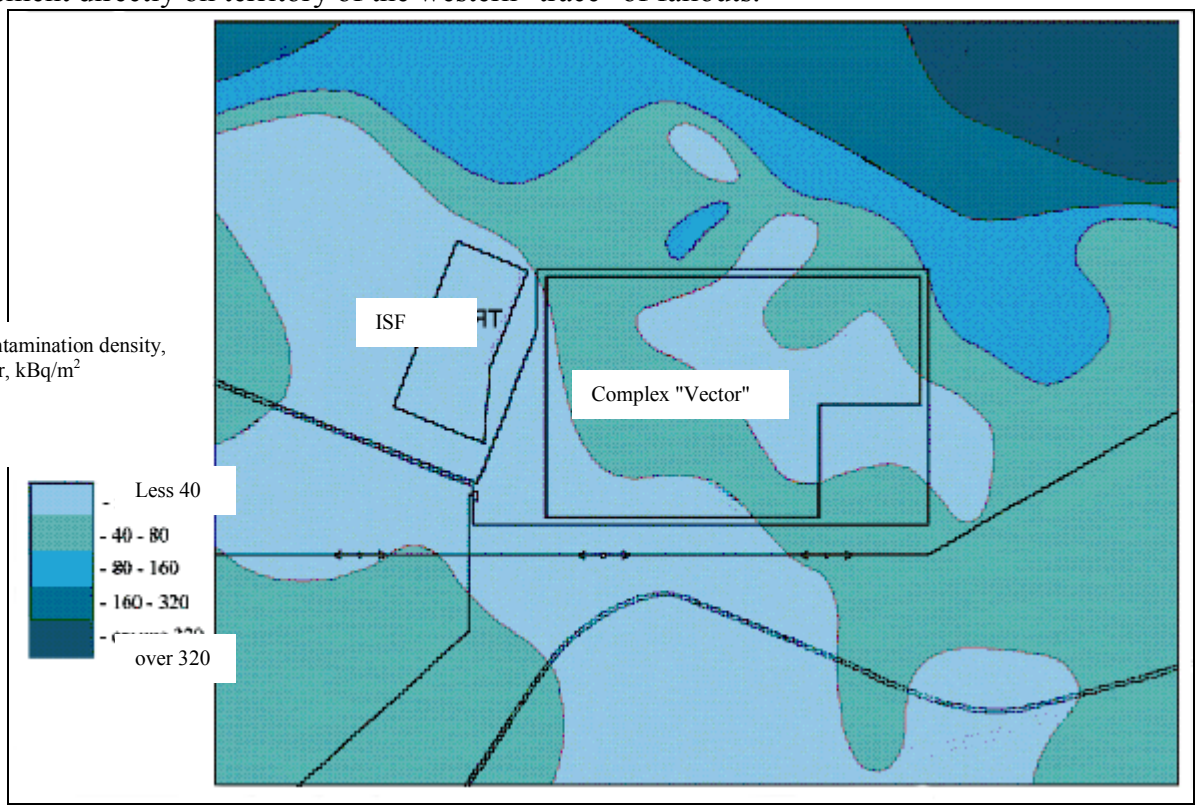

Figure 4.5.5 - Density of 90Sr contamination at territory of CSFSF site [12], the forecast for date of presumable construction (01.07.2006)

According to data of SSE "Technocenter", initial contamination of territory of complex "Vektor" (before construction of facility) adjoined by CSFSF site by $^{239+240}$Pu was 1,9-2,2 kBq /m^2 [12]. This value also should be considered as the most probable index of contamination 239+240Pu of CSFSF site.

Value of density of contamination of soils of CSFSF site by ^{238}Pu was determined according to data of measurements on the nearest ARMS point "Chistogolovka" (table 4.5.1). It conservatively makes 5,0 kBq/m^2 (average value of the maximum magnitudes).

Background properties were determined during radioecological survey of the territory of complex "Vektor" construction site, ref. table 4.5.3.

Table 4.5.1 - Density of radioactive contamination of soils (layer 0-5 cm) in points of ARMS in CSFSF site, 2001-2002[23]

Date	**Name of point, direction and distance from CSFSF site**									
	Density of contamination by radionuclides, kBq/m2									
	^{137}Cs		**^{90}Sr**		**^{238}Pu**		**$^{239+240}$Pu**		**^{241}Am**	
	max	**average**	**max**	**average**	**max**	**average**	**max**	**average**	**max**	**average**
Buryakovka (5 km to North)										
2001	6400	3800	2800	1100	19	9,3	48	21	65	29
2002	4100	1900	550	310	30	3,4	75	6,9	21	12
Chistogolovka (5 km to Northeast)										
2001	1100	800	410	300	6,5	4,2	14	8,6	19	1,4
2002	720	440	140	100	3,6	2,0	7,8	4,3	10	7,1

Table 4.5.2 - Density of radioactive contamination soils (layer 0-10 cm) in points ARMS in CSFSF site in 2001-2002[23]

	The name of Item, direction and distance from CSFSF site			
Date	**Density of contamination by radionuclides, kBq/m^2**			
	^{137}Cs		**^{90}Sr**	
	maximum	**average**	**maximum**	**average**
Buryakovka (5 km to North)				
2001 2002	7300 12300	5000 4200	3100 690	1300 410
Chistogolovka (5 km to Northeast)				
2001 2002	1600 1600	1200 1100	560 340	410 210

Table 4.5.3 – Background properties of construction site of complex "Vektor", soil - vegetative layer 0-5 cm [12]

Radionuclide	**Specific activity, Bq/kg**	**Density of contamination**	
		kBq/m^2	**Ci/km^2**
137Cs	3200	230	6,2
134Cs	67	4,5	0,12
90Sr	1450	105	2,8
239+240Pu	30	1,9-2,2	0,05-0,06

Analyzing available data (tables 4.5.1-4.5.3), taking into account diversity of radioactive fallouts and applying the conservative approach, at calculations of radiation impacts it is necessary to use values of density of contamination soils by various radionuclides in area of CSFSF construction site, represented in table 4.5.4.

Table 4.5.4 - Average values of density of topsoil contamination by RN of CSFSF site (the conservative approach)

Radionuclide	**Bq/kg**	**kBq/m^2**
^{90}Sr	1450	105
^{134}Cs	67	4,5
^{137}Cs	3200	230
^{238}Pu	34	5,0
$^{239+240}$Pu	15	2,2
^{241}Am	30	4,3

4.5.2 Impacts under Normal Conditions of Operation

Calculation of radiation impacts on topsoil at normal operation of CSFSF was carried out with use of the modified Gauss procedure recommended by IAEA (Attachment B).

Figure 4.5.6 represents calculation results of density of surface contamination ^{60}Co topsoil in conditions of CSFSF normal operation (emission from HI-STORM). According to figure it is visible that the maximum contamination by ^{60}Co during 1 year of operation of storage facility (under constant weather conditions) will not exceed 12 Bq/m^2 and will be observed at distance of 50 – 70 m from CSFSF.

It is known that the period of active operation (filling) CSFSF does not exceed 50 years. Accordingly for this period, under constant weather conditions, at lack of secondary migration and without taking into account relatively short half-life period ^{60}Co (5,27 years), the maximum additional contamination of surface of topsoil at distance of 50 – 70 m from storage facility will not exceed 600 Bq/m^2.

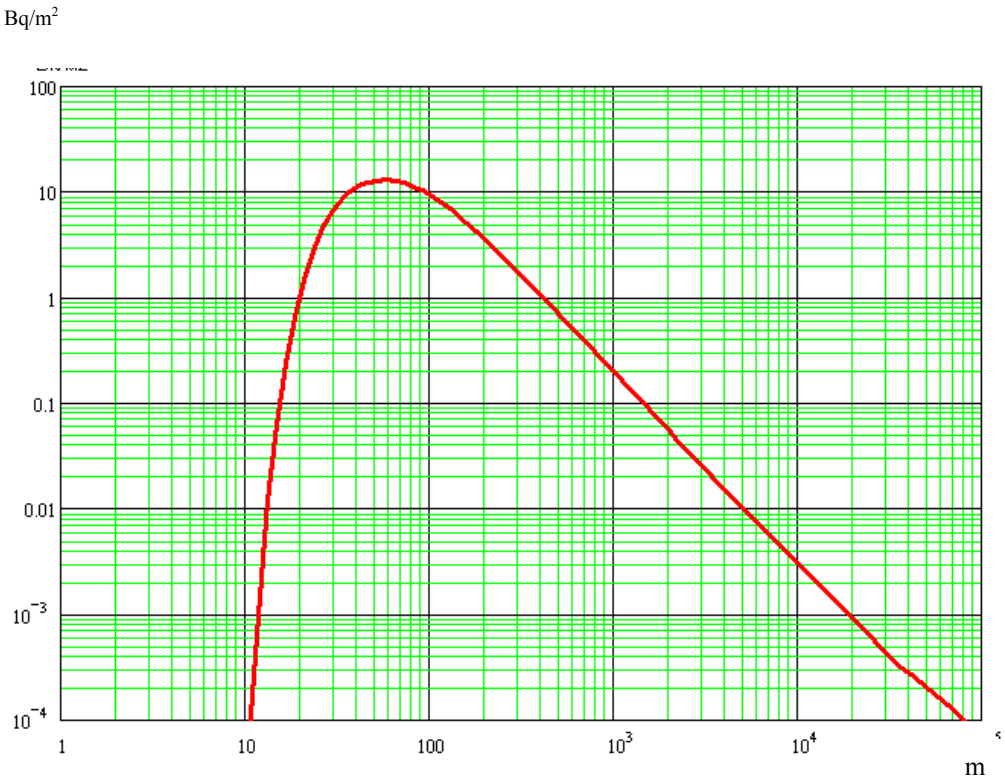

Figure 4.5.6 - Dependence of density of contamination of surface soils ^{60}Co (Bq/m^2) from distance (m) up to CSFSF at its normal operation in the course of the year (emission from HI-STORM). Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

Under the same conditions, for 50 years of CSFSF operation, maximum additional contamination of surface of topsoil on boundary of 10-km zone of ChNPP (distance – 2 km) and on boundary of EZ and OEA (distance – 13 km) will not exceed, accordingly, 2,5 and 0,002 Bq/m^2 that certainly are insignificant impact on condition of topsoil.

Therefore, essential radiation impacts on topsoil of residential territories it is not assumed during the CSFSF normal operation.

4.5.3 Impacts under Design Basis Accident with the Maximum Consequences

Calculation of impacts on topsoil under maximum design basis accident (MDBA) was carried out by the modified Gauss procedure recommended by IAEA (Attachment B). Results of calculations of additional surface contamination by ^{60}Co of the territories adjoining CSFSF are represented in figure 4.5.7.

Bq/m^2

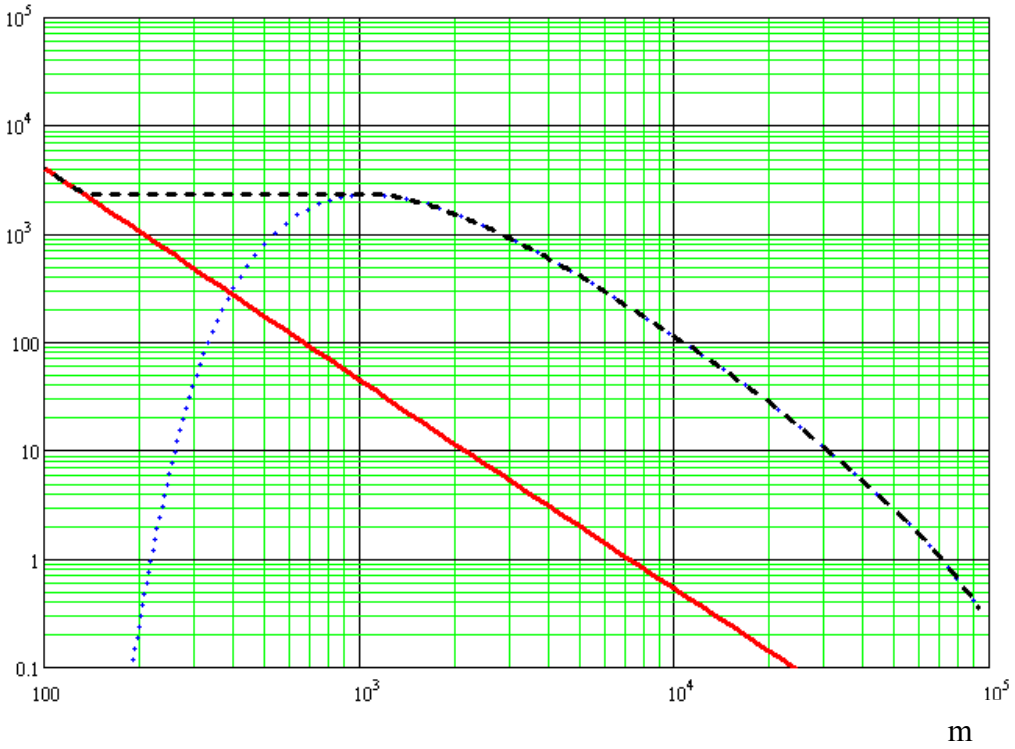

Figure 4.5.7 - Dependence of density of contamination of surface soils ^{60}Co (Bq/m^3) from distance (m) up to CSFSF in case of MDBA. Red continuous line - emission from HI-STORM during 1 year, dark blue (dot) line - instant emission from reception building, black (dotted) line - the maximum values for all distances from point of emission).

Legend: X-coordinate – m; Y-coordinate – mSv.

The analysis of results of forecasting calculations shows that maximum deposition of radioactive aerosols, as a result of possible MDBA in CSFSF, will be observed during 1 km from emergency HI-STORM and will not exceed 10 kBq/m^2. Taking into account high initial level of surface contamination soils adjoining territories (142 kBq/m^2 on the sum of radionuclides), such impact practically will not affect condition of topsoil.

At distance of 13 km (boundary 30-km exclusion zones ChNPP), radiation impacts due to possible MDBA, accordingly, will be smaller. The additional density of surface contamination by ^{60}Co soils will not exceed 7 Bq/m^2 that also is insignificant impact.

Therefore, at possible maximum design accident in CSFSF, essential radiation impacts on topsoil of residential territories is not expected.

4.5.4 Impacts under Beyond Design Basis Accident (BDBA)

Calculation of additional radioactive topsoil contamination under BDBA in CSFSF was carried out by the modified Gauss procedure recommended by IAEA (Attachment A).

In case of BDBA radioactive emission will be represented by gas-aerosol mix of radionuclides. From them at topsoil contamination isotopes of cesium (134Cs and 137Cs), 90Sr and transuranium elements (TUE) have the greatest value.

Due to the fact that emission is assumed from zero elevation, the maximum value of additional surface contamination will be observed near to emergency HI-STORM and, at the distance 100 m from it it will not exceed 30 kBq/m^2 for isotopes of cesium, 15 kBq/m^2 for ^{90}Sr and 60 Bq/m^2 for TUE (fig. 4.5.8 - 4.5.10) that will not result in essential changes of radiation conditions.

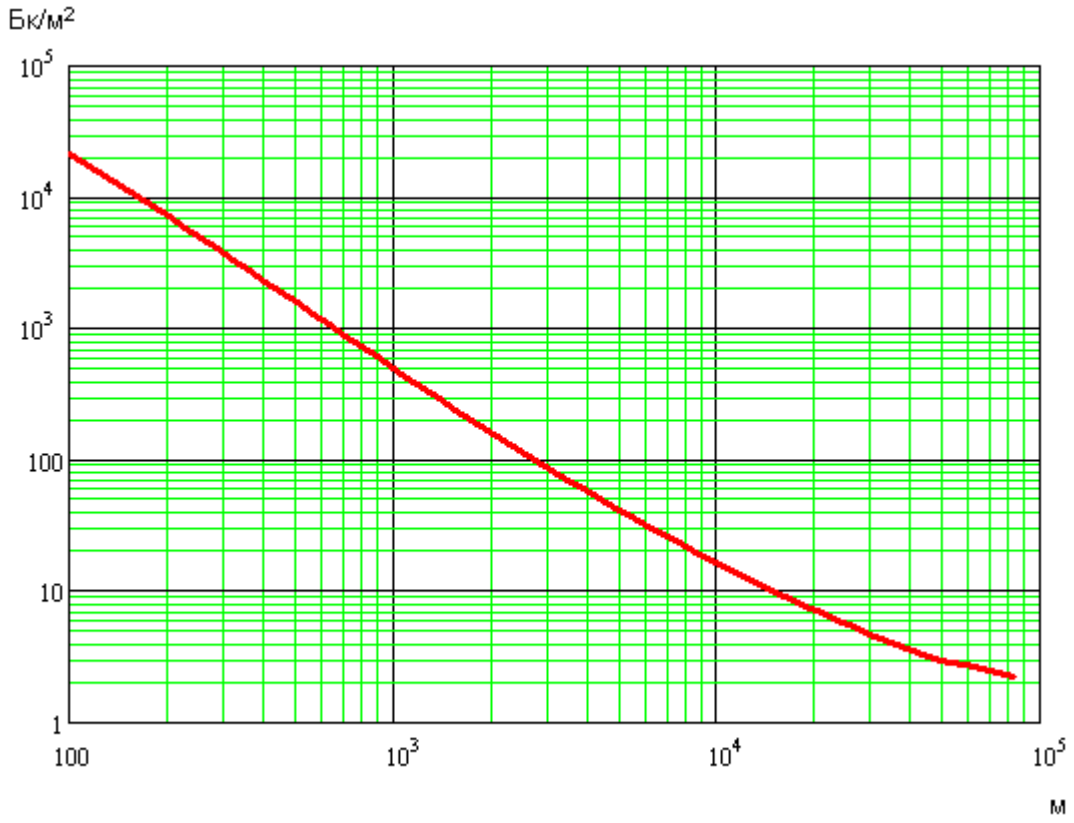

Figure 4.5.8 - Figure 4.5.8 - Dependence of density of surface topsoil contamination isotopes of cesium (Bq/m^2), due to BDBA from distance (m) up to CSFSF

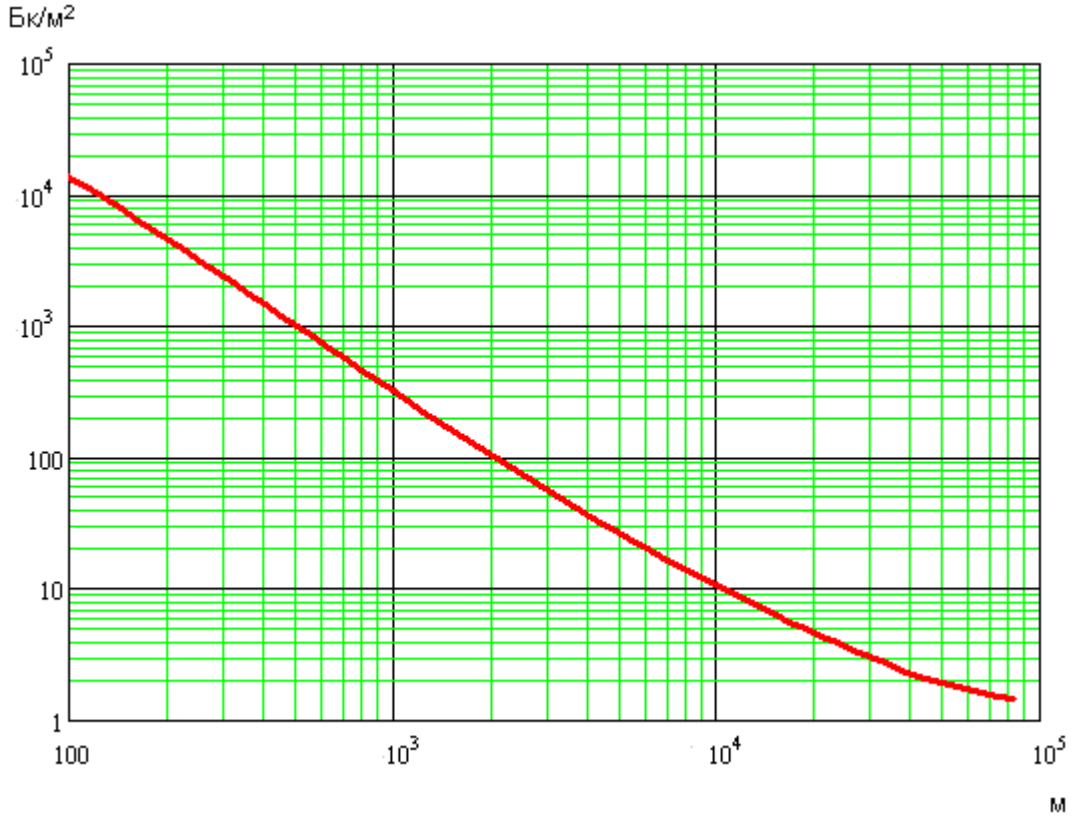

Figure 4.5.9 - Dependence of density of surface topsoil contamination by ^{90}Sr (Bq/m^2), due to BDBA, from distance (m) up to CSFSF

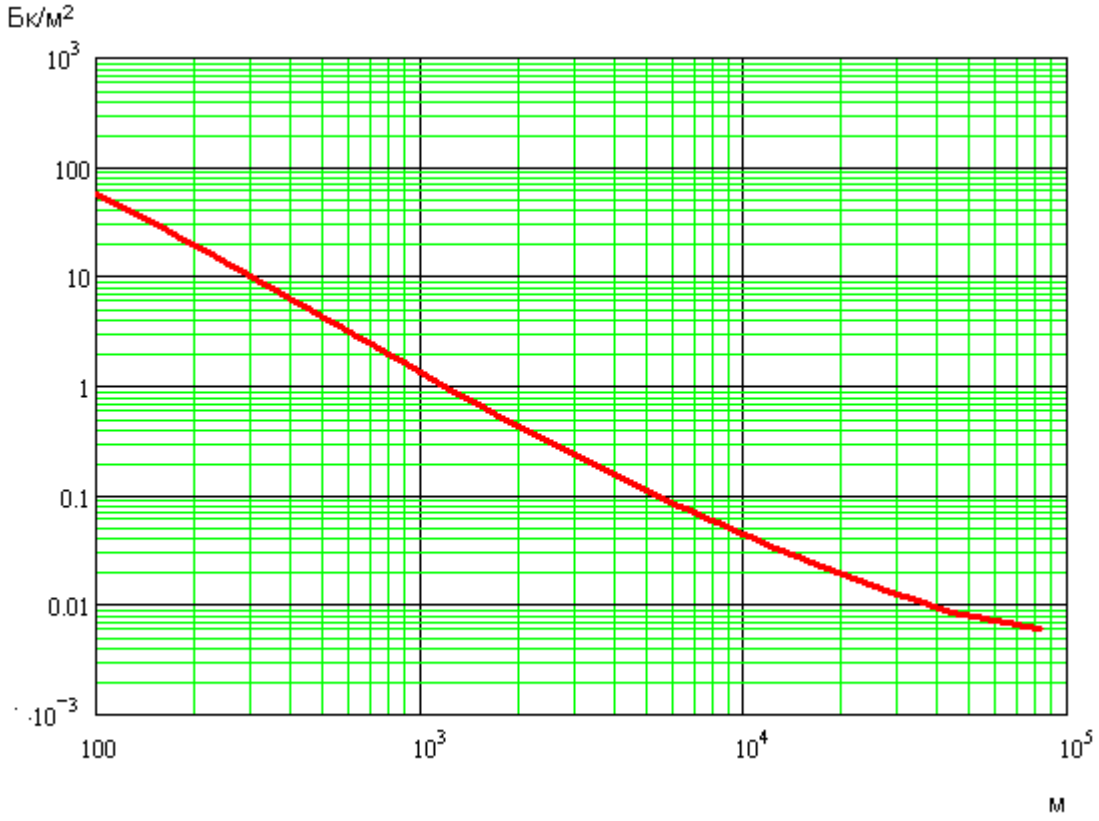

Figure 4.5.10 - Dependence of density of surface topsoil contamination by TUE (Bq/m^2), due to BDBA, from distance (m) up to CSFSF

On the nearest boundary of EZ and OEA (distance 13 km), the additional density of surface contamination by isotopes of cesium will be much less (that typically for emission from height 0 m) and will not exceed 20 Bq/m^2 by isotopes of cesium, 8 Bq/m^2 by 90Sr and 0,03 Bq/m^2 by TUE that also will not affect radiation conditions, since additional contamination will make less than 0,1 % from background contamination.

Therefore, taking into account small probability of BDBAin CSFSF, radiation impacts on topsoil should be considered as permissible.

4.5.5 Brief Conclusions of Impact on Topsoil During Operation

Normal operation. During 1 year of CSFSF normal operation (emission from HI-STORM at storage area), the maximum topsoil contamination by ^{60}Co (under constant weather conditions) will not exceed 12 Bq/m^2 and will be observed at distance of 50 – 70 m from storage facility. During long (till 50 years) period of loading of storage facility, the maximum topsoil contamination can reach 600 Bq/m^2, however taking into account stochastic character of the current weather conditions, relatively short (5,27 years) half-life period of ^{60}Co and its secondary migration, this additional contamination is possible to consider as insignificant.

Under the same conditions, for 50 years of CSFSF operation, on the nearest boundary of EZ and OEA (distance – 13 km) the maximum additional contamination of soil surface will not exceed 0,002 Bq/m^2 which is certainly an insignificant impact on the topsoil condition.

Therefore, at the CSFSF normal operation, essential radiation impacts on topsoil of residential territories are not assumed.

Maximum design basis accident. The maximum values of contamination of surface soils by ^{60}Co, as a result of possible MDBA in CSFSF, will be observed during 1000 m from emergency HI-STORM and will not exceed 10 kBq/m^2. Taking into account high initial level of surface contamination soils adjoining territories (142 kBq/m^2 on the sum of radionuclides), such impact will practically have no effect on condition of topsoil.

Therefore, radiation impacts on the greater removal from storage facility to boundary of EZ and OEA (–13 km) will not exceed distance 0,007 kBq/m^2 that also will not affect condition of topsoil.

Therefore, at possible design accident with the maximum consequences in CSFSF, essential radiation impacts on topsoil of residential territories are not assumed.

Beyond design basis accident (BDBA). In case of BDBA the maximum additional surface contamination will be observed near the emergency module HI-STORM and, at the distance 100 m from it, will not exceed value of 30 kBq/m^2 for isotopes of cesium, 15 kBq/m^2 for ^{90}Sr and 60 Bq/m^2 for TUE that will not result in essential changes of radiation conditions. Thus, the maximum additional contamination of residential territories outside EZ and OEA will not exceed 20 Bq/m^2 for isotopes of cesium, 8 Bq/m^2 for 90Sr and 0,03 Bq/m^2 for TUE that also will not affect radiation conditions, since additional contamination will make less than 0,1 % from background contamination. Taking into account small probability BDBAin CSFSF, radiation impacts on topsoil should be considered as acceptable.

4.6 Impact on Flora and Fauna

4.6.1 Normal Operation Conditions

Results of calculations of radiation impacts on such components of the environment as surface layer of the atmosphere and topsoil performed in sections 4.3 and 4.5 of this document testify to lack of essential impacts on them under normal conditions of CSFSF operation. Being based on these assessments, it is possible to draw a conclusion that impact on vegetative communities and the fauna, CSFSF site taking place in area, also will be insignificant and will not result in deterioration of inhabitancy of living organisms.

Besides it is necessary to note that biocenoses are available and successfully develop in CSFSF site at presence of significant density of radioactive contamination of the soil - vegetative cover, reaching on separate areas of adjoining territories 200 - 400 Ci/km^2 total activity.

The dominating factors of development of biocenoses are non-radiation factors, namely - natural serial processes. Therefore to expect any changes in structure of natural populations, due to radioactive CSFSF emissions, making the tenth fractions of percent from the existing density of contamination of territory, is not reasonable.

Major factor of impact under normal conditions of CSFSF construction on flora and fauna is deforestation directly on territory construction sites (area - 8,6 hectares) and at routing of railway track (area - 7 hectares) to storage facility.

Areas of forest to be removed are unproductive artificial pine plantings created in 60th years of the last century on poor dry sandy soils which are unsuitable for agriculture. On forest growing conditions, they concern to type dry forests and have the least growth class among forests at EZ and OE territory (see section 2.3). Dry pine forests at EZ and OE territory will usually consist of invaluable coniferous trees and represented by unproductive forage reserve for wild animals. In this connection, chopping down of specified areas of forests does not make appreciable impact on specific variety of phytocenosises and, accordingly, faunistic complexes of adjoining areas.

Deforestation under routing of railway track with extent 6,4 km can appreciably limit movement of wild ungulate animals due to infringements of historically developed ways of their migration. However, taking into account high number of local population of these animals (see section 2.3.2), increased percentage of forest land of adjoining areas and, practically, the reserved mode of the territory, essential damage for number and specific variety of animals is not expected.

4.6.2 Design Basis Accident with the Maximum Consequences

The analysis of impact of emergency contamination on components of the environment in case of MDBA occurrence (ref. section 4.3 and 4.5) shows that the maximum of additional surface topsoil contamination by ^{60}Co will not exceed 10 kBq/m^2 (0,3 Ci/km^2) at the distance 1000 m from storage facility. Taking into account the fact that background of total contamination of adjoining territories by gamma - radiating radionuclides (analogues ^{60}Co on biological impact), makes not less than 93 kBq/m^2 (2,5 Ci/km^2) additional impact on flora and fauna due to MDBA will be, practically, insignificant.

4.6.3 Beyond Design Basis Accident

Due to BDBA an essential contamination of soil - vegetative cover (see section 4.5.5), air (see section 4.3.5) and water media (see section 4.4.2.2) will not take place. Taking into account these circumstances, essential radiation impacts on animal and flora also are not expected.

Therefore, radiation impacts on fauna and flora due to BDBA should be considered as acceptable.

5 DESCRIPTION OF SOCIAL ENVIRONMENT AND ASSESSMENT OF IMPACT ON IT

5.1 Description of Social Environment

Character of social environment in the given territory is caused by number of the specific factors determining number of the personnel and the population, as well as its structure. The main determining factor is the belonging of the given territory to EZ and OEA where according the Low of Ukraine “Legal regime of territories contaminated by radionuclides due to Chernobyl accident ” [25], permanent residing of the population is forbidden.

Main social, ecological, medical principles of functioning and content of exclusion zone, as well as priority industrial and scientific and technical types of activity in the given territory are regulated by Concept of EZ and OEA [26]

The stay of the personnel in the given territory is caused by necessity of carrying out of measures on minimization of accident consequences and prevention of carrying out of radionuclides outside the limits exclusion zones, as well as works, related to decommissioning of Chernobyl NPP and transformation of the SO into ecologically safe system. Direct regulation of working conditions for the personnel, as well as regulation of conditions of its residing is carried out based on state standard "Main controlled levels, levels of clearing and levels of action relatively radioactive contamination of facilities of exclusion zone" [5].

Due to developed social and economic conditions in society, the civilians live on EZ and OEA territory. The given group of people called as "unauthorized residents", has returned (re-evacuated) after evacuation to the dwellings and conducts former, almost natural, way of life. Unfortunately, lawful base residing of these people at exclusion zone are not regulated. According to the Law of Ukraine “Legal regime of territories contaminated by radionuclides due to Chernobyl accident” (clause 12) permanent residing of people at exclusion zone is forbidden. However, half of citizens of the given category have legislative grounds to stay on the given territory as they were not provided with habitation or it was returned to the State due to unfitness for residing. By the beginning of 2003 total "unauthorized residents" on territory of EZ and OEA made 315 person.

Existing rules of behavior of the personnel on EZ and OE territory is directed to implementation of organizational - technical measures called to promote increase of level of radiation safety.

The main sources forming dose uptakes to the person within the limits of exclusion zones are the following:

- external γ-exposure formed at the present stage practically completely ^{137}Cs;
- external β-exposure formed at the present stage ^{90}Sr and ^{137}Cs;
- internal exposure from inhalated radionuclides (main impact is formed α- radiating group of radionuclides);
- internal exposure from radionuclides incoming via respiratory organs (mainly formed by ^{90}Sr and ^{137}Cs).

Formation of dose uptakes on the personnel occurs, mainly, due to sources of external irradiation.

The control of external irradiation of the personnel EZ and OEA, organization and performance of individual dosimetry control of the personnel working at the enterprises, establishments and organizations of EZ and OEA is carried out by "Ecocenter", SSE "ChNPP" and ISTC "Shelter".

Measurements of individual doses of external irradiation are carried out by the complete set of thermoluminescent equipment KDP-02M whose structure includes the thermoluminescent detector TLD-500K and portable dosimeters DPG-03, containing glass from oxide of aluminum. Definition of the content of incorporated ^{137}Cs in organism of the working personnel and

"unauthorized residents" is performed by means of the counter of radiation of the person (HES) which is performed at annual preventive physical examination.

Distance of CSFSF site from the nearest cities and boundaries is represented in table 5.1.1.

Table 5.1.1 - Direction and remoteness of CSFSF site from the nearest cities and important facilities

Name of facility	Direction from area	Distance from area, km
Chernobyl	Southeast	20
Slavutich	Northeast	58
Chernigov	Northeast	90
Ivankov	South	43
Kiev	South	110
Frontier of Ukraine	Northwest	13
Boundary of EZ and OEA	North East South Southwest West Northwest	13 28 23 12 39 29
Boundary of 10-km area of special radiation danger	Southwest	0,5
Flood-plain of river Sakhan	North	9
Flood-plain of river Uzh	Southwest	11
Flood-plain of river Pripyat	Northeast	12
Shelter object	Northeast	12
CDF «Vektor»	West	0,1
Facility RWDF "Buryakovka"	Southwest	1,1

Number of the personnel staying in exclusion zone and results of measurements of doses of external irradiation of the personnel are represented in tables 5.1.2 and 5.1.3.

Table 5.1.2 **-** Number and average annual doses of external irradiation of the personnel of the enterprises of Ministry of Emergencies (MOE) for 2003.

No.	**Name of the enterprise**	**Quantity of controllable persons, man**	**Average annual dose of external irradiation, mSv**
1.	EZA	23	0,75
2.	SE "Complex"	326	1,57
3.	SE "SBK"	224	1,03
4.	SE "UKB"	27	1,21
5.	SE "Chernobylservis"	1314	0,84
6.	SSE KVP "ChVE"	244	1,26
7.	SSE KLP "Chernobylles"	614	1,16
8.	SE NPP "ECOCENTR"	406	1,15
9.	SSE "RUOOD"	261	1,12
10.	EPK	375	1,04
11.	SVASO	32	1,07
12.	SE "Technocenter"	172	1,04
13.	Chernobylinterinform	24	1,04
14.	Chernobyl special REM	67	1,17
	Total	4109	1,10
15.	Enterprises of other departments and Contractors	2164	0,68
	Grand total	6273	0,89

The table 5.1.2 shows that the average dose of external irradiation on one worker of exclusion zone in 2003 has 0,89 mSv, and for the enterprises of Ministry of Emergencies of Ukraine – 1,10 mSv.

Table 5.1.3 - Number of the personnel and average annual doses of external irradiation of the personnel SSE «ChNPP», ISTC "Shelter" and the contract enterprises in 2003[27]

No.	Name of enterprise	Quantity of controllable persons, man	Average annual dose of external irradiation, mSv
	Personnel of SSE «ChNPP»	3463	3,01
	Personnel of Shelter object	775	3,34
	Personnel of Contractors working on "ChNPP"	2236	1,34
	ISTC "Shelter"	341	2,37

In 2003 controlled levels of individual doses of external irradiation for the enterprises specified in table 5.1.3 make:

- SSE «ChNPP» - 17 mSv;
- Personnel of Shelter object- 16 mSv (1 group); 5 mSv (2 group); 1,5 mSv (3 group);
- ISTC "Shelter" - 15 mSv for the personnel performing works in laboratories 1 and 2 classes and 3 mSv for the personnel working on territory of exclusion zones.

5.2 Dose Uptakes on the Personnel and the Population Within the Limits of Exclusion Zone

5.2.1 Normal Operation Conditions

For calculation and modeling of RN spreading in the atmosphere at CSFSF emissions at normal operation, the modified Gauss procedure recommended by IAEA (Attachment B) is used. Calculation results of individual effective dose depending on distance up to emission source are represented in figure 5.2.1.

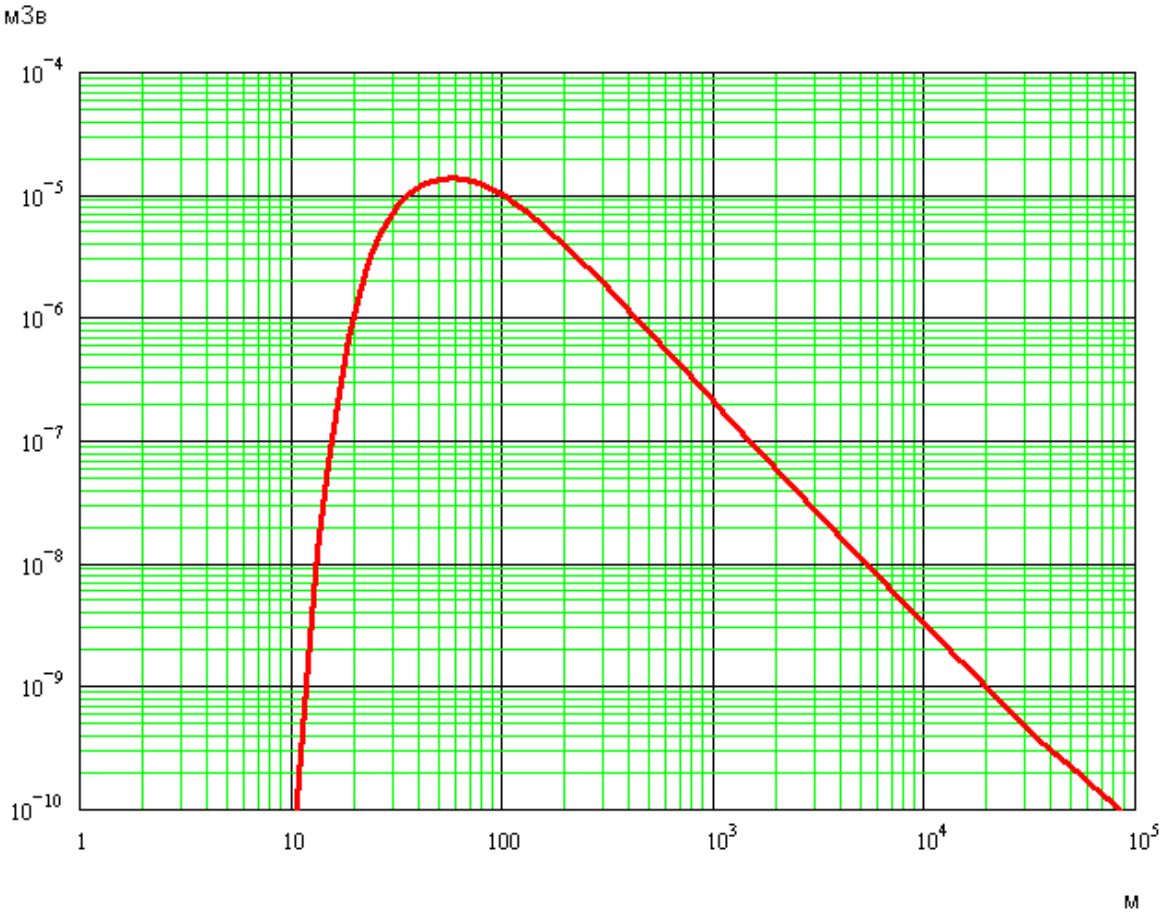

Figure 5.2.1 – Dependence of value of individual effective dose of exposure (mSv) due to inhalation of ^{60}Co from distance (m) up to CSFSF at normal operation (emission from HI-STORM).

Legend: X-coordinate – m; Y-coordinate – mSv.

As follows from figure 5.2.1, the maximum value of individual effective dose due to ^{60}Co inhalation at CSFSF normal operation will not exceed $1{,}5 \cdot 10^{-5}$ mSv, and will be observed at distance of 50 – 70 m from the storage facility.

On boundary 10-km zone of ChNPP (distance 2 km) individual effective doses due to inhalation of ^{60}Co, caused by CSFSF operation in normal conditions, will not exceed $6 \cdot 10^{-8}$ mSv.

The carried out calculations show that at CSFSF normal operation additional dose uptakes due to inhalation of ^{60}Co on the personnel of the enterprises located on EZ and OEA territory, will not exceed the controlled levels [5] specified for the personnel of these enterprises.

On the nearest boundary of EZ and OEA (13 km in "south-west" direction) individual effective doses will not exceed $2 \cdot 10^{-9}$ mSv due to inhalation of ^{60}Co; the radiation impact is not expected due to ^{60}Co inhalation on the population outside EZ and OEA at CSFSF normal operation.

The maximum value of individual effective dose due to all ways of impact of emission will be observed at distance of 50 – 70 m from source and will not exceed 5,6 mkSv (fig. 5.2.2).

At the distance 2 km from storage facility the value of individual effective dose due to all ways of impact of emission will not exceed $3{,}1 \cdot 10^{-5}$ mSv, and at the distance 13 km – $1{,}4 \cdot 10^{-6}$ mSv that is rather small value (fig. 5.2.2).

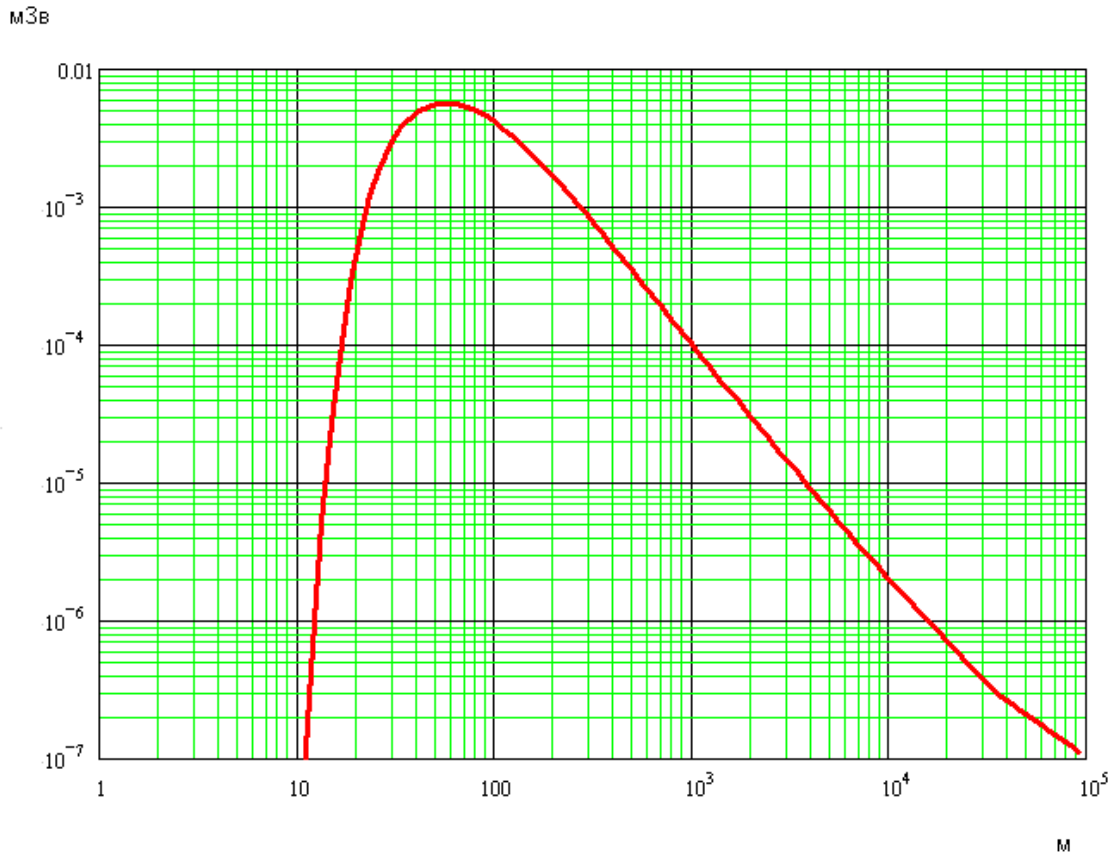

Figure 5.2.2 - Dependence of value of annual individual effective dose due to all ways of impact of emission (mSv / year) from distance (m) up to CSFSF at its normal operation (emission from HI-STORM)

Legend: X-coordinate – m; Y-coordinate – mSv.

Figure 5.2.3 represents isolines of effective dose (mkSv/year) due to all ways of impact of emission of ^{60}Co after 30 years of CSFSF normal operation taking into account mean annual indexes of the current weather conditions.

Taking into account current weather conditions (mean annual frequencies of winds of different directions), the value of additional individual effective dose of exposure, due to 30-years operation of storage facility, at the distance 2 and 13 km will make, accordingly – $3{,}8 \cdot 10^{-6}$ and $9{,}4 \cdot 10^{-7}$ mSv / year (Fig. 5.2.3). These values are less than annual effective dose limit for the population of Ukraine (1 mSv / year). Therefore, radiation impacts of CSFSF at normal operation will not result in essential additional exposure of the population during all service life of storage facility (100 years) and will not be an obstacle at approximation of residential territories to boundary of 10-km zone of ChNPP.

Therefore, radiation impacts on social environment at CSFSF normal operation should be considered as insignificant.

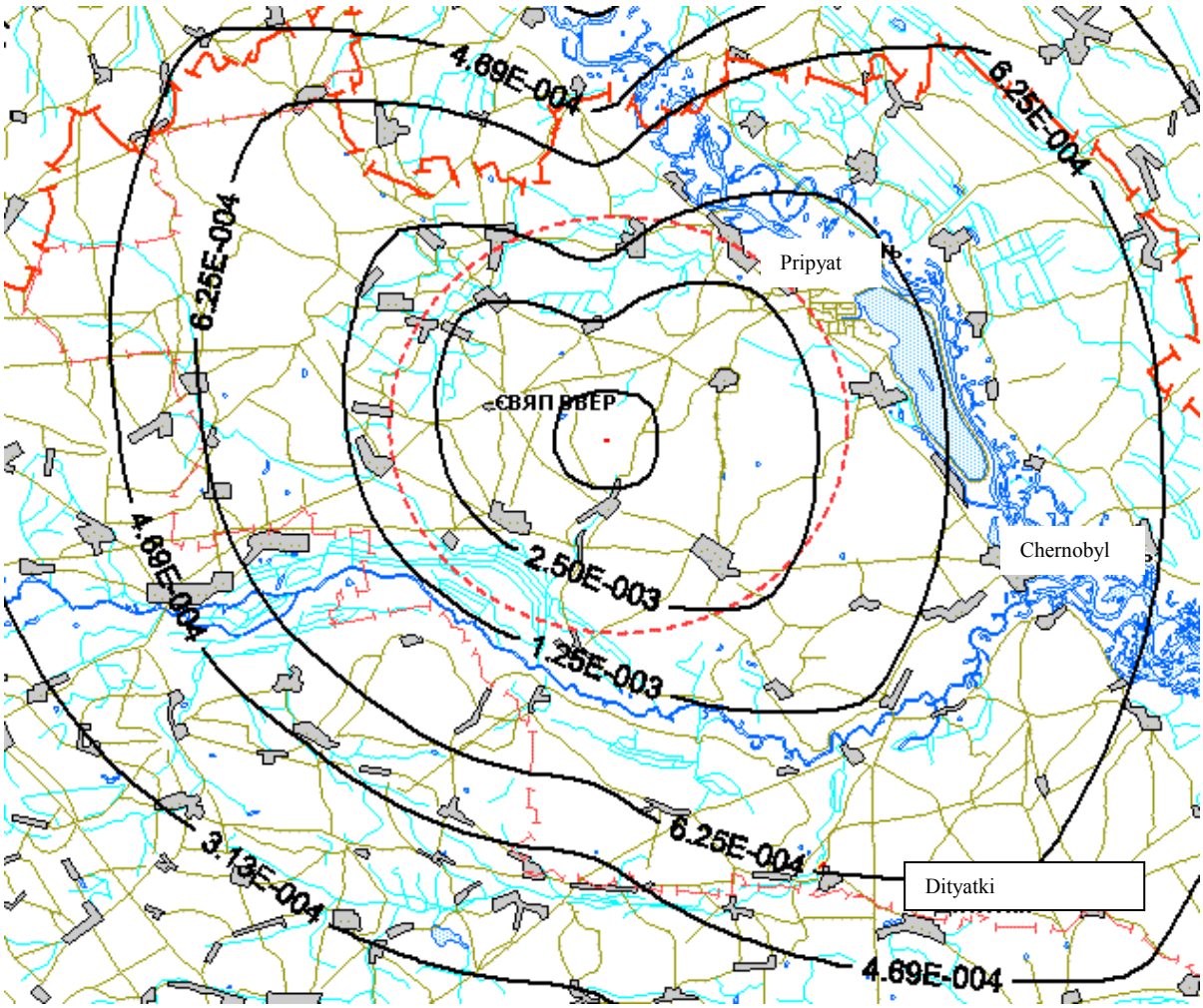

Figure 5.2.3 - Individual effective dose of exposure the population (mkSv/year) due to all ways of impact of emission of ^{60}Co at CSFSF normal operation taking into account mean annual indexes of the current weather conditions. Calculation is given for the period: 30 years after the beginning of CSFSF operation. Thin red dotted line – boundary of EZ and OEA.

Legend: СВЯП ВВЕР – is CSFSF

For assessment of individual effective doses of personnel exposure on CSFSF industrial site, calculation of dependence of dose rate from area of storage completely filled with containers HI-STORM (design quantity of 458 pieces) is performed.

The dose rate from containers storage area will characterize radiation conditions on CSFSF industrial site, off site of containers storage and for definition of dimensions of control area.

Data at distance of 1 m from surface of container HI-STORM, given by Holtek International and given in table 5.2.1 are accepted as the input data on radiation source.

Table 5.2.1 - GEDR from HI-STORM (extent of burning up: 55,000 MWt/tU extent of enrichment: 4,8 % 235U, thermal load on cover: 51,33 kW)

Location of dose generation source	**GEDR of neutron stream, mREM/hour**	**GEDR gamma mREM/hour**	**General GEDR mREM/hour**
middle of lateral surface	3	47	50
1 m from the middle of lateral surface	1	25	26

Dependence of greatest possible individual effective dose (mSv / year) (taking into account actual arrangement of HI-STORM at CSFSF storage area) on the distance is represented in figure 5.2.4.

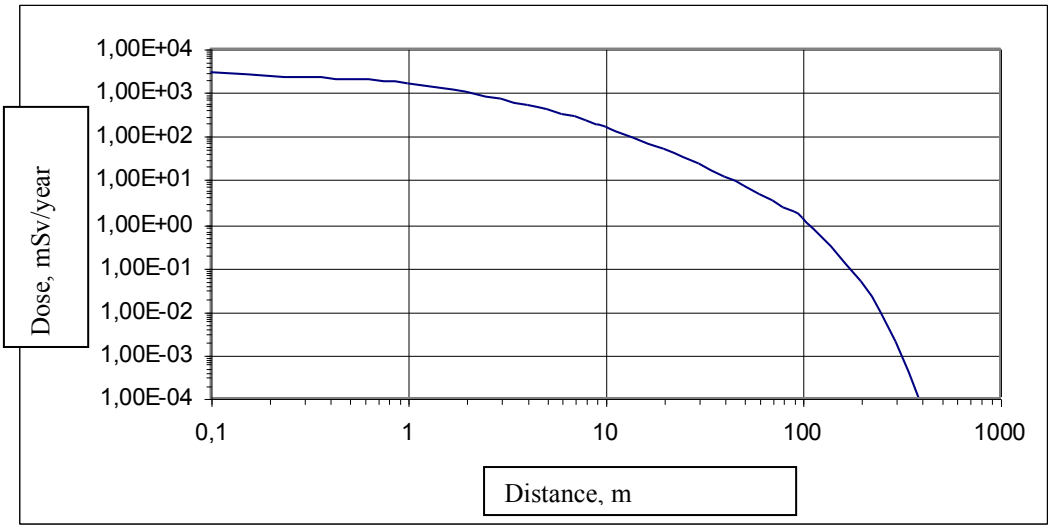

Figure 5.2.4 - Dependence of value of individual effective dose (mSv / year) from distance (m)

Legend: X-coordinate – distance, m; Y-coordinate – dose uptake, mSv/year.

Therefore, under conditions of CSFSF normal operation, boundary on which individual effective dose does not exceed 1 mSv / year for the population is a distance not less than 100 m from CSFSF boundary.

5.2.2 Design Basis Accident with the Maximum Consequences

The description of initial events of design basis accident with maximum consequences (MDBA) (i.e. delivery of the container with exceedance of permissible surface contamination in CSFSF) is described in Section 3.7 and Attachment B to this document.

Calculation of RN spreading in atmosphere, in case of MDBA occurrence, was carried out by the modified Gauss procedure recommended by IAEA (Attachment B). Calculation results of individual effective equivalent dose depending on distances up to emission source are represented in figure 5.2.5.

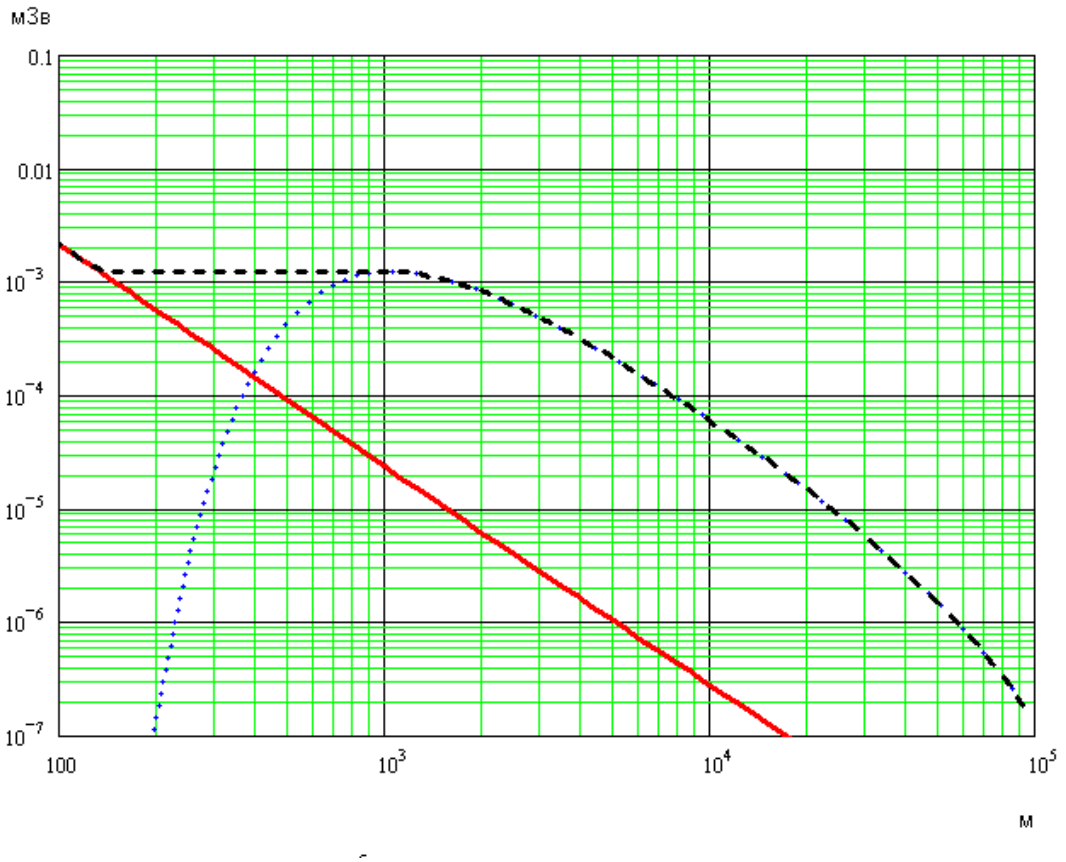

Figure 5.2.5 – Dependence of effective dose (mSv, due to inhalation of ^{60}Co) from distance (m) up to CSFSF in case of MDBA. Red continuous line - emission from HI-STORM during 1 year, dark blue (dot) line - instant emission from reception building, black (dotted) line - the maximum values for all distances.

Legend: X-coordinate – m; Y-coordinate – mSv

In case of MDBA occurrence during CSFSF operation, the maximum value of individual effective doses due to inhalation of ^{60}Co, will not exceed $3 \cdot 10^{-3}$ mSv, and will be observed near the storage facility (fig. 5.2.5).

On the nearest boundary of EZ and OEA (distance 13 km) at MDBA individual effective doses will not exceed $3{,}6 \cdot 10^{-5}$ mSv that is a rather small value.

Calculation of value of effective exposure dose (mSv / year) due to all ways of impact of ^{60}Co shows that on the nearest boundary of EZ and OEA (removal – 13 km) this index will not exceed $1{,}5 \cdot 10^{-3}$ mSv / year (fig. 5.2.6) that there is less than quota of annual effective dose limit (40 mkSv) for the population of Ukraine.

The carried out calculations have shown that at MDBA in CSFSF additional dose uptakes on the personnel of the enterprises located on EZ and OE territory will not result in exceedance of controlled levels (1,5 – 17 mSv / year), specified for the personnel of these enterprises [5].

Taking the above into account radiation impacts on social environment due to MDBA on CSFSF will be insignificant.

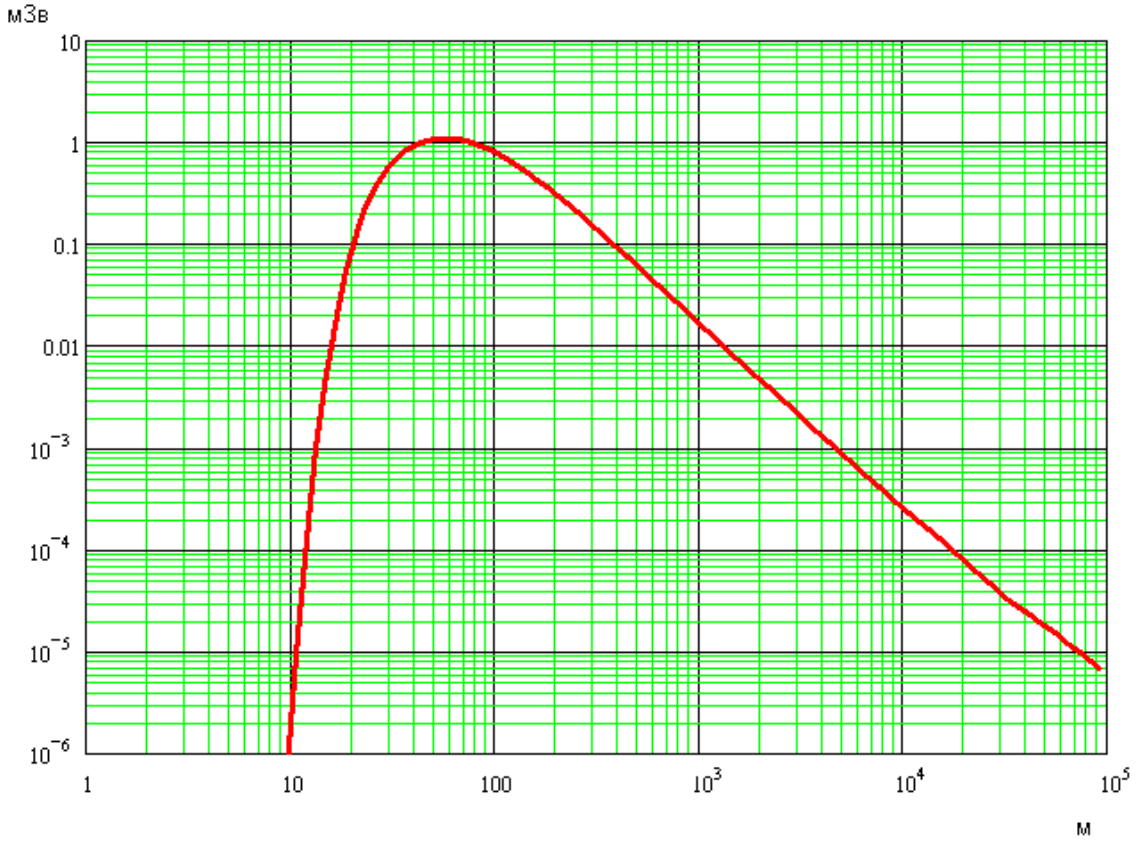

Figure 5.2.6 - Dependence of value of effective dose exposure (mSv / year) due to all ways of impact from ^{60}Co from distance (m) to CSFSF in case of MDBA (emission from HI-STORM during a year)

Legend: X-coordinate – m; Y-coordinate – mSv

5.2.3 Beyond Design Basis Accident

Calculation of RN spreading in the atmosphere in case of BDBA at CSFSF was based on the modified Gauss procedure recommended by IAEA (Attachment B). Thus it was conservatively assumed that radiation dose of the person was generated at its round-the-clock stay on open space during all emergency period (30 days).

Calculation results of individual effective dose (total for 30 days) depending on distances up to emission source at BDBA in CSFSF are represented in figure 5.2.7.

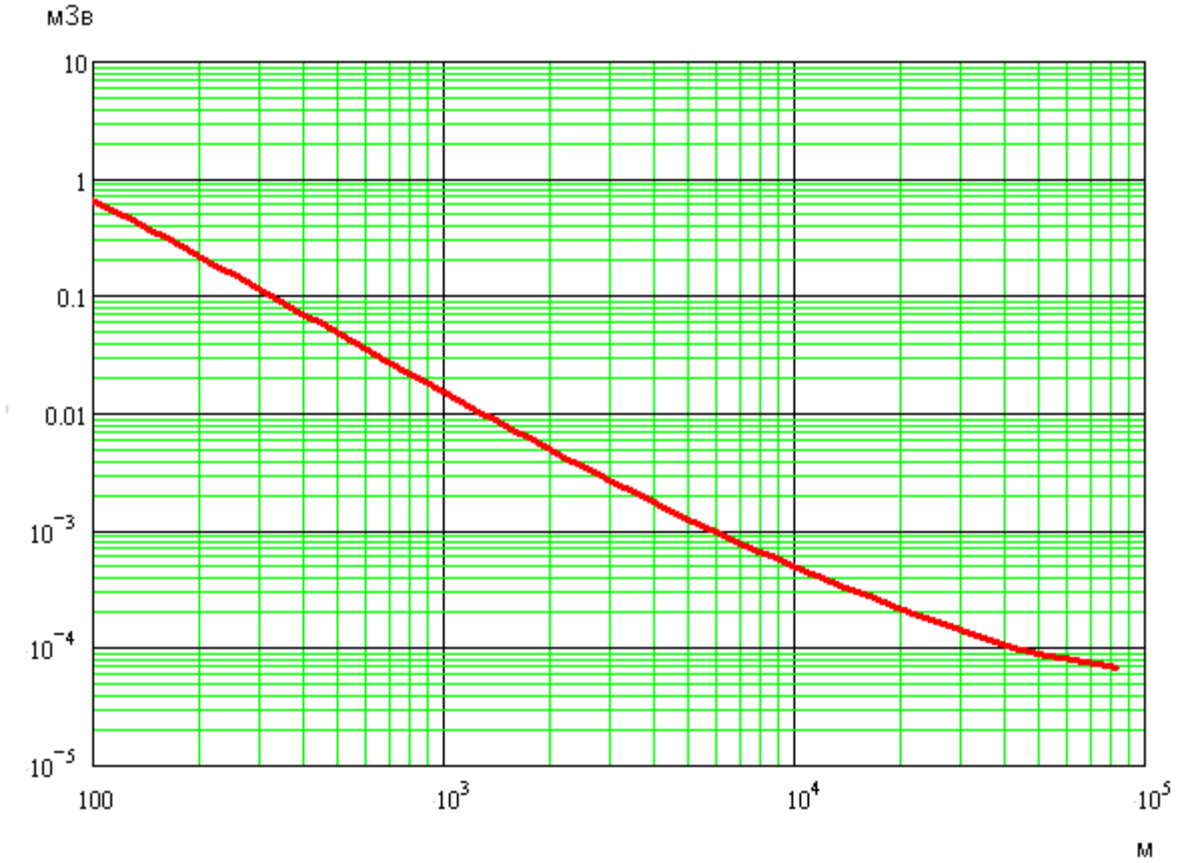

Figure 5.2.7 – Dependence of individual effective dose (mSv) from distance (m) to CSFSF in case of beyond design basis accident. Legend: X-coordinate – m; Y-coordinate – mSv

During BDBA at CSFSF the maximum value of individual effective dose (total for 30 days) will be observed near the storage facility and at distance 100 m from emergency HI-STORM will not exceed value 0,6 mSv (fig. 5.2.7). Thus, at the nearest boundary of EZ and OEA (up to storage facility – 13 km) this index will not exceed distance value $4 \cdot 10^{-4}$ mSv that will not result in exceedance of annual effective dose limit for the population (category B), specified in NRBU - 97.

Therefore, radiation impacts on the social environment in case of BDBA in CSFSF are necessary to be considered as comprehensible.

5.3 Impacts on Social Environment Outside of Exclusion Zone

Values of additional radiation impacts on the personnel working at EZ and OE territory and the population living in adjacent territories are represented in table 5.3.1.

Table 5.3.1 - Additional dose uptakes during CSFSF operation on the personnel of enterprises EZ and OEA and the population living beyond its limits

Distance from CSFSF, km	**Limits of radiation dose for the population (NRBU - 97), mSv / year**	**Additional dose uptakes during CSFSF operation**		
		Normal conditions, * mSv / year	**MDBA *, mSv**	**BDBA, mSv**
13 (boundary of 30-km exclusion zone)	1	$1,5 \cdot 10^{-6}$	$3,6 \cdot 10^{-5}$	$4 \cdot 10^{-4}$
21 (Chernobyl)	1 ("unauthorized residents")	$7,0 \cdot 10^{-7}$	$1,3 \cdot 10^{-5}$	$2 \cdot 10^{-4}$

* - doses are calculates taking into account all ways of impact of emission.

The analysis which is represented in section 5.2 of this document, as well as data of table 5.3.1 show that radiation impacts on social environment at normal operation and possible accidents in CSFSF will not result in exceedance of national limitations on radiation safety for the population.

6 ASSESSMENT OF IMPACT OF PLANNED ACTIVITY ON MAN-CAUSED ENVIRONMENT

CSFSF operation will take place on territory of EZ and OEA. At the territories adjoining to CSFSF working facilities of housing-and-municipal and welfare purpose, as well as monuments of architecture, history and culture protected by the State are unavailable. recreational areas and cultural landscapes are unavailable in the areas of possible impacts.

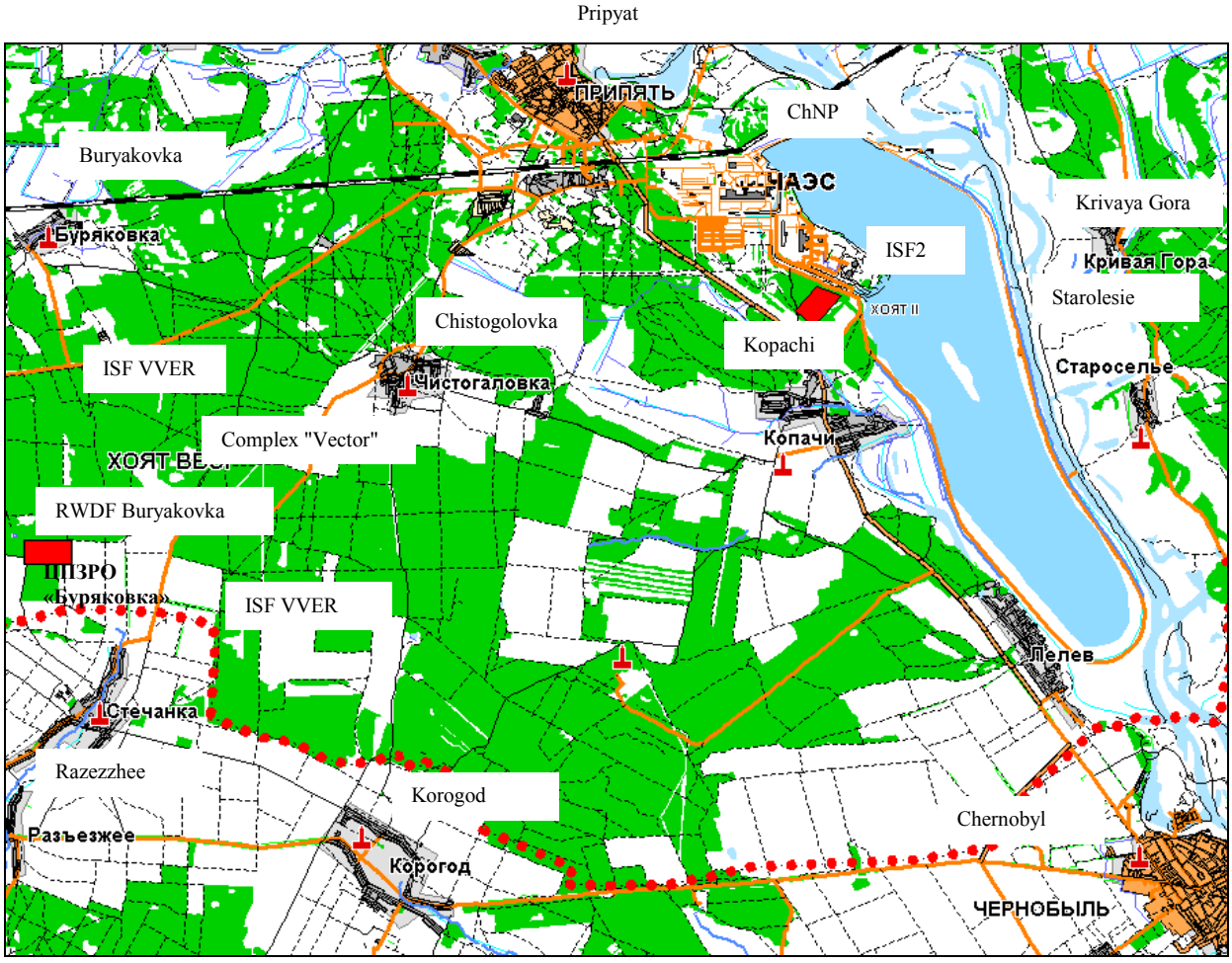

Figure 6.1 –Layout of man-caused facilities in CSFSF site

Activity on CSFSF operation does not assume change of existing operation conditions of the nearby enterprises. (Complex "Vektor", ChNPP, etc.). The unique factor of impact is usage of infrastructure of complex "Vektor" and ChNPP, as well as increase of dose uptakes of the personnel of the enterprises related to CSFSF operation.

Table 6.1 - Dose uptakes on the personnel of enterprises EZ and OEA during operation and accidents at the CSFSF

Enterprises and their structural subdivisions	**Distance from CSFSF, km**	**Controlled levels [5], mSv / year**	**Existing dose uptakes, mSv / year**	**Additional dose uptakes**		
				Normal conditions, mSv / year	**Emergencies *, mSv**	
					MDBA	**BDBA**
1 and 2 turns of SSE «ChNPP»	12,7	17	3,01	$1,5 \cdot 10^{-6}$	$3,8 \cdot 10^{-5}$	$4 \cdot 10^{-4}$
LRTF	13	17	3,01	$1,5 \cdot 10^{-6}$	$3,8 \cdot 10^{-5}$	$4 \cdot 10^{-4}$
ISF - 2	13,3	17	3,01	$1,5 \cdot 10^{-6}$	$3,8 \cdot 10^{-5}$	$4 \cdot 10^{-4}$
RWDF "Vektor" (enterprise at construction stage)	0,2	No data	0,14	$6 \cdot 10^{-3}$*	$1,2 \cdot 10^{-3}$	0,**2**
Chernobyl enterprises	21	2,3 - 15	0,1 - 3,9	$7 \cdot 10^{-7}$	$1,3 \cdot 10^{-5}$	$2 \cdot 10^{-4}$
RWDF "Buryakovka"	1,1	18	1,64	$7 \cdot 10^{-5}$	$1,2 \cdot 10^{-3}$	0,6

* - due to the fact that for small distances from CSFSF the used calculation procedure of spreading of emission gives the big mistakes, values at distance of the maximum concentration of radioactive aerosols in the air are conservatively used.

The table 6.1 shows that radiation impact on the personnel neighboring with CSFSF facilities at normal operation and possible accidents in CSFSF will not result in exceedance of CL of personnel exposure of these facilities. Taking into account small probability of occurrence of accidents, such impacts are acceptable.

A minimum possible impacts on infrastructure of nearby man-caused facilities are provided by process decisions in feasibility study.

Use of infrastructure of complex "Vektor" assumes usage of the following structures related to its infrastructure:

- Use of water intake structures;
- Use of artesian boreholes waters deferrization plant;
- Use of sanitary sewage clearing structures;
- Use of rain water sewage system clearing structures;
- Use of substation " Buryakovka ";
- Use of fire depot.

For export LRAW, generated during CSFSF operation, rent of the specialized tank truck for LRAW transportation is assumed.

For reception and processing of liquid and solid radwastes, generated during CSFSF operation, it is assumed to use systems and facilities of EZ and OEA. Thus, for SRAW transportation rent of vehicles on ChNPP is assumed. Besides for decontamination of overalls of CSFSF personnel, use of special laundry ChNPP is assumed. Taking into account that the special laundry was designed for reception of overalls from four power units of ChNPP and currently the plant is decommissioned and the quantity of the personnel is reduced, processing of insignificant quantity of CSFSF overalls will not affect the normal work of special laundry of ChNPP.

The analysis of possibility of use of infrastructure of complex "Vektor" and ChNPP is represented in table 6.2. Thus, possibility of use of infrastructure of complex "Vektor" is confirmed by letters of Technocenter. Confirming letters are given in volume 1, part 1 of feasibility study.

Table 6.2 – Analysis of possibility of use of infrastructure

Infrastructure		**Possibility of enterprise**		**Need of CSFSF**	
	Measuring units	**Availability of capacities**	**Own consumption**	**Active period**	**Passive period**
Complex "Vektor"					
Water of drinking quality	m^3/day	192 (1 borehole with debit 8m^3/hour)	93	30,36	8,33
Technical water (filling for 24 hours)	m^3/day	300	300	382	382
Electric power	kW	8600	2710 (without taking into account 2 turns)	4073	2253
Sanitary sewage water	m^3/day	100	57,48	14,7	6,17
Contaminated rain waters	m^3/day	13000	10300	74	74
Not contaminated waters of rain water sewage system	m^3/day	15000	12545	936	936
ChNPP					
SRAW (reception on ICSRM)	m^3 / year	3500		65,1	7,2
LRAW	m^3/day	120-240	10-20	1,8	0,12

The data represented in tables 6.1 and 6.2 testify that under normal conditions of CSFSF operation the impact on facilities of man-caused environment do not exceed the permissible levels.

To prevent CSFSF influence on operation of facilities of man-caused environment regarding influence on infrastructure of facilities, the following measures are envisaged:

- Taking into account that CSFSF needs for water of drinking quality are provided on limit of possibilities industrial complex «Vektor», feasibility study provides for arrangement additional artesian boreholes with an assumed flow rate 8 m3 / hour at water-intake station of complex Vektor;
- For power supply of consumers CSFSF, on substation "Buryakovka", serving consumers of complex "Vektor", feasibility study provided for replacement of both transformers with unit power 6300 kVA to transformers with the capacity of 16 MVA.

As shown in table 6.1, impact (comparable with the current dose uptakes) on the personnel neighboring with CSFSF facilities at normal operation, MDBA and BDBA is negligible enough.

As shown in table 6.2, increase in discharge of complex Vektor under condition of reception of effluents from CSFSF is assumed no more than on 5%. Taking into account that within the framework of complex "Vektor" it is planned to treat the effluents, the insignificant increase in discharge will not render essential impact on the environment.

Therefore, taking into account the approved measures the design activity on CSFSF operation will not render essential impact on man-caused environment.

7 MEASURES ON MINIMIZATION OF ADDITIONAL IMPACT ON THE ENVIRONMENT

7.1 Security Measures

The following measures within the framework of the feasibility study provided for security measures:

- arrangement of radiation monitoring system;
- arrangement of the monitoring system and registration of nuclear material;
- arrangement of physical protection system;
- arrangement of monitoring and control system by technological processes.

7.1.1 Radiation Monitoring System

Radiation monitoring system (RMS) of CSFSF carries out collection, processing and representation of the information on radiation conditions:

- in CSFSF rooms;
- at area of containers;
- gas-aerosol emissions in the environment;
- radiation process parameters;
- radiation doses of the personnel.

RMS solves the tasks related to measurement of parameters on which they are estimated:

- impact of industrial activity on the personnel and the environment;
- work of process systems;
- condition of the process equipment.

RMS means provide:

- radiation process monitoring;
- radiation monitoring;
- environment radiation monitoring;
- radiation monitoring behind non-distribution of radioactive contaminations.

For the decision of the mentioned above tasks the following is envisaged:

- continuous remote control;
- control by permanently installed local means;
- control by portable devices;
- control by sampling method of average with the subsequent processing and measurement in laboratories.

CSFSF radiation impact on the environment is supervised by means of environment radiation monitoring subsystem (ERM) and subsystems of the control over non-distribution of radioactive contaminations.

The subsystem ERM supervises sources of possible radioactive environmental contamination.

The control over the following parameters is carried out:

- activity and radionuclide content of gas-aerosol emissions in the atmosphere through vent stack;
- activity and radionuclide content of waste waters with sanitary sewage;
- activity and radionuclide content of water of observation boreholes.

The control of activity of emissions over the atmosphere is performed on the following components:

- alpha and beta - by aerosols;
- inert radioactive gases (IRG).

Radiation monitoring of gas-aerosol emissions in vent stack is carried out stationary system. This system provides for measurement of specific activities of radionuclides and, taking into account volume of off-gases, day integration is carried out.

The complete analysis of isotope structure of emission periodically is made for definition of monthly average permissible release on separate radionuclides by means of object laboratories of radiation monitoring.

The control of radiation conditions in area of CSFSF industrial site is carried out on dose rate of gamma-radiation by means of RPM subsystem, placed around perimeter of CSFSF site.

The control of activity of liquid discharges over sanitary sewage is carried out by RPM detecting units and duplicated by sampling method with the subsequent laboratory analysis by means of radiation monitoring object laboratories.

For the control of leakages of radioactive liquids in soil and prevention of their ingress in ground waters the control of activity groundwater from the control boreholes located around perimeter CSFSF is envisaged. The control is carried out sampling method with the subsequent laboratory analysis means object laboratories of radiation monitoring.

The subsystem of radiation monitoring over not spreading of radioactive contaminations provides the control of level of contamination with radioactive substances of surfaces of footwear, hands and clothes of the personnel and transport.

The control of contaminations of skins and IPE by beta-active radionuclides is carried out by stationary control installations on entry and exit of change facility.

The control of carrying out of radioactivity outside the CSFSF limits is carried out the stationary control installation installed in lobby of access control point - 1.

The control of radioactive contamination level of surfaces of walls of rooms and the equipment is carried out by portable radiometers as well as wipe test method of with the subsequent measurements in radiation monitoring laboratory.

The control of surface contamination level of vehicles is carried out portable radiometers.

7.1.2 Nuclear Material Monitoring and Registration System

The nuclear materials received in storage facility, will be taken into account by computerized database under the management with nuclear fuel.

The system includes complex technical and organizational measures providing the permanent control of quantity of nuclear materials, (including: keeping records, identification and inventory of incoming spent fuel assemblies).

The control and registration of fissionable materials will be carried out in manual mode, with entering the necessary information in personal computer from the workplace of engineer on control and registration of fissionable materials. The information from personal computer will come to archiving and will be protected from the non-authorized access by system of passwords.

7.1.3 Physical Protection System

It is planned to develop a physical protection system, which is designed as a set of organizational, legal, efficient, and engineering, and technical measures for arrangement of conditions which would make impossible fulfillment of acts of nuclear terrorism, plunder or any other illegal withdrawal of the spent nuclear fuel and radwastes from CSFSF territory,

7.1.4 Technological Processes Monitoring and Control System

Monitoring and control system (MCS) of CSFSF should provide the comprehensive control and management of technological processes over acceptance and storage of containers with the spent nuclear fuel.

MCS will integrate separate primary systems into uniform system that will make possible to perform comprehensive processing, representation, archiving of the information in one place – on central information and control panel. MCS should provide support of radiation and general industrial safety at acceptance of multi-purpose container with spent fuel assemblies and their storage. MCS should perform function of information support for the personnel convenient for

withstanding and the analysis for the purpose of definitions of negative tendencies in change of condition of hazardous sources in CSFSF and implementation of measures on prevention of these tendencies development.

The following design criteria will serve as a basis of MCS:

- Reliability of system (reached due to applications of elements with high reliability indexes and optimum construction of structure, possibility of failure detection at work of system by diagnostics of means);
- Openness of system (reached due to possibilities of inclusion of additional elements and systems in the structure and own integration into other information systems).

MCS –distributed information and controlling system having two levels of hierarchy.

Lower MCS level consists of the following local systems:

- Control of transport containers reception;
- Control of storage process;
- Radiation monitoring;
- Registration and control of fissionable materials;
- Control and management of heating and ventilation;
- Control and management of special sewage system;
- Control and management of compressed air;
- Control and management of water supply;
- Control and management of shower rooms of waters;
- Control and management of rain effluents;
- Control and management of power supply;
- Control and management of fire safety system;
- communication.

The following functions will be assigned to top level of MCS:

- Collection and processing of the information from means of a lower level;
- Display of controllable parameters in convenient for withstanding, diagnosing and management to the form;
- Archiving of the information;
- Information interchange with adjacent systems.

Management and the control by CSFSF technological processes will be carried out from control panels - central CCP and local I (MCP).

7.2 Security Measures

The following security measures are envisaged within the framework of the Feasibility Study:

- Construction of access control point - 1 with permanent stay of the guarding personnel to control the personnel and motor transport to CSFSF territory is envisaged;
- Construction of access control point - 2 is envisaged which will function during travel of rolling stock for the permit of railway transportation on CSFSF territory;
- Access control point for travel of railway and motor transport will be equipped with the main anti- ramming and auxiliary rolling mechanized gates. Emergency departure road for transport will be equipped with main rolling anti- ramming and auxiliary rolling gates;
- Development of ventilation system with clearing air of transportation and process corridor of reception building and rooms of controlled access area of aerosols on filters of special ventilation is envisaged for reduction and/or prevention of radioactive emission during CSFSF operation;
- In order to prevent ingress of liquid radioactive substances in the environment all operations with LRAW will be made within the framework of rooms of controlled access area cladded with stainless steel;

- In order to prevent ionizing radiation impact on the personnel and the environment during operations with spent nuclear fuel, use of protective containers HI-TRAC whose design provides for required normalized protection against ionizing and neutron radiation is envisaged;
- In order to reduce ionizing radiation impact on the personnel and the environment at long-term storage of spent nuclear fuel, use of reinforced concrete HI-STORM whose design provides for required biological protection is envisaged;
- Use of the transport protective container HI-STAR providing normalized protection against ionizing and neutron radiation is assumed For transportation of spent nuclear fuel from NPP to CSFSF;
- Use of the transport protective container (reinforced concrete from with thickness web of 150 mm), providing normalized protection against ionizing radiation is assumed for collection and transportation SRAW from CSFSF on the Vektor / ChNPP;
- For reduction of probability and/or exceptions of accidents related to transportation spent nuclear fuel from NPP it is assumed to use transport containers HI-STAR which are meeting the requirements of radioactive and nuclear materials transportation rules along nation-wide roads;
- To ensure CSFSF fire safety measures on prevention of occurrence of fire, fire-prevention protection and organizational - technical measures are provided for;
- Technical measures including application of the equipment in silent execution, application of special acoustic inserts, etc. are envisaged For reduction and/or exception of impact of noise of CSFSF equipment on the environment;
- In order to exclude the loss of the control of spent nuclear fuel and technological process at full blackout of CSFSF the system of reliable power supply of consumers of radiation monitoring, the control and registration of nuclear material, physical protection and the fire signaling system will be developed;
- For reduction of probability and/or exception of CSFSF impact on the environment at the external initial events typical for this area, designing reception building and area of containers according to the requirements of PiN AE 5.6 to buildings of 1 category, showing the requirements for loads and impacts on NPP structures depending on their responsibility for nuclear and radiation safety is envisaged;
- For protection CSFSF structures from possible external fire, fire-prevention strips shall be arranged around of CSFSF perimeter;
- For reduction of probability and/or exception of occurrence of a fire during CSFSF construction it is assumed to apply fire-prevention measures;
- For reduction of exception of impact on the environment at the accident of aircraft falling on CSFSF, container HI-STORM which is designed for impact from aircraft impact is used and, therefore, accident will not result in release of radioactive substances into the environment.

7.3 Reconditioning Measures

Within the framework of feasibility study the following reconditioning measures are envisaged:

- removal of radioactively contaminated soil and its delivery to RWDF "Buryakovka";
- leveling works improving existing conditions of relief, reducing exogenic processes in CSFSF site;
- land improvement with landing bushes;
- asphalting of covering of in-site roads and the prohibited zone, reducing probability and/or excluding penetration of radioactive substances into soil;
- arrangement of rain water sewage system of industrial site with the control and the further clearing;
- clearing of territory of exclusion zone on the area approximately 18 hectares (the approximate area of facilities of construction) during construction from radioactive contamination.

7.4 Compensation Measures

Within the framework of the feasibility study the following compensating measures are envisaged:

- allocation of part of funds (3 %) invested in CSFSF construction for construction of social purpose facilities;
- at assessment of operational expenses CSFSF the additional payment, extra charges and premiums to tariff salaries of the personnel are taken into account according to the valid legislation of Ukraine;
- at estimation of cost of construction additional means for compensation of expenses for work as shift operation and operating conditions in ChNPP exclusion zone which are regulated by the valid legislation are taken into account;
- as the indemnifications for possibility of influence on infrastructure of complex "Vektor" the arrangement additional artesian boreholes and reconstruction of substation "Buryakovka" is envisaged.

Besides, within the framework of the valid legislation:

- the personnel of nuclear installation (CSFSF) has the right to social and economic indemnification of negative ionizing radiation impact on its health;
- citizens whose health and property were damaged by negative ionizing radiation impact during use of nuclear energy have the right to its compensation in full scope;
- the personnel of nuclear installations is subjected to obligatory risk insurance against the negative ionizing radiation impact due to licensees funds.

7.5 Resource-saving Measures

Within the framework of the feasibility study the following resource-saving measures are envisaged:

- rejection of use of artesian water for regulation of air temperature in rooms, i.e. for electric heating is envisaged;
- rejection of use of pure water for watering territories, i.e. clarified rain water is planned to be used for watering of territories;
- application of the equipment (cranes, fans, pumps), consuming a minimum electric power at other equal performance data;
- use of technology which allows to place a maximum quantity of spent fuel assemblies in one multi-purpose container that reduces specific consumption of media on one spent fuel assemblies;
- leveling elevation (138,5 m) of CSFSF site allowing to minimize scope of ground works is chosen;
- CSFSF site is chosen excluding additional filling of the pure ground in order to make possible normalized water table.

8 COMPREHENSIVE ENVIRONMENT IMPACT ASSESSMENT

8.1 Comprehensive Assessment of CSFSF Impact under Normal Operation Condition

Assessments developed in the previous EIA sections have shown that under normal operation conditions the main type of CSFSF impact on components of the environment is the radiation (selection of components is made in conformity with DBN A. 2.2-1-2003[1]).

Application of measures on noise and vibration suppression (section 7.2) makes possible to consider insignificant impacts of noise and vibration on the environment. During operation it is not assumed to use the technologies resulting in intensive electromagnetic radiation and ultrasound.

The air ambient, water media (surface and ground waters), topsoil, flora and fauna, social and man-caused environment are related to components of the environment to which are assumed radiation impact. Results of assessment of CSFSF impact on these components under normal operation condition are given below.

At present and during CSFSF operation period man-caused changes of condition of geological environment under impact of CSFSF are not predicted. Geological environment of industrial site of CSFSF is characterized by sufficient stability and does not render negative influence on CSFSF structures operation.

Negative CSFSF impact on facilities of social environment is not forecast also, due to lack of the population in ChNPP exclusion zone, however CSFSF impact outside exclusion zone is considered.

Based on the results of assessment of CSFSF impact on the environment under decommissioning given in sections 4-6, the main source of radiation impact which took place at commercial operation is the spent fuel assemblies. An equipment associated with the spent fuel assemblies handling is excluded during this period as well. Taking this fact into account the forecast shows that the potential of CSFSF radiation impact on the environment and the population under decommissioning is much lower than at stage of commercial operation.

8.1.1 Assessment of Impact on the Air Medium

During CSFSF normal operation the emission of radioactive substances in the environment is possible only during dust release from the contaminated external surface of MPC. Conservatively it was accepted that surface contamination is represented exclusively by ^{60}Co. The dust release can occur in two cases:

- under MPC overloading from transport container HI-STAR into HI-STORM and subsequent emission of activity through the vent stack (height – 21 m) of the reception building of storage facility;
- directly during MPC storage inside of HI-STORM at storage area (emission through top ventilating openings of HI-STORM).

Besides, calculations consider additional surface contamination of railway platform with module HI-STAR due to travel on contaminated territory EZ and OEA. Conservatively it was assumed that all surface contamination of platform with ^{137}Cs (basis of main dose generating) is released into the environment through the vent stack of CSFSF reception building.

The calculated quantity of ^{137}Cs which will get in CSFSF reception building as surface contamination of railway platform and release in the environment will make no more than 190 Bq a year. The analysis of results of calculations of impacts on the air ambient (section 4.3.2) by means of emission through the vent stack of reception building has shown that the greatest possible value of volumetric concentration of radionuclide ^{60}Co as 6 Bq/m^3 on the surface air will be observed at distance of 250 – 300 m from the source under conditions of normal operation.

On the nearest boundary of EZ and OEA (13 km in "South-West" direction) the value of volumetric concentration of ^{60}Co will not exceed 0,02 Bq/m^3 under normal operation conditions of storage facility.

Taking into account the fact that permissible concentration of radionuclide ^{60}Co in air (PC_B^{inhal}) for the population of Ukraine makes 1 Bq/m^3 [NRBU - 97] it is stated that this

concentration under condition of normal operation of storage facility will not be exceeded at the boundary of residential territories.

Based on results of forecasting calculations, a maximum of volumetric concentration of ^{60}Co in the surface air as $6,0 \cdot 10^{-5}$ Bq/m^3 will be observed at distance of 50 – 70 m from source under emission of radioactive substances from HI-STORM during a year due to contaminations of external surface of MPC.

Accordingly, at the distance of 13 km from CSFSF the value of volumetric concentration of ^{60}Co will not exceed $8,0 \bullet 10^{-9}$ Bq/m^3 that much less than the specified normative values.

Therefore, the level of radiation impacts on the air ambient of territories with population location will not exceed the specified normative values irrespective of source and character of emission under CSFSF normal operation.

8.1.2 Assessment of Impact on Water Media

Sources of impact on water media under CSFSF normal operation are:

- waters of sanitary sewage;
- waters of rain water sewage system;
- the waters of the industrial sewage system contaminated with mineral oil;
- liquid radwaste.

Discharges of radioactive and non-radioactive contaminated substances on environmental water media under CSFSF normal operation condition are excluded due to design decisions accepted in feasibility study (reference to section 3 of this EIA) regarding to collection, control and transportation of sewage waters generated at CSFSF site.

The maximum saving of water resources is reached in CSFSF – the annual need for water of drinking quality does not exceed 4500 m^3 .It is possibly due to refuse of artesian water usage for rooms air temperature regulation and site cleaning.

Therefore, under normal conditions, CSFSF impact on water objects is possible only by the air medium due to direct sedimentation of contaminated substances on water surfaces from atmosphere or surface filtrations of these substances from topsoil.

The analysis of spreading of radioactive emissions into the air medium under normal conditions of CSFSF operation has shown that surface contamination of territories (at distances more than 1 km) will make 100-th fractions of percent from the existing contamination caused by emergency emission from ChNPP. Being based on data results and taking into account that surface reservoirs are located at the great distance from CSFSF (river Uzh – 6-8 km, river Sakhan –- 7 km, river Pripyat – 12 km), volumetric concentration of radioactive substances in water of the specified reservoirs, caused by CSFSF, will be lower than levels of reliable detecting.

Radioactive contamination of ground waters during CSFSF operation is possible only due to the vertical migration of the radionuclides which can be accumulated on surface of topsoil. Results of calculations show that during stage of active operation of the facility within of 50 years (annual reception of spent nuclear fuel), the maximum additional surface topsoil contamination by ^{60}Co will not exceed 600 Bq/m^2 (without taking into account a half-life period of ^{60}Co making 5,27 years). Water tables of CSFSF construction site occur on the depth 18 - 21 m. Considering such a fact that an average speed of vertical migration of radionuclides in soils of EZ and OEA is 0,1-1,5 cm / year, ^{60}Co intake on ground waters at CSFSF normal operation can be neglected.

8.1.3 Assessment of Impact on Topsoil

Under the design data the complex of CSFSF structures occupies no more than 19 hectares (including the area under routing of railway way - 7 hectares, industrial site – 11,72 hectares) that makes 0,02 % from the area of all 30-kilometer zone. CSFSF requires the area of 11,72 hectares (CSFSF site inside fencing).

Therefore, possible changes of physical and chemical, and water and physical soil properties should be considered at the following design stages after performance of additional

investigations. At the same time, taking into account insignificant percent of occupied territory, significant changes of soil properties are not expected.

Besides the main CSFSF site it is required to have an area for entrance of transport, storing of soil and cut down forest. Exact determination of the area of the assigned grounds and their cost will be made at the design stage. Taking into account lack of agricultural use of the grounds in area of construction and non-inclusion of the assigned grounds in structure of facilities of natural-reserved fund, such assignment of the grounds for the specified purposes is permissible.

Source of impact on topsoil under CSFSF normal operation are radioactive release from HI-STORM. The maximum contamination by ^{60}Co during 1 year of operation of storage facility (under constant weather conditions) will not exceed 12 Bq/m^2 and will be observed at distance 50 – 70 m from CSFSF.

Accordingly, the maximum additional topsoil contamination surface at distance 50 – 70 m from storage facility will not exceed 600 Bq/m^2 for the period of 50 years (active period of spent nuclear fuel reciving) under constant weather conditions, lack of secondary migration and without considering of relatively short half-life period of ^{60}Co (5,27 years),.

Under the same conditions, during 50 years of CSFSF operation, the maximum additional contamination of surface of topsoil on boundary of EZ and OEA (distance – 13 km) will not exceed 0,002 Bq/m^2 that certainly are insignificant impact on condition of topsoil.

Therefore, at the CSFSF normal operation, essential radiation impacts on topsoil of residential territories is not assumed.

8.1.4 Assessment of Impact on Flora and Fauna

Being based on the above stated assessments it is possible to draw a conclusion that impact will not result in deterioration of conditions of growth and dwelling of the living organisms which are available in the area of site under CSFSF normal operation conditions.

Besides, it is necessary to note that biocenoses in CSFSF site are available and successfully develop at presence of significant density of radioactive contamination of the soil and vegetative cover, reaching at the separate areas of adjoining territories of 200-400 Ci/km^2 of total activity. Therefore, it is not necessary to expect any changes in structure of natural populations caused by impacts of radioactive CSFSF emissions, that make the tenth fractions of percent from the existing density of contamination of territory.

Therefore, CSFSF impacts on flora and fauna are estimateted as acceptable at normal operation Condition.

8.1.5 Assessment of Impacts on Man-caused Environment

Section 6 of the entire EIA considers the following facilities of CSFSF impact on man-caused environment:

- main buildings of Chernobyl NPP;
- LRTF;
- ISF - 2 of CHNPP;
- complex "Vektor";
- enterprises in Chernobyl town;
- RWDF "Buryakovka".

Activity on CSFSF operation does not assume change of existing conditions of operation of the enterprises located nearby (Complex "Vektor", ChNPP, etc.). The unique factor of impact is use of infrastructure of complex Vektor and ChNPP, as well as increase of dose uptakes of the personnel of the enterprises related to CSFSF operation.

The data represented in table 6.1 of the present EIA testify that under normal conditions of CSFSF operation the impacts on facilities of man-caused environment do not exceed permissible levels. For exception of CSFSF influence on operation of man-caused environment facilities regarding influence on infrastructure of facilities there will be provided for the compensating measures.

As a result of calculations of dose uptakes for the personnel of considered facilities as a result of CSFSF normal operation, section 6 of this EIA shows that additional dose uptakes of the personnel of these facilities taking into account existing dose uptakes do not exceed the controlled levels for the specified personnel. Results of calculations are represented in table 8.1.1.

Table 8.1.1 – Dose uptakes on the personnel of facilities at normal operation condition

Facility	**Controlled levels, mSv / year**	**Existing dose uptakes, mSv / year**	**Additional dose uptakes during operation, mSv / year**
Main buildings of ChNPP	17	3,01	$1{,}5 \cdot 10^{-6}$
LRTF	17	3,01	$1{,}5 \cdot 10^{-6}$
ISF - 2	17	3,01	$1{,}5 \cdot 10^{-6}$
Complex Vektor	18	0,14	$6 \cdot 10^{-3}$
Enterprises in Chernobyl town	2,3-15	0,1-3,9	$7 \cdot 10^{-7}$
RWDF "Buryakovka"	18	1,64	$7 \cdot 10^{-5}$

8.1.6 Assessment of Impacts on Social Environment

As a result of calculations of dose uptakes of the population outside the exclusion zone at CSFSF normal operation, section 5.2 of the current EIA shows that additional dose uptakes for the population do not exceed the limits specified in NRBU - 97. Results of calculations are represented in table 8.1.2.

Table 8.1.2 – Dose uptakes on the population during operation

Distance from CSFSF, km	**Exposure dose limits, regulated NRBU - 97, mSv / year**	**Dose uptakes for population during operation, mSv / year**
13 (boundary of 30-km exclusion zones ChNPP)	1	$1{,}5\ 10^{-6}$
21 (Chernobyl)	1 (unauthorized residents)	$7{,}0\ 10^{-7}$

8.2 Comprehensive Assessment of CSFSF Impact under Accident Conditions

Data represented in section 3 of the present EIA demonstrate that safety related structures and systems of CSFSF will be designed taking into account extreme external impacts to be determined by environment conditions of the site (seismic impact, up to MDE), tornado, extreme ambient temperatures). At the specified impacts conditions of safety are provided for CSFSF and, accordingly, additional impacts CSFSF on the environment are unavailable.

Section 3 of this EIA describes possible emergency situations whose consequences can impact on the environment.

The air medium, water media, topsoil, flora and fauna, man-caused environment, social environment are related to components of the environment that should be considered by impact analysis under emergency situations.

Results of the generalized assessments of impact are given in the subsections below.

8.2.1 Considered Accidents

The accident with the maximum consequences is defined in section 3.7 of the given EIA under consideration of possible design-basis accidents during CSFSF operation. Such accident is an emergency emission due to surface contamination of MPC in fuel pool of NPP and, therefore, release of the radioactive aerosols either in ventilation system of reception building, or in the environment at storage area of HI-STORM. It is conservatively considered that all activity by

surface contamination of MPC is instantly thrown out from the reception building. The description of accident sequence and expected consequences are given in section 3.7.1 of this EIA and Attachment B.

The beyond design basis accident with the maximum consequences is determined by consideration of possible options of the beyond design basis accidents presented in section 3.7 of the given EIA and Attachment B, based on materials of Holtec International and performed Safety Analysis Report for CSFSF of Zaporozhye NPP. As the most severe beyond-design-basis accident is considered an accident with violation of heat removal inside MPC, loss of sealing of all fuel rods and leakage of radioactive substances through out the lid of MPC-31 by unknown reasons. Thus, the release of gas-aerosol mix occurs during 30 days from zero elevation of height into the environment. The description of accident sequence and expected consequences are given in section 3.7.1 of the EIA.

8.2.2 Assessment of Impact on the Air Ambient

8.2.2.1 Assessment of MDBA

Calculations show that at the area of possible contamination of surface of MPC-31 equal to 30,54 m^2, the activity of instant emission from CSFSF reception building will make $2{,}67 \cdot 10^9$ Bq. As a result of such accident, volumetric activity of radionuclides in the air and level of surface contamination of environmental territory can temporarily rise. Thus, such impacts can render the greatest danger for the personnel of complex "Vektor".

The maximum value of volumetric concentration of ^{60}Co in the air (average for 5 hours) - 16 Bq/m^3 will be observed at the length 1100 m from emission source. At the distance 13 km (boundary of residential area), values of volumetric activity ^{60}Co in the air (average for 5 hours), accordingly will be smaller, and will not exceed 0,5 Bq/m^3. According to NRBU – 97 this value in 2 times less than permissible concentration of ^{60}Co in the air for the population (category B).

Therefore, radiation impacts of possible MDBA on the air should be considered as acceptable.

8.2.2.2 Assessment of Beyond-Design-Basis Accident

Emission of $1{,}8 \cdot 10^{10}$ Bq of total activity is expected in accordance with calculations represented in section 4.3.3 of the given EIA as a result of the beyond design basis (hypothetical) accident. Thus, the maximum value of total volumetric activity of radionuclides in the air ambient will be observed near to emergency HI-STORM and will not exceed 100 Bq/m^3 at distance of 100 m from it. On boundary of EZ and OEA (distance 13 km) this index will not exceed 0,05 Bq/m^3.

Taking into account low probability of similar accident and insignificant air contamination of residential territories due to beyond-design-basis accident radiation impacts should be considered as acceptable.

8.2.3 Assessment of Impact on Water Media

8.2.3.1 Assessment of MDBA

Under assessment of MDBA impact it was assumed that a part of the activity released into the air ambient after accident will fall-out on river Pripyat surface without deposition on a river bottom and taken out outside the border of EZ and OEA. The smallest distance from CSFSF up to waters' edge on the right bank of the river Pripyat makes 13 km and the width of the river in this place is equal to 300 m (conservatively).

The analysis of MDBA impact on the water surface is given in section 4.5.2 of this EIA. This analysis has shown that about $5{,}6 \cdot 10^6$ Bq of ^{60}Co will fall-out on the area of water surface that is negligibly small value in comparison with total annual activity that is transferred by river Pripyat stream (up to 10^{13} Bq by the sum of radionuclides).

Therefore, radiation impacts on water media in case of possible MDBA will be insignificant.

Intake of ^{60}Co in ground waters due to soil surface contamination during MDBA is excluded because of low speed of vertical migration and relatively small half-life period (5,27 years) of this radionuclide.

8.2.3.2 Assessment of Beyond-Design-Basis Accident

Area of delta of river Pripyat at the distance 20 km (south-east direction) from CSFSF was chosen for conservative assessment of impact of emission on water objects under BDBA. This area is characterized by the greatest area of water surface mirror (width about 1000 m) of flowing reservoirs (river-bed of Pripyat with dead channels). Pursuant to the design data the total quantity of the radionuclides which have dropped out on this area (along axis of emission plume) will not exceed $4{,}3 \cdot 10^5$ Bq. Such quantity of activity is less than activity transferred with annual stream of river Pripyat in many times (up to 10^{13} Bq per a year).

Taking into account that concentration of radioactive substances in river Pripyat currently does not exceed value of permissible concentration for potable water, the radiation impacts on surface of water, at possible BDBA in CSFSF, also will not result in essential increase of their concentration in water of river Pripyat. Therefore, due to BDBA radiation impacts on surface waters should be considered as permissible.

In case of BDBA intensity of processes of contamination of ground waters will be determined both level of groundwater occurrence and level of the additional surface contamination dependent on distance up to emission point.

CSFSF site is located on the leveled plateau with deep (above 18 m) groundwater occurrence, where in radius of 2 - 3 km there are unavailable the large closed downturn of relief which surface contamination eventually can result in their essential contamination.

Taking into account such a fact that the greatest (comparable with background) surface contamination of soils due to BDBA will be observed in radius up to 300 m from CSFSF industrial site only (see section 4.5), additional contamination of ground waters will not take place at possible BDBA at CSFSF site.

8.2.4 Assessment of Impact on Topsoil

8.2.4.1 Assessment of MDBA

The analysis of MDBA impact on concentration of radionuclides in the air medium (given in section 4.4.3 of this EIA) has shown that maximum deposition of radioactive aerosols ^{60}Co will be observed at the length of 1100 m from emergency HI-STORM and will not exceed 10 kBq/m^2. Taking into account small probability of such contamination of soils in actual conditions (emission in the course of the year under constant weather conditions) and high initial level of surface contamination of soils of adjoining territories (142 kBq/m^2 by the sum of radionuclides), such impact practically will not affect to condition of topsoil.

Therefore, on 13 km (boundary of 30-km exclusion zone of ChNPP) radiation impacts of MDBA will be smaller. The additional density of soils surface contamination by ^{60}Co will not exceed 0,007 kBq/m^2. Taking into account high background radioactive contamination of soils of the CSFSF adjoining territories (142 kBq/m^2 by the sum of radionuclides), such additional contamination does not render essential impact on topsoil.

Therefore, essential radiation impact on topsoil of residential territories is not assumed under possible maximum design accident in CSFSF.

8.2.4.2 Assessment of Beyond-Design-Basis Accident

In case of BDBA radioactive emission will be represented by gas-aerosol mix of radionuclides. Isotopes of cesium (^{134}Cs and ^{137}Cs) and ^{90}Sr have the greatest value in case of topsoil contamination.

The analysis of spatial distribution of radioactive fallouts due to BDBA has shown (section 4.5.4) that the maximum value of additional surface contamination will be observed near the emergency HI-STORM. At the distance of 100 m from emergency HI-STORM it will not exceed

30 kBq/m^2 for isotopes of cesium and 15 kBq/m^2 for ^{90}Sr that will not result in essential changes of radiation conditions. Thus, the maximum additional contamination of residential territories outside EZ and OEA will not exceed 20 Bq/m^2 by isotopes of cesium and 8 Bq/m^2 by ^{90}Sr that also will not affect on radiation conditions, since additional contamination will make less than 0,1% of background contamination. Taking into account small probability of BDBA in CSFSF, radiation impacts on topsoil should be considered as acceptable.

8.2.5 Assessment of Impact on Flora and Fauna

8.2.5.1 Assessment of MDBA

The analysis of impact of emergency contamination on the environment components in case of MDBA occurrence (see section 4.3and 4.5) shows that the maximum of additional surface soil contamination by ^{60}Co will not exceed 10 kBq/m^2 (0,3 Ci/km^2) and will be observed at the length 1100 m from the storage facility. Taking into account the fact that total background contamination of adjoining territories by gamma - radiating radionuclides (^{60}Co analogues by biological impact), is not less than 93 kBq/m^2 (2,5 Ci/km^{2,}) the actual additional impact on flora and fauna due to MDBA will be insignificant.

8.2.5.2 Assessment of Beyond Design-Basis Accident

In case of the beyond the design basis (hypothetical) accident there will not be any significant contamination of soil - vegetative cover (see section 4.5.5), air (see section 4.3.5) and water media (see section 4.4.2.2). Taking into account these conditions, there will not be any significant radiation impact on animals and flora.

Therefore, radiation impact on fauna and flora due to BDBA can be considered as acceptable.

8.2.6 Assessment of Impact on Man-caused Environment

Section 6 of this EIA considers the following facilities likely to be affected by CSFSF impact during accidents:

- Main buildings of Chernobyl NPP;
- LRTF;
- ISF - 2 CHNPP;
- Complex Vektor;
- Chernobyl enterprises;
- RWDF "Buryakovka".

8.2.6.1 Assessment of MDBA

The estimate of personnel dose uptakes for the facilities considered in section 6 of this EIA shows that in case of the MDBA at the CSFSF the additional dose uptakes of personnel working at these facilities will not exceed the control levels specified taking into account the existing dose uptakes. Results of calculations are represented in table 8.2.1.

Table 8.2.1 – Personnel dose uptakes in case of MDBA

Facility	**Control levels, mSv / year**	**Existing dose uptakes, mSv / year**	**Additional dose uptakes due to MDBA, mSv**
Main buildings of Chernobyl	17	3,01	$3{,}8\cdot10^{-5}$
LRTF	17	3,01	$3{,}8\cdot10^{-5}$
ISF - 2	17	3,01	$3{,}8\cdot10^{-5}$

Facility	Control levels, mSv / year	Existing dose uptakes, mSv / year	Additional dose uptakes due to MDBA, mSv
Complex Vektor	18	0,14	$1,2 \cdot 10^{-3}$
Chernobyl enterprises	2,3-15	0,1-3,9	$1,3 \cdot 10^{-5}$
RWDF "Buryakovka"	18	1,64	$1,2 \cdot 10^{-3}$

8.2.6.2 Assessment of Beyond Design Basis Accident

The estimate of additional dose uptakes for the personnel working at the facilities considered (refer to section 6), shows that in case of BDBA at the CSFSF the additional exposure will not exceed annual effective dose limit (20 mSv) for the personnel, taking into account existing dose uptakes. Results of calculations are represented in table 8.2.2.

Taking into account small probability of occurrence of such accident radiation impacts in case of BDBA in CSFSF, it is considered as acceptable.

Table 8.2.2 – Additional personnel dose uptakes due to BDBA

Facility	Control levels, mSv / year	Existing dose uptakes, mSv / year	Additional dose uptakes due to BDBA, mSv
Main buildings of Chernobyl	17	3,01	$4 \cdot 10^{-4}$
LRTF	17	3,01	$4 \cdot 10^{-4}$
ISF - 2	17	3,01	$4 \cdot 10^{-4}$
Complex "Vektor"	18	0,14	0,**2**
Chernobyl enterprises	2,3-15	0,1-3,9	$2 \cdot 10^{-4}$
RWDF "Buryakovka"	18	1,64	0,6

8.2.7 Assessment of Impacts on Social Environment

8.2.7.1 Assessment of MDBA

Calculations of dose uptakes for the population living outside EZ and MRZ (see section 5.2.2) show that in case of the MDBA at the CSFSF the additional dose uptakes will not exceed the limits specified in NRBU - 97. Results of calculations are represented in table 8.2.3.

Table 8.2.3 - Additional dose uptakes estimated for the population due to MDBA at the CSFSF

Distance from CSFSF, km	Limits of radiation dose for the population (category B), mSv / year	Additional dose uptakes during MDBA *, mSv
13 (boundary of 30-km exclusion zone of ChNPP)	1	$3,6\ 10^{-5}$
21 (Chernobyl)	1 ("unauthorized residents")	$1,3\ 10^{-5}$

* - doses are calculated with consideration of all ways of impact of emission.

8.2.7.2 Assessment of Beyond Design Basis Accident

Calculations of dose uptakes for the population (ref. section 5.2) show that in case of BDBA the additional dose uptakes will not exceed the limits specified NRBU - 97 (1 mSv / year). Results of calculations are represented in table 8.2.4.

Table 8.2.4 - Additional dose uptakes estimated for the population due to Beyond-the-Design-Basis Accident in CSFSF

Distance from CSFSF, km	**Limits of radiation dose for the population, mSv / year**	**Additional dose uptakes due to BDBA, mSv**
13 (boundary of 30-km exclusion zone of ChNPP)	1 (population)	$4 \cdot 10^{-4}$
21 (Chernobyl)	1 ("unauthorized residents")	$2 \cdot 10^{-4}$

8.3 Description of Residual Impacts

Tables 8.3.1 and 8.3.2 contain the summary list of residual impacts caused by the CSFSF under normal operation conditions, as well as in case of the accidents during CSFSF operation. The information presented is based on the data of the sources of impacts, described in sections 3,4 of this EIA, and the results of assessments given in sections 4-6 taking into account implementation of ecological safety measures included into design and stated in in section 7 of this EIA.

Table 8.3.1 – List of residual impacts of CSFSF under normal operation conditions

Types and sources of impact	Parameters of releases and discharges	Description of impacts on components of the environment					
		Air ambient	Water medium	Topsoil	Flora and fauna	Man-caused environment	Social environment
Normal operation conditions							
Radioactive gaseous releases to the atmosphere through vent stack of reception building due to surface contamination of railroad platforms and permissible surface contamination of MPC	Release of Cs will make 190 Bq/year), ^{60}Co-1,61·107 Bq/year. Release of other radionuclides (^{90}Sr, TUE and etc.) makes negligible small value	Greatest possible concentration of ^{60}Co – 6,0 Bq/m^3, will be observed at distance of 250 – 300 m from a source, on boundary of 10-km zone 0,4 Bq/m^3, on the nearest boundary of EZ and OEA – 0,02 Bq/m^3	At depth of groundwater over 10 m and average speed of vertical migration through aeration zone 10^{-2}-10^{-4} m / day negative radiation impacts are not expected.	Negative radiation impacts will not be occurred because of the design decisions made for ventilation system	The content of natural populations is unlikely to be changed due to CSFSF radioactive releases which constitute the tenth percent fractions of the existing contamination rate of the territory	Maximum additional radiation doses expected for the personnel of complex Vektor will be – 0,006 mSv/year that along with existing dose does not exceed 0,08% of control levels	Dose uptakes for the population outside exclusion zone do not exceed limit of 0,0004% specified by NRBU - 97 (1 mSv/year)

Types and sources of impact	Parameters of releases and discharges	Description of impacts on components of the environment					
		Air ambient	Water medium	Topsoil	Flora and fauna	Man-caused environment	Social environment
Radioactive gaseous releases to the atmosphere through vent channels of HI-STORM due to permissible surface contamination of MPC	Release of ^{60}Co-$1{,}61 \cdot 10^{7}$ Bq/year. Release of other radionuclides (^{90}Sr, TUE and etc.) makes negligible small value	The greatest possible concentration of ^{60}Co – $6{,}0 \cdot 10^{-5}$ Bq/m^3 will be observed at distance 50 – 70 m from area of containers that makes less than 17 % CL for area by the sum of radionuclides on boundary 10-km zone – less than 0,3 % CL, on the nearest boundary of EZ and MRZ – 0,2 % CL	At the depth of groundwater over 10 m and and average speed of vertical migration through aeration zone 10^{-2}-10^{-4} m / day negative radiation impacts will not be rendered	For 50 years maximum topsoil additional surface contamination with ^{60}Co will be at distance of 50-70 m and will make 600 Bq/m^2 that is 12% of the existing rate. At the boundary of the CHNPP 10-km zone additional surface contamination with ^{60}Co will not exceed 2,5Bq/m^2 At the nearest boundary of the EZ and MRZ additional surface contamination will be 0,0025Bq/m^2 that corresponds to 0,05 and 0,0005 % of the actual topsoil contamination.	The content of natural populations is unlikely to be changed due to CSFSF radioactive releases, which constitutes the tenth percent fractions of the existing contamination rate for the territory considered.	Maximum additional radiation doses expected for the personnel of complex Vektor will be 0,006 mSv/year that along with existing dose does not exceed 0,08% of the controllevels	Dose uptakes for the population outside exclusion zone do not exceed the limit 0,0004% specified NRBU - 97 (1 mSv / year)

Types and sources of impact	Parameters of releases and discharges	Description of impacts on components of the environment					
		Air ambient	Water medium	Topsoil	Flora and fauna	Man-caused environment	Social environment
Final assessments of residual impacts under normal operation		Impacts do not exceed permissible levels	Impacts do not exceed permissible levels	Impacts do not exceed permissible levels	Impacts do not exceed permissible levels	Impacts do not exceed permissible levels	Impacts do not exceed permissible levels

Table 8.3.2 – List of residual impacts of CSFSF during accidents

Types and sources of impact	Parameters of releases and discharges	Description of impacts on components of the environment					
		Air ambient	Water medium	Soils	Flora and fauna	Man-caused environment	Social environment
Emergencies							
Maximum design basis accident (MDBA)	Activity of expected release (Bq): ^{60}Co-2,67·10^{9}	The maximum value of airborne volumetric concentration of ^{60}Co - 16 Bq/m^3 will be detected within 1100 m from the source. At the boundary of the 10-km zone it will be 11 Bq/m^3 and At the boundary of the EZ and MRZ it will constitute 0,5 Bq/m^3	It will fall-out activity about 6·106 Bq on the nearest river Pripyat surface. It is less than annual discharge with the river flow (up to 10^{13} Bq)	The surface contamination will not exceed 10 kBq/m^2 within 1100 m from a damaged HI-STORM At the boundary of the 10km zone additional surface contamination (ASC) will be -1,5 kBq/m^2, At the nearest boundary of the EZ and MRZ additional surface contamination will be - 0,007 kBq/m^2. All ASC values are up to 10 % of the actual soil contamination rate.	Soil PSC with ^{60}Co will not exceed 10 kBq/m^2 (0,3 Ci/km^2) within1100 m from the storage facility that is lower than background contamination with gamma - radiating radionuclides at the adjacent areas (^{60}Co analogues by biological impact), not less than 93 kBq/m^2 (2,5 Ci/km^2)	Maximum additional radiation doses expected for the complex Vektor personnel will be 10^{-3} mSv that along with the actual dose does not exceed 10% of the control levels	Effective radiation doses (mSv / year) due to all paths of ^{60}Co impact will be -5·10^{-3} mSv / year at the boundary of the 10-km zone and 1,5·10^{-3} mSv/year at theboundary of EZ and MRZ - that is much lower than the limit for population specified in NRBU - 97

Types and sources of impact	Parameters of releases and discharges	Description of impacts on components of the environment					
		Air ambient	Water medium	Soils	Flora and fauna	Man-caused environment	Social environment
Beyond the Design Basis Accident (BDBA)	Total activity of releases will be as $1{,}8 \cdot 10^{10}$ Bq	At the distance 100 m from the damaged HI-STORM the total volumetric activity will not exceed 100 Bq/m^3. At the nearest boundary of EZ and MRZ the volumetric activity will not exceed 0,05 Bq/m^3	Total activity of radionuclides released within the most hazardous area (20 km southeast) of the river Pripyat will not exceed $4{,}3 \cdot 10^5$ Bq that is many times less than activity discharged with the annual river Pripyat flow (up to 10^{13} Bq)	Additional surface contamination (ASC) within 100 m will not exceed 30 kBq/m^2 for isotopes of cesium, 15 kBq/m^2 for ^{90}Sr and 60 Bq/m^2 for TUE. At the boundary of EZ and MRZ ASC will not exceed 20 kBq/m^2 for isotopes of cesium, 8 kBq/m^2 for ^{90}Sr and 0,03 Bq/m^2 for TUE that is insignificant.	Taking into account that radiation impacts on air, topsoil and surface water will be insignificant, the impacts on flora and fauna are considered as acceptable	Additional radiation doses (for 30 day) will not lead to excess of CL for the personnel of enterprises located at the EZ and MRZ	At the boundary of EZ and MRZ an individual effective dose (for 30 day) will not exceed $4 \cdot 10^{-4}$ mSv that is not bigger than the annual dose limit specified for population in NRBU - 97 (1 mSv / year).
Final assessments of residual impacts during accidents		Impacts are acceptable	Impacts are acceptable	Taking into account the probability of BDBA the impacts are acceptable	Impacts are acceptable	Impacts are acceptable	Impacts are acceptable

8.4 Control Area and Surveillance Area of CSFSF

According to the requirements of the sanitary legislation an establishment of control area and surveillance area is required for such facilities as CSFSF. The control area is a territory around the CSFSF where the level of public exposure under normal operation can exceed the quota of the dose limit specified for category B that is 1 mSv/year in accordance with NRBU - 97 .

Based on the results of the performed analysis, the dose uptakes of the population due to release of radioactive products outside the CSFSF site do not exceed 0,001 % of the limit specified by NRBU - 97 (1 mSv / year). The only source of impact on the environment is the ionizing radiation from containers HI-STORM located at the CSFSF storage area. As estimated, an individual effective dose of 1 mSv received from the completely filled storage facility (458 HI-STORM containers) will not be exceeded at distance of 100 m from the CSFSF boundary. Therefore, the CSFSF control area should be located at the distance of 100 m from the boundary of the site taking into account the geometry of CSFSF site.

Taking into account the decisions made for the plot plan and general CSFSF layout, it is reasonable to outline the CSFSF control area as the one coinciding with the complex "Vektor". boundaries The mentioned decision is relative, since CSFSF site is located within the ChNPP exclusion zone, outlined within 10 km from the ChNPP, which will not be used for economic activities in terms comparable to the CSFSF service life. Therefore, the people are not expected to settle beyond the CSFSF site located within the ChNPP 10-km zone

So as not to exceed the dose limit quota specified for population by NRBU – 97, which is 40 mkSv/year obtained by all intake paths due to process releases into atmosphere, the value of permissible release for the CSFSF was estimated as ~ $4 \cdot 10^{10}$ Bq . It is approximately 2400 times more than the CSFSF releases under normal operation.

Taking into account that the controlled discharge during CSFSF construction and operation is not envisaged, the value of permissible discharge was not determined.

The surveillance area is the territory where the influence of radioactive discharges and CSFSF emissions is possible and where the radiation monitoring is carried out.

It is a fact that CSFSF site is located in the ChNPP exclusion zone where the radiation monitoring is carried out according to valid legislation, and use of land and water basins without the sufficient radiological monitoring is limited. Therefore, it is assumed that the EZ and MRZ be considered as a common surveillance area rather than establish it separately for the CSFSF.

Therefore, the area likely to be affected by the CSFSF is assessed for normal operation condition, MDBA and BDBA accident. The distance associated with the dose limit quota inhalation intake of radionuclides can be exceeded under BDBA (hypothetical) accident is 600 m. Therefore, the actual area of possible CSFSF influence, and, therefore, CSFSF surveillance area is about 600 m from the storage site.

Taking into account that radiation monitoring at the EZ and MRZ is carried out by Exclusion zone Administration (EZA) according to valid legislation, the CSFSF surveillance area will be subject to radiation monitoring to be provided by the EZA. Interrelation between radiation monitoring for the CSFSF and EZ, and MRZ should be determined after selection of the CSFSF site by this Feasibility Study.

8.5 Assessment of Ecological Risk

Ecological risk is the probability of occurrence of negative changes in the environment or consequences of these changes arising due to negative anthropogenic impact on the environment.

The analysis performed in the previous sections of this EIA shows that:

- The CSFSF impact on natural, man-caused and social environment is caused by radiation impact only;

- Impact on the environment does not affect current condition of this environment and can be considered as acceptable;
- Under normal operation condition of CSFSF operation impact on man-caused environment does not deviate from effective hygienic requirements applied for the ChNPP exclusion zone;
- Under normal operation condition of CSFSF operation impact on social environment does not deviate from effective hygienic requirements specified in NRBU - 97.

According to HI-STORM system leak studies financed by the USA government, the probability of a MPC depressurization under normal storage conditions is $3{,}71 \times 10^{-12}$ leakage per joint weld.

Based on the above-mentioned it can be stated that the ecological risk of CSFSF operation under normal operation conditions will be acceptable.

The analysis of CSFSF impact under maximum design accidents during construction and operation have shown the following:

- Impact in case of an accident during CSFSF construction (forest fire) will exceed normative values;
- Impact on the environment in case of the MDBA and BDBA during operation will not affect current environment condition and can be considered as acceptable;
- Impact on man-caused environment in case of the MDBA and BDBA during operation will not exceed valid hygienic requirements specified in NRBU - 97 [4];
- Impact on social environment in case of MDBA and BDBA during operation will not exceed effective hygienic requirements specified by NRBU - 97 [4];

Therefore, the ecological risk during accidents at the CSFSF can be associated with a fire during CSFSF construction.

The impact as a result of a fire is not associated specifically with CSFSF construction: this initial event can be related to any construction in the ChNPP exclusion zone. If the normative measures to ensure fire safety during CSFSF construction are implemented, the ecological risk associated with a fire during CSFSF construction can be considered acceptable.

In assessing the ecological risk under BDBA, taking into account relation of risk to radiation impact on personnel and population outside the exclusion zone, the risk of potential exposure was estimated and compared with normative values specified for acceptable risk by NRBU - 97/D-2000:

- for the personnel – 2x10-4 $year^{-1}$;
- for the population – 5x10-5 $year^{-1}$.

Negligible risk according to the requirements of NRBU - 97/D-2000 is 10^{-7} $year^{-1}$.

In assessing the probability of risk under BDBA it is necessary to consider the following:

- as above mentioned, the maximum dose is 0,7 mSv for personnel and 0,4 μSv for public under hypothetical accident due to 100% loss of fuel rod integrity and leakage of $1{,}95 \bullet 10^{-5}$ cm^3/sec due to failure of MPC welds (considered as BDBA);
- US Nuclear Regulatory Commission performed probabilistic assessment of risks for HI-STORM dry storage system, entitled "Probabilistic analysis of integrity of welds of containers for storage of the spent nuclear fuel", ASME Paper PVP Vol. 425, 2002. As a result of BDBA the probability of failure of weld of MPC is estimated as $2{,}56 \times 10^{-11}$ per one weld.

Taking into account the probability of this event and the maximum dose uptakes estimated for population at the nearest boundary of the EZ and MRZ and for the personnel, the risks are negligible.

9 ENVIRONMENT IMPACT ASSESSMENT DURING CONSTRUCTION

9.1 List of Sources of Impacts

Description of normal construction conditions, initial events for possible MDBA and BDBA as well as the description of accident sequences and possible impacts under a maximum design accident is given in volume 3, part 1, sections 3.6-3.7. Table 9.1 contains the data given in the first part of EIA analyses of CSFSF impact sources on the environment under normal construction conditions, under the accident with the maximum consequences. Based on the analysis of CSFSF non-radiological impacts made in the first part of the EIA, significant non-radiological environment impacts are unlikely to occur during CSFSF construction.. Therefore, the main radiation impact on the environment is associated with dust generation and fire during construction, as shown in table 9.1.

Table 9.1 - List and description of sources of radioactive releases during CSFSF construction

Source of impacts	Unit of measurement	Radionuclide	Activity of release
Construction in normal conditions			
Preparation work at construction site for main facilities, construction of access roads and utilities, including removal of wood vegetation and vertical leveling of surface	Bq	137Cs 90Sr ά active TUE	$1{,}4 \cdot 10^{6}$ $6{,}5 \cdot 10^{5}$ $3 \cdot 10^{4}$
Accident during construction			
Forest fire (ground fire)	Bq	137Cs 90Sr ά active TUE	$5{,}4 \cdot 10^{10}$ $2{,}9 \cdot 10^{10}$ $5{,}8 \cdot 10^{8}$

9.2 Justification of Considered Environmental Components

Selection of environment components (for which impacts during CSFSF construction were assessed) is performed according to Item 3.1 of normative document DBN A. 2.2-1-2003 [1] and on the basis of analysis given in section 3.6, 3.7 of the EIA (Ref. volume 3, Part 1).

CSFSF construction does not influence on the intensity of solar radiation, temperature, wind speed, humidity, atmospheric inversions, duration of fogs and other climatic conditions. Due to this the influence on microclimate by the constructed CSFSF is not considered.

Therefore, the given chapter contains the assessment of impacts (including averaged) during CSFSF construction on the following environment components :

- geological environment;
- air ambient;
- water medium;
- topsoil;
- flora and fauna, wildlife preserves.

9.3 Assessment of Influence on Geological Environment

The following unfavorable natural and technogenic exogenic processes can occur at the CSFSF construction site:

- plane erosion (plane washout);
- atmogenic erosion (sand relocation by wind);
- swamping.

CSFSF construction will assume implementation of measures to prevent or limit influence of man-induced factors leading to adverse natural processes listed above, which includes the following :

- improvement of geological environment properties to mitigate exogenic processes influence;
- prevention of soil deterioration (decrease of compressibility and strength) underneath the foundations ;
- prevention of local flooding.

The measures also assume the following:

- Leveling, asphalt-cover and implementation of area to completely eliminate water and wind erosion ;
- Removal of filling within the construction sites and implementation of backfilling to be compacted layer-by-layer;
- drainage and removal of surface flow.

Therefore, performance of comprehensive measures to prevent or limit possible ISF impact on geological environment at the storage facility construction site will eliminate development of adverse technogenic conditions .

Impacts on endogenic processes due to CSFSF construction (structure of bedding at the top of a sedimentary cover, change of the structural - tectonic section of the territory, etc.) are not expected.

9.4 Assessment of Impacts on the Air Ambient

9.4.1 Impacts under Normal Conditions

Implementation of CSFSF construction activities will be inevitably accompanied by releases of radioactive matters into the atmosphere both under normal conditions and accidents.

Spread of RN released into the air during construction was modeled with use of the modified Gauss procedure recommended by IAEA (Attachment B). Input data and assumptions, which were used for calculations, also are represented in the attachment.

Main sources of impacts on the environment during CSFSF construction are the activities, which are related to preparation of the construction site, and construction of access roads. According to available data [8], forestry works (tree cutting and skidding) can lead to 50 times increase of radionuclide concentration in the surface air. As shown below, during site leveling the concentration of airborne radioactive aerosols can increase by 500 and more times. Therefore, in assessing the impacts of RN releases in consider site leveling activities because of the more signigicant impact.

Results of modeling of processes of radioactive substances spreading in the atmosphere and calculation of airborne RN concentration depending on distances up to radiation source, are represented in figures 9.4.1-9.4.3.

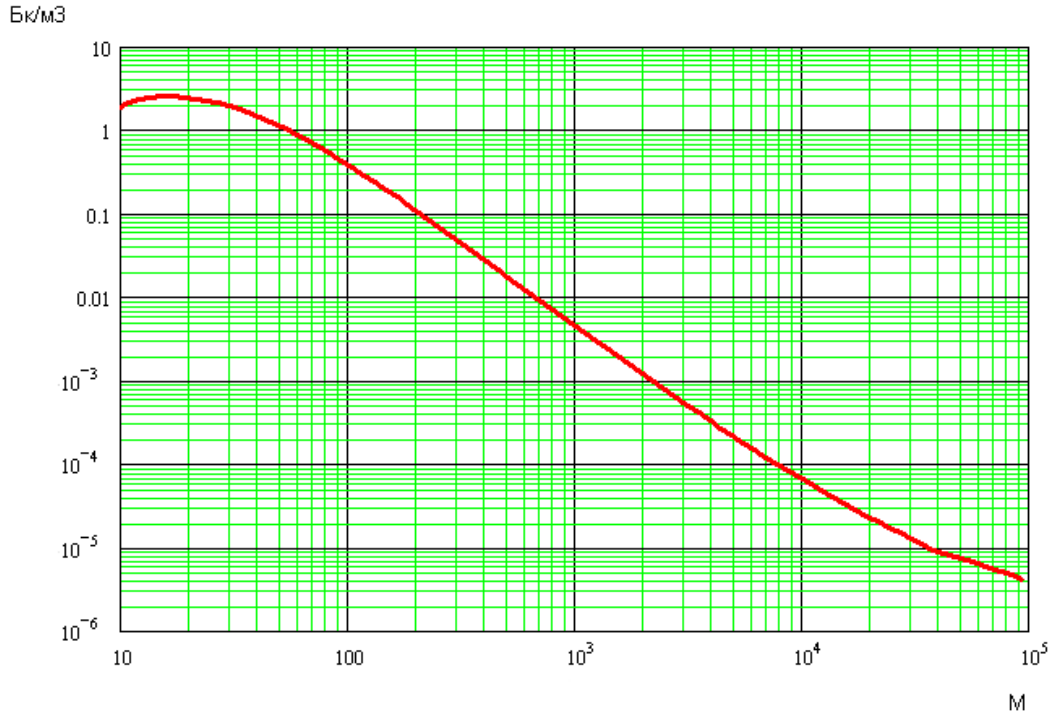

Figure 9.4.1 - Dependence of average volumetric concentration of ^{137}Cs in air (Bq/m^3) during earthworks from distance (m) up to radiation source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

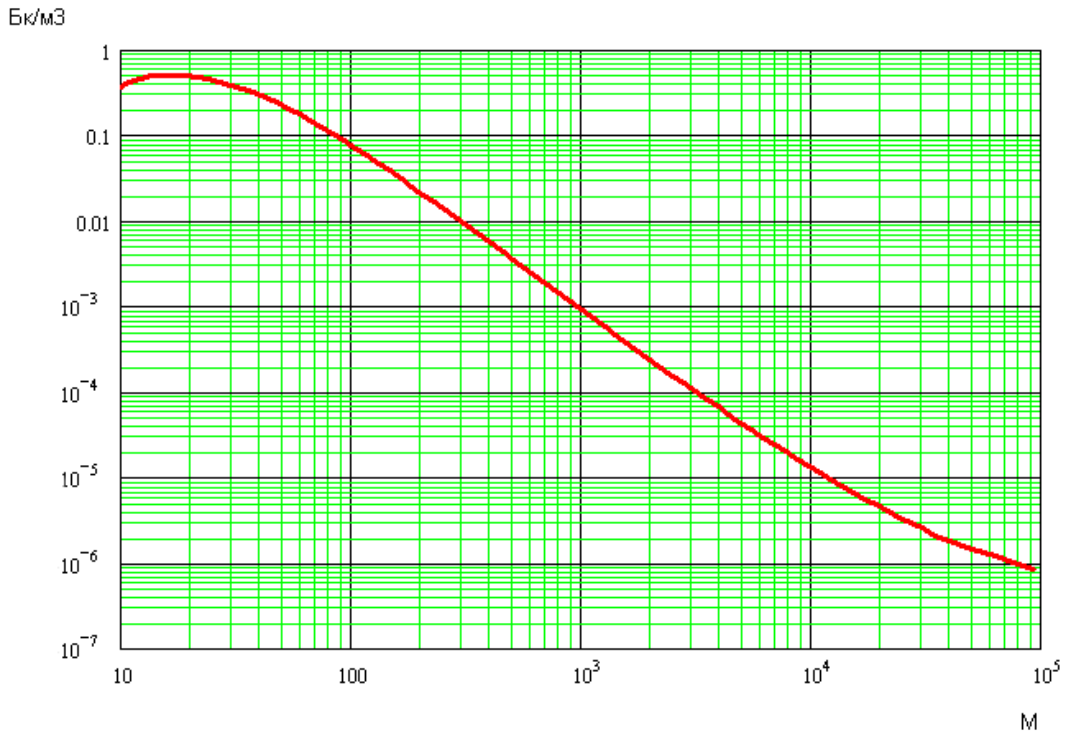

Figure 9.4.2 - Dependence of volumetric concentration ^{90}Sr in air (Bq/m^3) during earthworks from distance (m) up to radiation source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

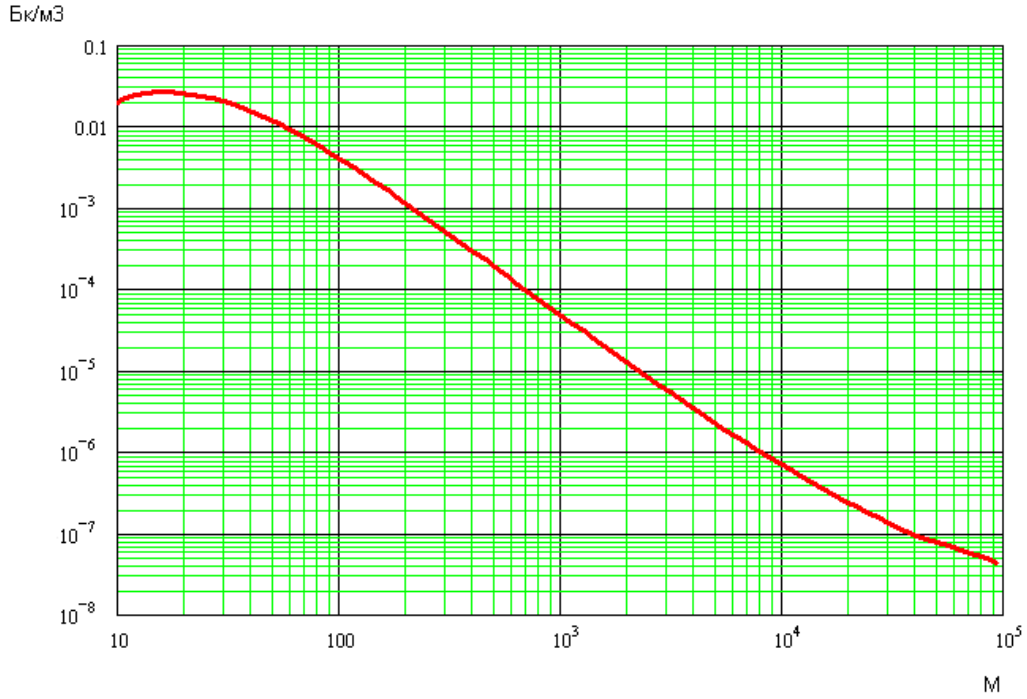

Figure 9.4.3 - Dependence of volumetric concentration of transuranium elements in the air (Bq/m^3) during earthworks from distance (m) up to radiation source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

The results of calculations characterize average volumetric activity of airborne radionuclides ^{137}Cs, ^{90}Sr and TUE, released during CSFSF construction.

Figure 9.4.1 shows that the maximum airborne concentration of ^{137}Cs will be in the proximity to the earthwork areas. The maximum volumetric airborne activity of ^{137}Cs will be ~ 3 Bq/m^3.

Volumetric activity of ^{137}Cs, ^{90}Sr and alpha-emitting TUE at the boundary of the ChNPP 10-km zone at the distance of 2 km southwards from the CSFSF, is about $1*10^{-3}$, $2*10^{-4}$ and $1*10^{-5}$ Bq/m^3 correspondingly.

Average volumetric air contamination with ^{137}Cs at the boundary of EZ and MRZ (at the distance approx. 13 km) caused by preparatory work at the CSFSF construction site will be ~ $5 \cdot 10^{-5}$ Bq/m^3 (ref. fig. 9.4.1).

The maximum air contamination with ^{90}Sr during civil work, will be ~ 0,5 Bq/m^3. At the nearest boundary of EZ and MRZ (12 km), volumetric air contamination with ^{90}Sr will be ~ 10^{-5} Bq/m^3.

The maximum air contamination with alpha-emitting TUE during civil work, will be ~ 0,03 Bq/m^3. At the nearest boundary of EZ and M,RZ (13 km), volumetric air contamination withTUE for typical weather conditions will be ~ $6 \cdot 10^{-7}$ Bq/m^3.

It is necessary to note that the railroad will cross (perpendicularly) the "western" plume of ChNPP emergency radioactive fallouts, therefore, a part of civil work will be performed in the area (600-700 m long) with surface contamination exceeding the average. During work in this area the design concentration of airborne radionuclides can be exceeded for a short time.

9.4.2 Impacts of Accidents During Construction

The only accident rendering essential radiation impact on the air during CSFSF construction is the ground forest fire during site preparatory work (up to the full burnt of wood vegetation).

Input data and methodology of the performed calculations of impacts on the air in case of a ground fire are represented in Attachment A.

Concentration of radioactive matters in the surface air depending on distances is represented in figures 9.4.4-9.4.6.

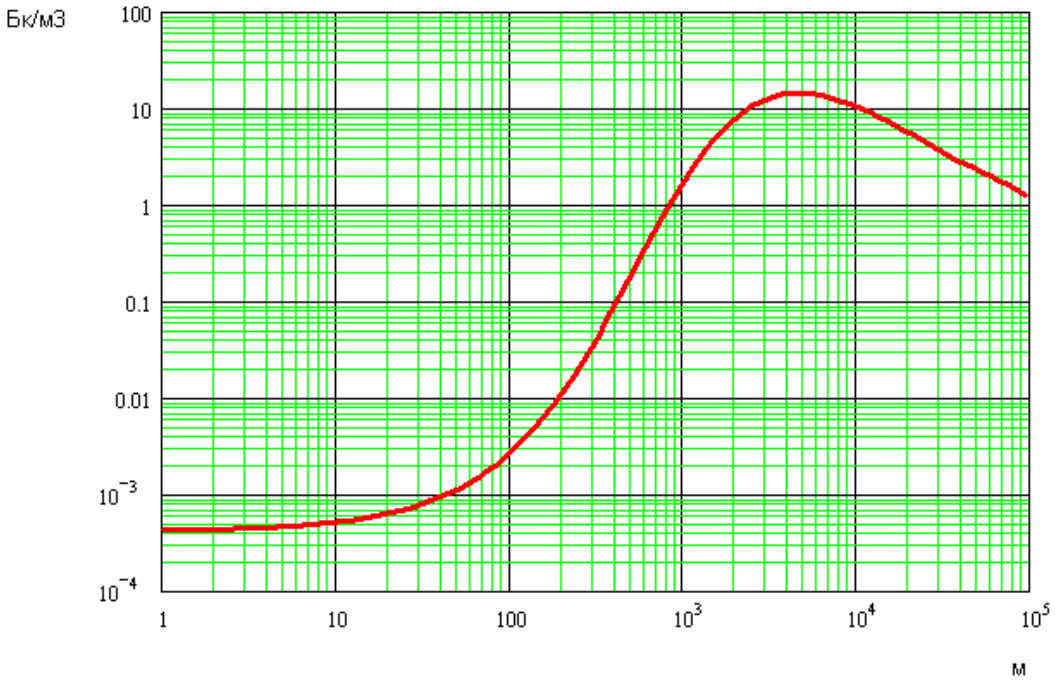

Figure 9.4.4 - Dependence of volumetric airborne concentration of ^{137}Cs (Bq/m^3) on distance to the center of a forest fire at the CSFSF construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

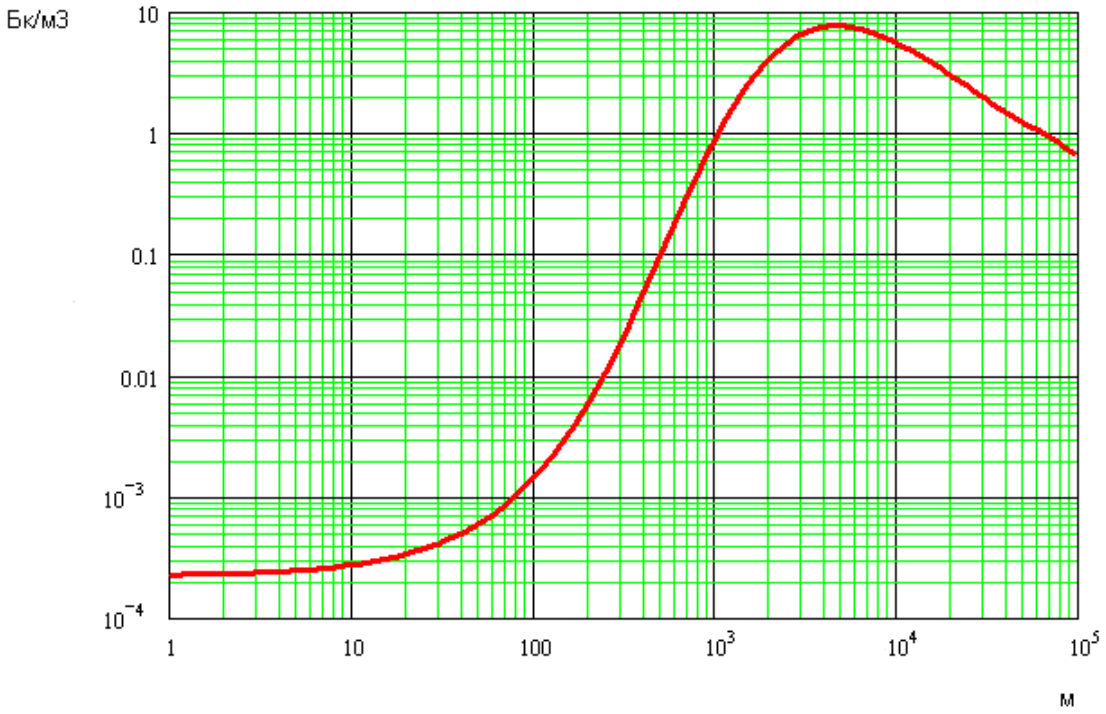

Figure 9.4.5 - Dependence of volumetric airborne concentration of ^{90}Sr (Bq/m^3) on distance up to the center of a forest fire at the CSFSF construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

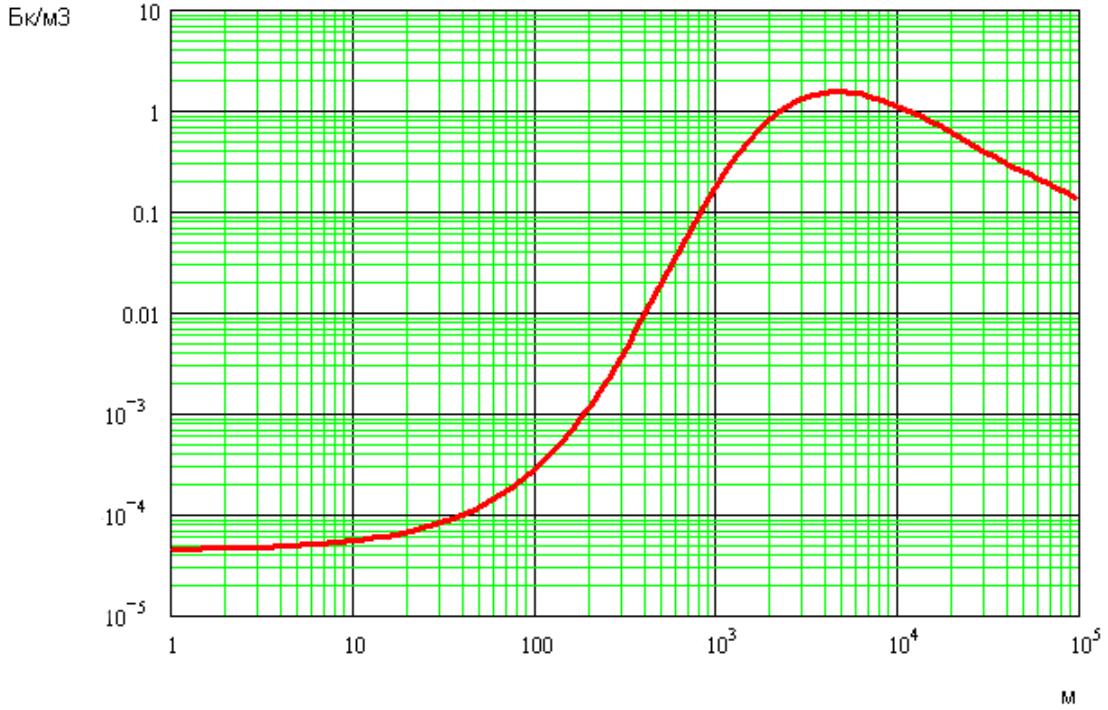

Figure 9.4.6 - Dependence of volumetric airborne concentration TUE (Bq/m^3) on distance up to the center of a forest fire at the CSFSF construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

Assessment of impact due to a ground forest fire on the air demonstrates that the maximum volumetric airborne activity of ^{137}Cs will be at the distances ~ 4-5 km from a fire and will be ~ 15 Bq/m^3.

Volumetric activity of ^{137}Cs, ^{90}Sr and alpha-emitting TUE in case of a fire at the boundary of the ChNPP 10-km zone at the distance of 2 km southwards from the CSFSF will be about 8, 4 and 0,8 Bq/m^3 accordingly.

At the nearest boundary of EZ and MRZ (13 km in the "south-west" direction) volumetric airborne activity of ^{137}Cs will be approximately 8 Bq/m^3.

The maximum value of volumetric airborne activity of ^{90}Sr, will be make ~ 8 Bq/m^{3}at the distance of 4-5 km and , and at the nearest boundary of EZ and MRZ it will be ~ 4 Bq/m^3.

The maximum values of volumetric activity of alpha-emitting TUE released intothe air in case of a ground fire will be at the distance of 4-5 km and will constitute approximately 2 Bq/m^3; at the nearest boundary of EZ and MRZ it will be about 1 Bq/m^3.

9.4.3 Summary of Impact on the Air Ambient during Construction

Under normal CSFSF construction conditions , the maximum impact on the air ambient will occur during preparatory work for the construction site (removal of soil - vegetative cover and vertical leveling of surface). Modeling of radioactive release travel in the air shows that during site vertical leveling the control levels specified for the ChNPP 10-km Exclusion Zone [5] will be exceeded. This excess will occasionally occur and last for a short time at the distances ~ 15-30 m from specific work areas.

At the nearest boundary of EZ and MRZ (13 km in the "south-west" direction) volumetric air contamination under typical weather conditions, will not exceed $ДК_в^{inhal}$ (0,8 Bq/m^3 for ^{137}Cs). Therefore, the volumetric activity of ^{137}Cs will be within $5*10^{-5}$ Bq/m^3. The volumetric activity of ^{90}Sr at this distance will be ~ $1*10^{-5}$ Bq/m^3 (with the maximum permissible value $ДК_в^{inhal}$ =0,2 Bq/m^3, specified for the given nuclide). The volumetric airborne concentration of alpha-emitting TUE ($ДК_в^{inhal}$ $4*10^{-4}$ Bq/m^3) at the nearest boundary of EZ and MRZ (12 km in the "south-west" direction) will reach ~ $6\cdot10^{-7}$ Bq/m^3.

Based on the results received from modeling the air contamination with radionuclides during preparation of the CSFSF construction site it can be concluded that the impact leading to excess of $ДК_в^{inhal}$ in the surface air will occur at the distances of no more than 400 m from the vertical leveling areas. To preventfrom excess of control levels specified for air contamination it is necessary to carry out a package of specfic measures (arrangement of work during the biggest soil humidity, dust suppression, etc.), which would eliminate contamination of air with radionuclides. Thelist and description of measures employed to meet the normative requirements for the air during CSFSF site leveling will be considered in section 9.10 of this EIA.

The analysis of impact on airborne RN concentration due to a possible ground forest fire shows that the CL specified can be exceeded. Taking into account that the forest fires are potentially radiologically and ecologically hazardous, it is necessary to perform the measures to prevent from ignition of wood and forest underlayer during preparation of the construction site.

It is necessary to take into account that some work (construction of railway from “Shchepelichy” railway station) will be carried out within the areas with high radioactive contamination rates that will result in exceedance of design values of RN concentration in the air. Existing maps of radioactive contamination rates within in the work are based on large-scale investigations with insufficient details to consider for develoment of the CSFSF EIA . Therefore, additional investigations are required prior to start-up of design for receiptof reliable assessments of impacts on the air during work performance. Assessment of impact on water media

9.5 Assessment of Impacts on the Water Medium

9.5.1 Impact on Surface Waters

9.5.1.1 Impacts under normal operation conditions

The analysis of spreading of radioactive emissions in the air has shown that under normal conditions of CSFSF construction the surface contamination of territories (at distances more than 1 km) will be the 100-th fractions of percent of the existing contamination caused by emergency

emission from ChNPP in 1986. Based on these results and taking into account that surface reservoirs are located at a great distance from CSFSF (river Uzh – 6-8 km, river Sakhan- 7 km, river Pripyat – 12 km), the volumetric concentration of radioactive substances in water of the specified reservoirs caused by radioactive CSFSF emissions will be lower than levels of reliable detectability.

Thus it is necessary to take into account that the water collecting territories nearest to the CSFSF rivers - Uzh and Sakhan, mainly are relatively leveled, forest-covered territories, which do not contain the surface effluent which is the main intake source of radioactive substances from water collecting territories. A significant part of the water collecting territories are boggy, and as a matter of fact, natural biogeochemical barriers that have a way of spreading radioactive substances.

Based on this fact it is possible to conclude that on intake of radioactive substances to water collecting territories under normal conditions of CSFSF construction, their direct transport in the rivers will be considerably limited by the existing biogeochemical barriers.

Therefore, under normal conditions of CSFSF construction the essential radiation impacts on surface waters are not expected.

9.5.1.2 Impacts under accidents

The analysis of impacts on surface waters for a possible accident during CSFSF construction (local forest fire) shows that the greatest contamination of the open reservoir will be observed as fallout of radioactive aerosols on the surface of the flood-plain and water mirror of the river Pripyat (distance of 12 km from the seat of the fire). Thus additional contamination of ^{137}Cs, ^{90}Sr and TUE deposited as aerosols directly on the water surface and washed off by hollow waters from the coastal flood-plain will be respectively - 0,30, 0,15 and 0,03 Ci.

Taking into account the value of annual distribution of activity by the river Pripyat including the most mobile radionuclide, ^{90}Sr, is 314-165 Ci/year, it is possible to draw a conclusion that the impact on surface waters from a possible accident during construction (local forest fire) will be insignificant.

9.5.2 Impacts on Ground Waters

Radioactive contamination of ground waters during CSFSF construction is possible only in the case of vertical migration of the radionuclides which have fall-out on the surface of the topsoil. Results of calculations show that during active construction, the maximum additional surface topsoil contamination by ^{60}Co will not exceed 600 Bq/m^2 (without taking into account a half-life period of ^{60}Co of 5,27 years). The level of groundwater occurrence at the construction site is 18 - 21 m depth (ref. section 2.1.5). At the average speed of vertical migration of radionuclides in soils of EZ and OEA - 0,1-1,5 cm / year, the incoming rate of ^{60}Co in the ground waters during CSFSF construction can be neglected.

For a possible accident during construction (local forest fire), the maximum surface contamination of ^{137}Cs, ^{90}Sr and TUE at local spots will be, respectively, 1,9, 1,1 and 0,2 kBq/m^2 (section 9.5.1.2).

For the current levels of radioactive contamination of the territories adjoining the CSFSF construction site, such additional impact of surface contamination on ground waters will be insignificant.

9.6 Assessment of Impacts on Topsoil

9.6.1 Impacts under Normal Operation Conditions

The main impacts on topsoil (as a component of the environment) during CSFSF construction will be rendered by work on preliminary preparation of the construction site, as well as work on construction of access roads to the area: automobile (length 1,145 km) and railway (length 6,4 km). They include two main stages – removal of woody- shrubby vegetation and leveling of the surface.

Due to the fact that the territories of the construction site and the areas of access roads are categorized as radioactively contaminated grounds, the impact on topsoil of adjoining territories

will be shown as secondary (additional) radioactive contamination which is related to dust generation from earthwork.

Calculation of the impacts on topsoil from emissions of radioactive substances generated during CSFSF construction under normal conditions of work was carried out by the modified Gauss procedure recommended by IAEA (Attachment A).

The results of modeling of radioactive substances sedimentation processes from the air on topsoil and calculation of the RN surface topsoil contamination caused by this process are represented in figures 9.6.1-9.6.3.

The represented results of calculations display the greatest possible (conservative approach) surface contamination of territory by isotopes Cs, ^{90}Sr and alpha-emitting TUE, caused by dust generation from earthwork during construction of the railway on the most contaminated area of construction.

Calculation of the intensity of topsoil contamination was carried out taking into account various scenarios of the current meteorological conditions. So, for typical (average annual) meteorological conditions the following parameters are accepted: category of atmospheric stability– D (by Pascwill) at wind speed - 2,1 km/s.

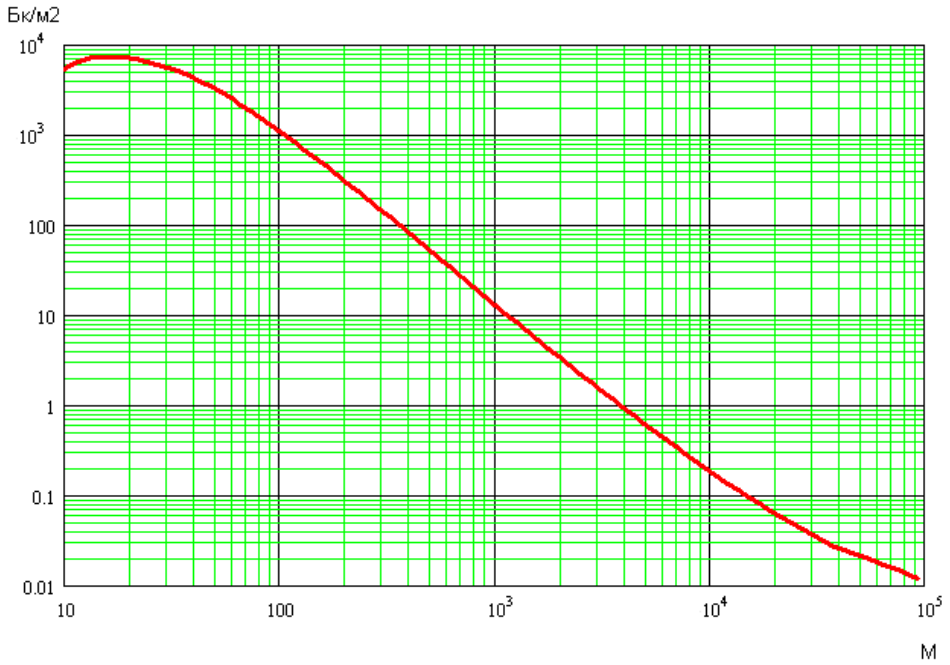

Figure 9.6.1 – Dependence of density contaminations (Bq/m^2) of topsoil by the isotopes of Cs at distance (m) to the place of work

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

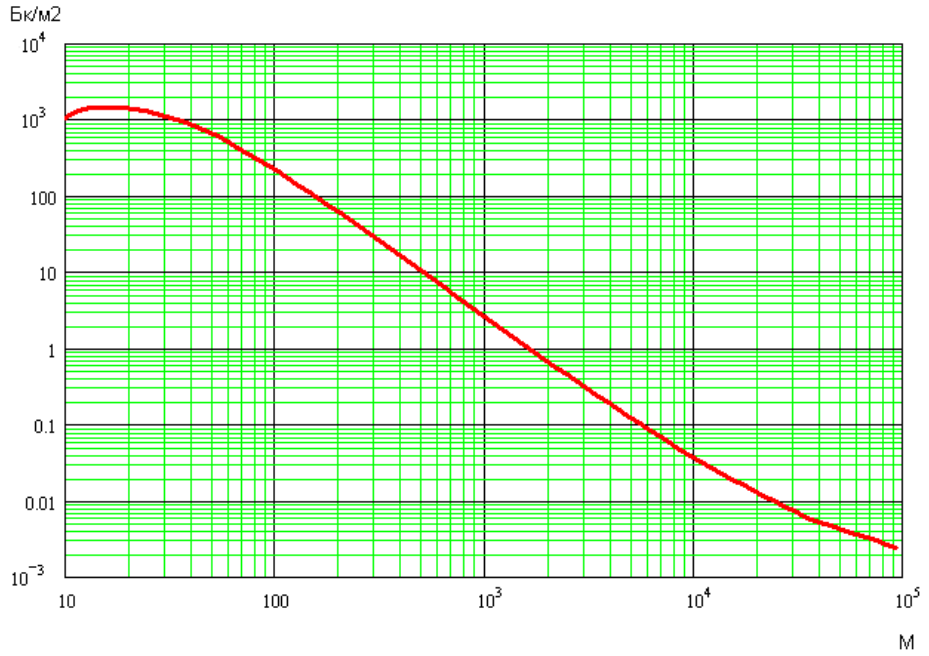

Figure 9.6.2 - Dependence of density contaminations (Bq/m^2) of topsoil by 90Sr at distance (m) to the place of work

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

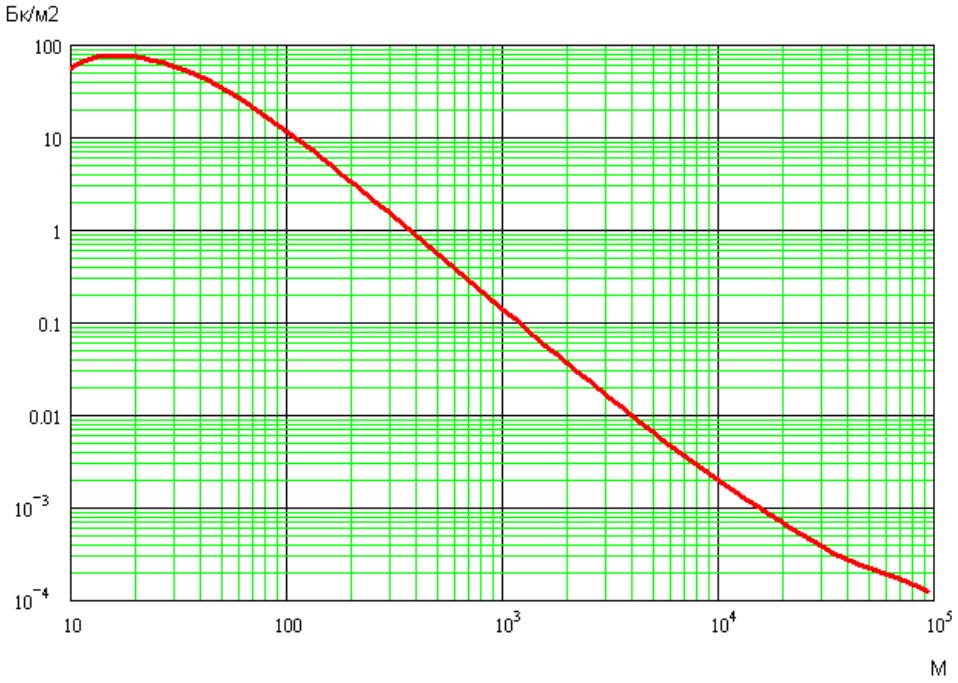

Figure 9.6.3 - Dependence of density contaminations (Bq/m^2) of topsoil by alpha-emitting TUE at distance (m) to the place of work

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

The values of the impacts received as a result of calculations on topsoil testify that at such conditions the impact will be insignificant in comparison with the existing contamination. So, the maximum surface contamination of soils by the isotopes of Cs which will be observed in immediate proximity to the work areas will not exceed a value of 7 kBq/m^2 that at current levels of radioactive topsoil contamination (7500 kBq/m^2) are about 0,1 % of the existing value.

On the boundary of the 10-km zone of ChNPP (2 km in the southerly direction), surface contamination by isotopes of Cs will be ~ 4 Bq/m^2 which corresponds to 0,002 % of the existing level of topsoil contamination.

The maximum surface contamination of soils by ^{90}Sr which will be observed in immediate proximity to work areas will not exceed 1,5 kBq/m^2 that at the current level of topsoil contamination (4000 kBq/m^2) is 0,04 % of the existing value.

On the boundary of the 10-km zone of ChNPP contamination of surface soils by ^{90}Sr will not exceed 0,8 Bq/m^2 which is 0,0001 % of the existing level of topsoil contamination.

The density of additional topsoil contamination by alpha-emitting TUE whose maximum will be observed in immediate proximity to the construction site will not exceed 70 Bq/m^2 that at current levels of topsoil contamination (2,2 kBq/m^2) is 3 % of existing contamination.

On the boundary of the 10-km zone of ChNPP contamination of surface soils by alpha-emitting TUE will be ~0,04 Bq/m^2 which corresponds to 0,01 % of the existing level of topsoil contamination.

On the nearest boundary of EZ and OEA (12 km in "south-west" direction) surface contamination by $^{134+137}Cs$, ^{90}Sr and alpha-emitting TUE will be 0,2, 0,04 and 0,002 Bq/m^2 respectively which is fractions of a percent of the existing levels of surface contamination by radionuclides of the given territory caused by emergency fallout in 1986.

9.6.2 Impacts of accidents during work performance

A forest fire during preliminary preparation of the construction site (before full removal of wood vegetation) is a unique accident which can render essential radiation impact on the environment during CSFSF construction,.

Input data and methodology of the calculations performed of impacts on the air from a local forest fire are presented in attachment A of this document.

Results of calculations of the additional radioactive topsoil contamination density on adjoining territories due to a wood local fire during preparation of the construction site are presented in figures 9.6.4 – 9.6.6.

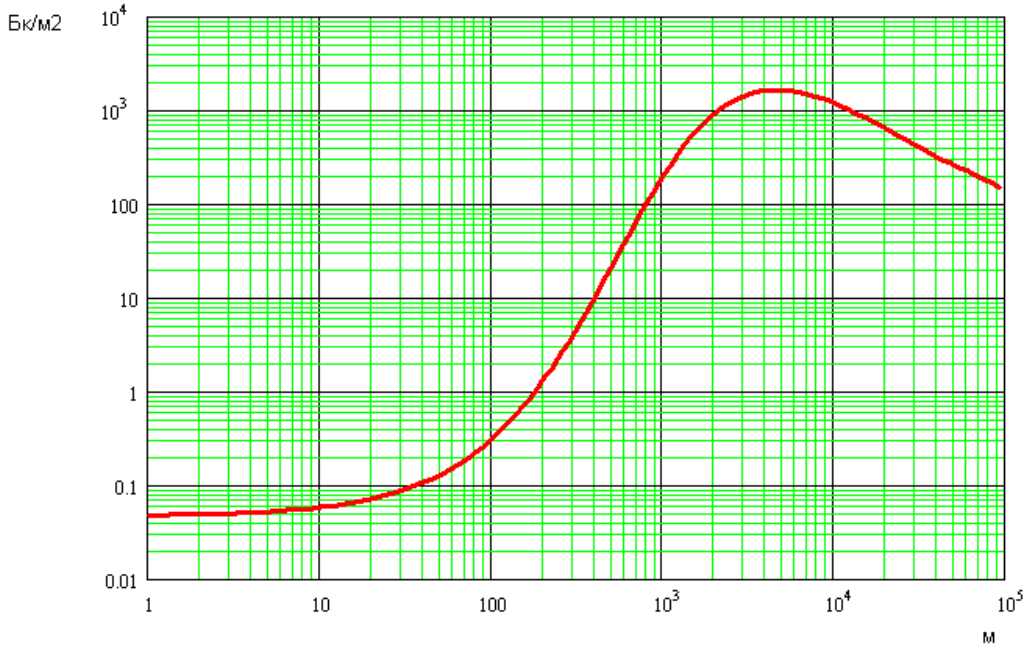

Figure 9.6.4 – Dependence of density of additional contamination 137Cs (Bq/m^3) of topsoil of adjoining territories at distance (m) from a local fire on the construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

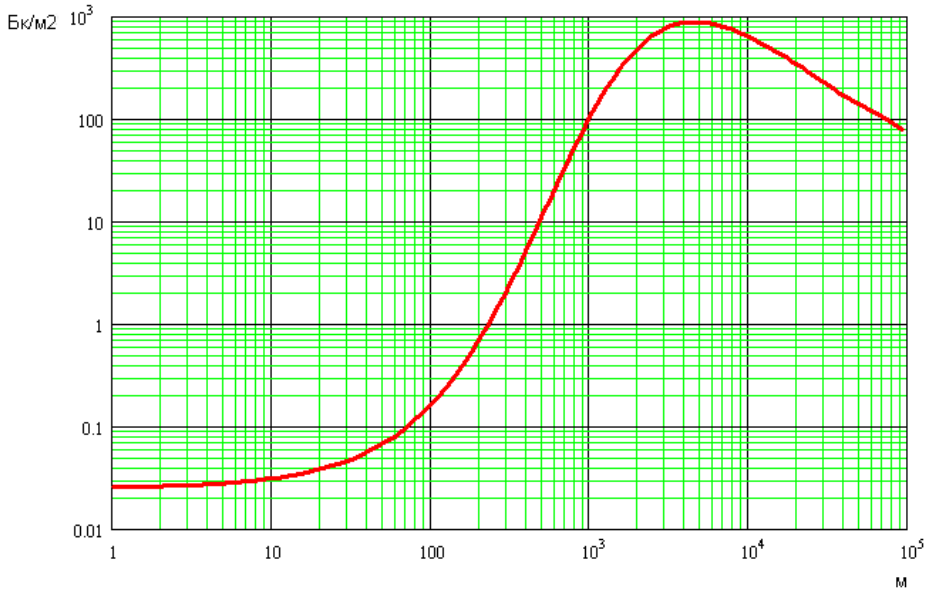

Figure 9.6.5 – Dependence of density of additional contamination 90Sr (Bq/m^3) of topsoil of adjoining territories at distance (m) from a local fire on the construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

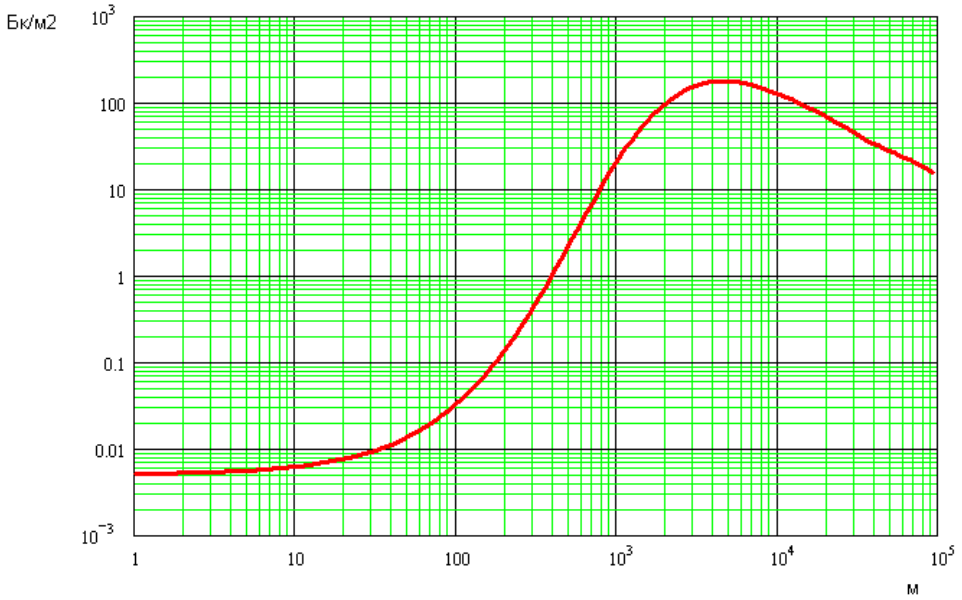

Figure 9.6.6 – Dependence of density of additional contamination alpha-emitting TUE (Bq/m^3) of topsoil of adjoining territories at distance (m) from a local fire on the construction site

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

Analysis of the results has shown that at a reference value of density of ^{137}Cs surface contamination of territories of the construction site of 230 kBq/m^2 (ref. section 4.4.1), the maximum additional surface topsoil contamination will be observed at a distance of 4 - 5 km from the place of the fire and will not exceed 2 kBq/m^2 (fig. 9.6.1). On the nearest boundary of EZ and OEA (13 km in "southwest" direction) additional topsoil contamination by 137Cs will be 100 Bq/m^2 which corresponds to ~ 0,1 % of the existing level of topsoil contamination.

The maximum values of additional contamination by ^{90}Sr and TUE also will be observed at a distance of 4 - 5 km from the seat of the fire and will be, respectively, 0,9 and 0,2 kBq/m^2. Thus, on the nearest boundary of EZ and OEA (13 km in "south-west" direction) additional topsoil contamination by ^{90}Sr will be 600 Bq/m^2 or ~ 1,2 % of background contamination, and additional contamination by TUE will be about 100 Bq/m^2 or 2,0 % of background contamination.

9.6.3 Brief Conclusions of Impact on Topsoil during Construction

Normal conditions of construction. The analysis of the results of calculations of additional impacts on topsoil under normal conditions of CSFSF construction has shown that the value of maximum surface topsoil contamination which will be observed in immediate proximity to the place of work will be ~ 0,2 - 0,3 % of the existing topsoil contamination (irrespective of the current meteorological conditions).

At a larger distance, for example, on the boundary of the 10-km zone of ChNPP (2 km in the southerly direction), the levels of additional surface contamination will not exceed 0,01 % of the existing contamination.

Therefore, impacts on topsoil under normal conditions of CSFSF construction will be insignificant. Besides additional impacts as a result of CSFSF construction will not serve as an obstacle to possible change of EZ and OEA configuration up to the boundaries of the 10-km zone of ChNPP and will not result in restriction of economic activities in territories which can be removed from the structure of EZ and OEA.

Accident during construction. In case of occurrence of an accident during construction (local forest fire), the maximum value of additional surface topsoil contamination by ^{137}Cs will be observed at a distance of 4 - 5 km from the place of the fire and will not exceed 2 kBq/m^2 which is 0,9 % of the background contamination (230 kBq/m^2) of the territory.

On the nearest boundary of EZ and OEA (13 km in "south-west" direction) additional topsoil contamination by ^{137}Cs will be 100 Bq/m^2 which corresponds to ~ 0,1 % of the existing level of topsoil contamination.

Therefore, an accident during CSFSF construction (local forest fire) does not render essential radiation impact on the topsoil of adjoining territories.

9.7 Impact on Flora and Fauna during CSFSF Construction

9.7.1 Normal Conditions of Construction

Results of calculations of radiation impacts on such components of the environment as the surface layer of the atmosphere and topsoil, given in sections 9.4 and 9.6 of this document, testify to the lack of essential impacts on them under normal conditions of CSFSF construction. Based on these assessments, it is possible to draw a conclusion that impacts on vegetative communities and the fauna, taking place in the area of CSFSF site, also will be insignificant and will not result in deterioration of inhabitancy of living organisms.

Except it is necessary to note that biocenoses in the CSFSF site exist and successfully develop at the presence of significant density of radioactive contamination of the soil - vegetative cover, reaching 200 - 400 Ci/km^2 total activity on separate areas of adjoining territories.

The dominating factor for development of biocenoses is non-radiation factors, namely - natural syngenetic processes. Therefore expectation of any changes in the structure of natural populations due to radioactive CSFSF emissions at tenth fractions of percent from the existing density of contamination of the territory is unreasonable.

The major factor of impact under normal conditions of CSFSF construction on flora and fauna is deforestation directly on the territory of construction sites (area - 8,6 hectares) and at the route of the railway track (area - 7 hectares) to the storage facility.

The areas of forest to be removed are unproductive artificial pine plantings created in the 60's of the last century on poor dry sandy soils which are unsuitable for agriculture. On forest growing conditions, they are a type of dry forest and have the least growth class among forests on the EZ and OE territory (see section 2.3). Dry pine forests on the EZ and OE territory will usually consist of low value coniferous trees and are unproductive forage reserve for wild animals. In this connection, chopping down of specified areas of forests does not have an appreciable impact on the specific variety of phytocenosises and, accordingly, faunistic complexes of adjoining areas.

Deforestation of the railway track routing with a length of 6,4 km can appreciably limit movement of wild ungulate animals due to infringement of historically developed migration paths.

However, taking into account the high number of the local population of these animals (see section 2.3.2), the increased percentage of forest land of adjoining areas and, practically, the reserved mode of the territory, essential damage to the number and specific variety of animals is not expected.

9.7.2 Accidents during Construction

The maximum emergency contamination of soil - vegetative cover by radionuclides (^{137}Cs, ^{90}Sr and alpha-emitting TUE) in case of occurrence of an accident during construction (local forest fire) will be observed at a distance of 4000 m from the seat of the fire and will not exceed 0,1 - 0,2 % of the values of background contamination of the area which practically will not result in deterioration of inhabitancy by living organisms.

It is assumed that ignition will take place on the territory of the construction site, where corresponding measures (fire-prevention mineral strips, etc.) to prevent fire propagation to adjoining large forests are planned. Therefore, an accident during construction does not render essential impact on flora and fauna.

9.8 Assessment of Impacts on Vital Activity of People

9.8.1 Dose Uptakes under Normal Work Performance Conditions

Modeling of spread of RN emissions in the atmosphere generated under normal work conditions during CSFSF construction was carried out by the modified Gauss procedure recommended by IAEA (Attachment A).

Results of modeling of processes of dispersion of radioactive substances in the atmosphere and their intakes in human organism, as well as calculation of corresponding dose uptakes, generated depending on distance to the emission source, are represented in figures 9.8.1-9.8.5. The results of calculations were obtained with use of a conservative approach.

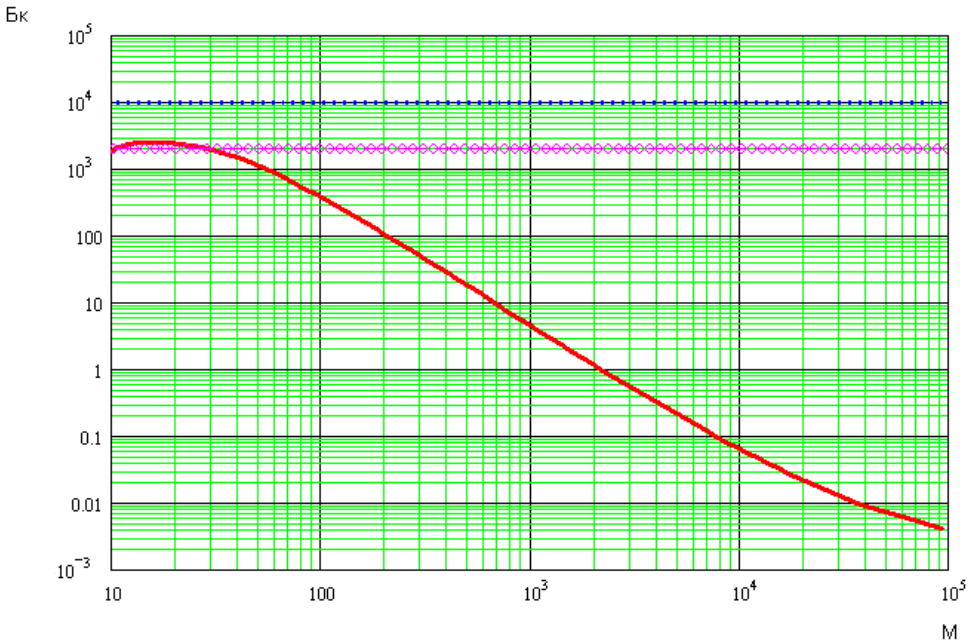

Figure 9.8.1 – Dependence of intake ^{137}Cs (Bq) in human organism at distance (m) to the emission source during earthwork for preparation of the area and its comparison (conservative approach) with values of permissible intake of nuclide $AL_Б$ (AL-permissible limit)(top dotted line) and $AL_в$ (top crossed line)

Legend: X-coordinate – m; Y-coordinate – Bq.

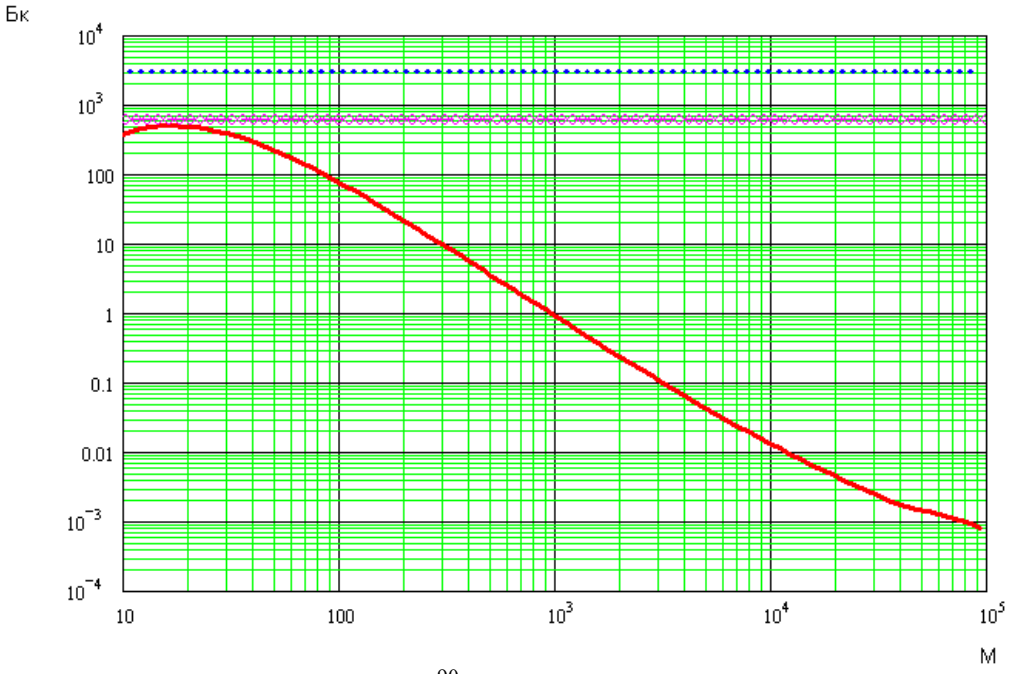

Figure 9.8.2 - Dependence of intake of ^{90}Sr (Bq) in human organism at distance (m) to the emission source during earthwork for preparation of the area and its comparison (conservative approach) with values of permissible intake of nuclide $AL_Б$ (top dotted line) and $AL_в$ (top crossed line)

Legend: X-coordinate – m; Y-coordinate – Bq.

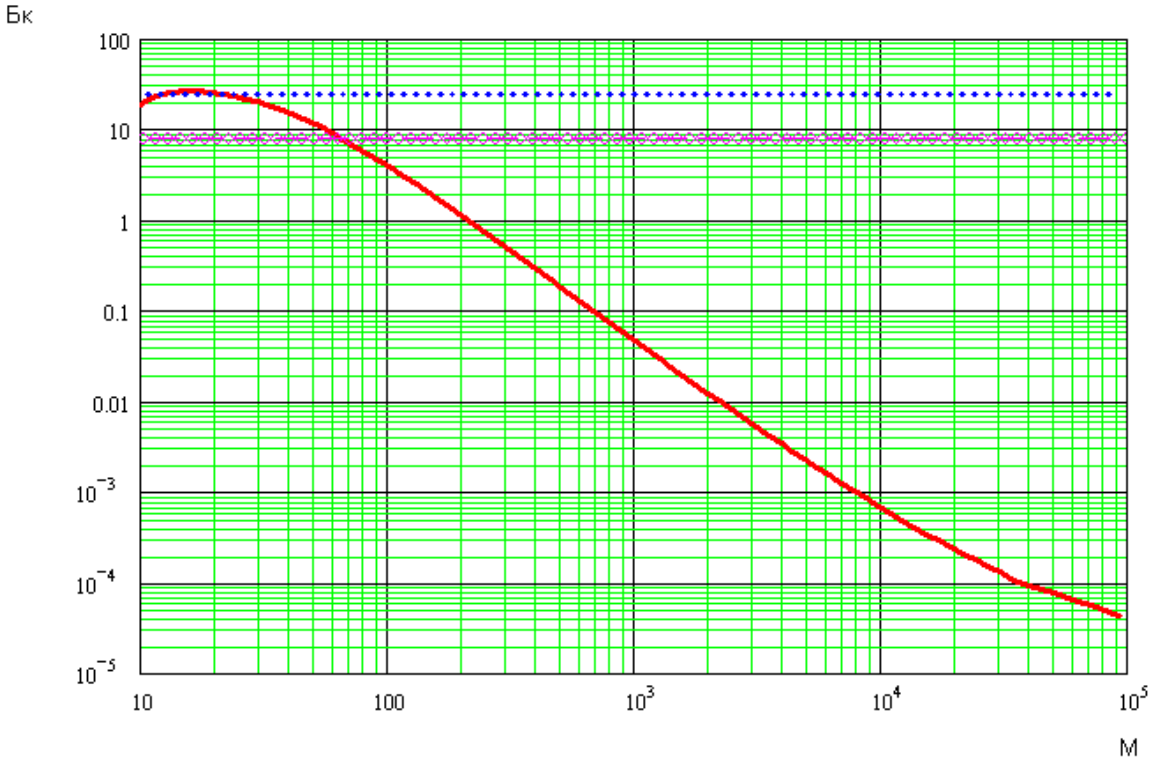

Figure 9.8.3 - Dependence of intake of transuranium elements (Bq) in human organism at distance (m) to the emission source during earthwork for preparation of the area and its comparison (conservative approach) with values of permissible intake of nuclides $AL_Б$ (top dotted line) and $AL_в$ ((top crossed line)

Legend: X-coordinate – m; Y-coordinate – Bq.

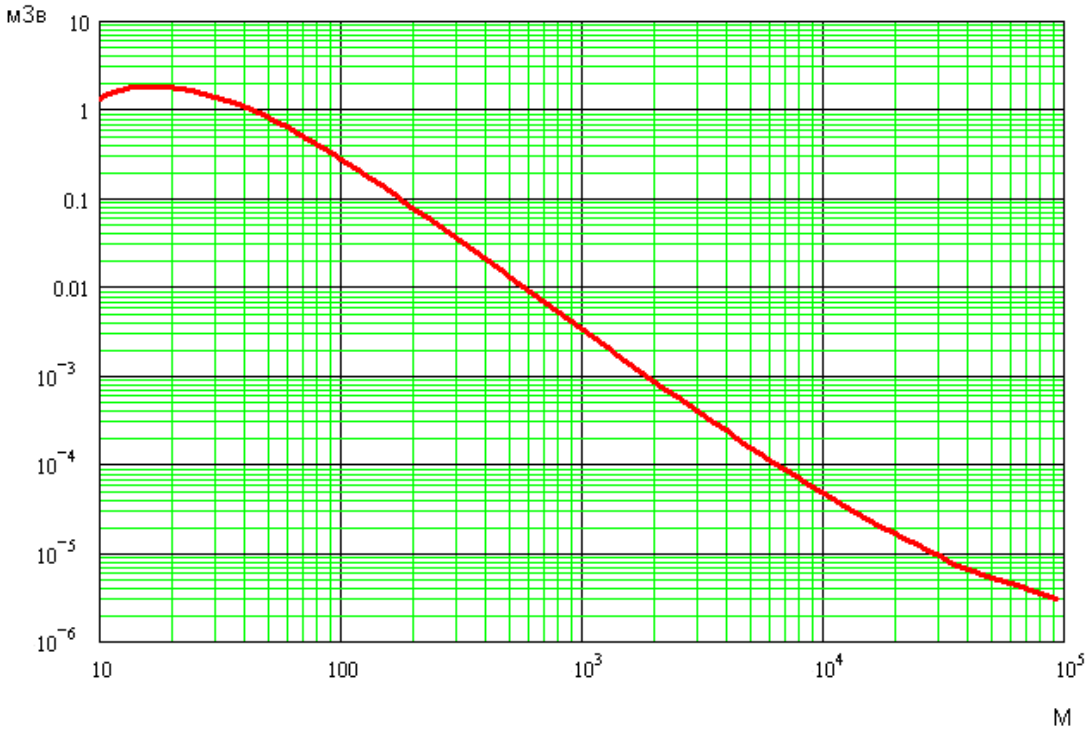

Figure 9.8.4 - Dependence of individual effective dose (mSv) at distance (m) to the emission source during earthwork for preparation of the construction site

Legend: X-coordinate – m; Y-coordinate – mSv.

Results of calculations represented in figure 9.8.4 show that under normal CSFSF construction conditions (earthwork) individual effective dose at the boundary of the 10-km zone of ChNPP will be about 10^{-3} mSv, and on the nearest boundary of the EZ and OEA (13 km to the southwest), individual effective doses will not exceed $4 \cdot 10^{-5}$ mSv.

9.8.2 Accidents During Construction

The most probable accident during construction, rendering the maximum radiation impact on the environment, is a local forest fire during preparation of the construction site. Input data and methodology of the calculations performed of the radiation impact on people from a local fire are represented in section 3.7.1 and attachment A.

The analysis of the results shows that the greatest values of individual effective dose will be observed at distances of from 2 up to 10 km from the seat of the fire and will vary from 0,05 up to 0,09 mSv (see figure 9.8.5).

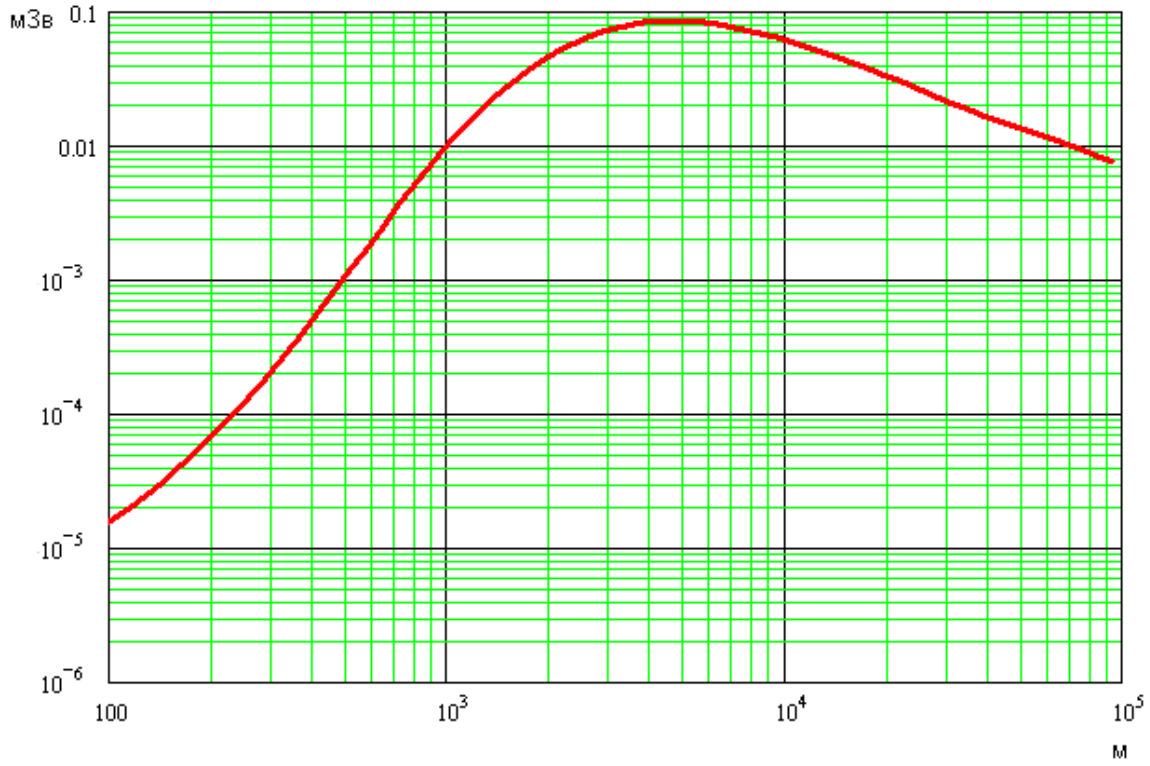

Figure 9.8.5 – Dependence of individual effective dose (mSv) at distance (m) to the center of the forest fire (accident during CSFSF construction)

Legend: X-coordinate – m; Y-coordinate –mSv.

As one can see from figure 9.8.5, on the boundary of the 10-km zone of ChNPP (2 km in southerly direction) the individual effective doses caused by a local forest fire on the CSFSF construction site will not exceed a value of 0,05 mSv. On the nearest boundary of EZ and OEA (12 km to the southwest), individual effective doses will be about 0,06 mSv.

9.8.3 Impacts on Social Environment During CSFSF Construction Outside Exclusion Zone

Values of additional radiation impacts on the personnel working on EZ and OEA territory and the population living in adjacent territories are represented in table 9.8.1.

Table 9.8.1 - Additional dose uptakes during CSFSF construction on the personnel of enterprises in EZ and OEA and the population living beyond its limits

Distance from CSFSF, km	**Limits of radiation dose for the population (category B), mSv / year**	**Additional dose uptakes during CSFSF construction, mSv**	
		normal conditions	**accident**
13 (boundary of ChNPP exclusion zone)	1	4·10-5	0,05
21 (Chernobyl)	1,5-17*	1,5·10-5	0,03

*Note – 1,5-17 mSv / year – value of controlled levels for personnel of the enterprises of the exclusion zone

The analysis which was carried out in section 9.8 of this document, as well as data in table 9.8.1 show that the radiation impacts on the social environment during CSFSF construction will not result in any exceeding of specifications on radiation safety of the population, accepted in Ukraine.

9.9 Assessment of CSFSF Construction Impact on Man-caused Environment

Construction and accompanying work on CSFSF construction will be made on territory of the EZ and OEA. On areas adjoining the work territory, there are no working facilities of housing-and-municipal and welfare purpose, as well as monuments of architecture, history and the cultures protected by the State.

Activity of construction and CSFSF operation do not assume a change of existing conditions of operation of the enterprises located on the EZ and OEA territory. During construction of the storage facility, the factors impacting them are an increase of dose uptakes for the personnel of enterprises of the EZ and OEA, as well as use of the infrastructure of complex "Vektor".

The analysis shows that in normal conditions of construction, as well as for accidents in CSFSF, increase of dose uptakes on the personnel will be insignificant (maximum of 0,077 mSv) in comparison with the existing radiation doses of the personnel of record of the enterprises [4] (ref. table 9.9.1).

Table 9.9.1 - Dose uptakes on the personnel of enterprises of the EZ and OEA during CSFSF construction

Enterprises and their structural subdivisions	Distance from CSFSF, km	Controlled levels [5], mSv / year	Existing dose uptakes, mSv / year	Additional dose uptakes	
				normal conditions, mSv / year	fire during construction **, mSv
1 and 2 turns of SSE «ChNPP»	12,7	17	3,01	$3{,}15 \cdot 10^{-5}$	0,05
LRTF	13	17	3,01	$3{,}04 \cdot 10^{-5}$	0,049
ISF - 2	13,3	17	3,01	$2{,}9 \cdot 10^{-5}$	0,048
RWDF "Vektor" (enterprise at a construction stage)	0,2	No data	0,14	0,077	0,08
Chernobyl enterprises	21	2,3 - 15	0,1 - 3,9	$1{,}48 \cdot 10^{-5}$	0,031
RWDF "Buryakovka"	1,1	18	1,64	$2{,}7 \cdot 10^{-3}$	0,013

* - due to the fact that for small distances from CSFSF the calculation procedure used for spreading of emission gives large errors, values at the distance of the maximum concentration of radioactive aerosols in the air are used conservatively.

** - due to the fact that the fire can take place at various distances from facilities of man-made environment, the worst option which will result in the greatest radiation dose to personnel is conservatively accepted.

Feasibility study process decisions provide for the minimum possible impacts on infrastructure facilities of nearby man-made facilities.

Use of the infrastructure of complex "Vektor" assumes use of the following structures, related to its infrastructure:

- water intake structures;
- substation " Buryakovka ";
- fire depot;
- canteen for feeding of CSFSF personnel.

For reception of possible SRAW generated during CSFSF construction, use of storage facilities at RWDF "Buryakovka" is assumed.

The analysis of the possibility of use of the infrastructure of complex "Vektor", ChNPP and RWDF "Buryakovka" is represented in table 9.9.2. The possibility of use of the infrastructure of complex "Vektor" is confirmed by letters of SSE "Technocenter"; confirming letters are given in volume 1, part 1 of the feasibility study report.

Table 9.9.2 –Analysis of the possibility of use of the infrastructure of enterprises EZ and OEA

Infrastructure		Possibility of enterprise		Need of CSFSF
	Measuring units	Availability of capacities	Own consumption	During construction
Complex "Vektor"				
Water of drinking quality	m^3/day	192 (1 borehole the debit $8 m^3$/hour)	93	84,220

Infrastructure		Possibility of enterprise		Need of CSFSF
	Measuring units	Availability of capacities	Own consumption	During construction
Electric power	kW	8600	2710 (without taking into account 2 turns)	705
Canteen	man / day	250 places	180	212
RWDF "Buryakovka"				
SRAW (soil)	m^3	600000		55200 (to be specified after additional investigations)

The data represented in tables 9.9.1 and 9.9.2 testify that under normal conditions of CSFSF construction, impacts on facilities of man-made environment do not exceed permissible levels. To avoid CSFSF influence on the operation of facilities of man-made environment regarding influence on the infrastructure of the facilities, the following measures are envisaged:

- Taking into account that CSFSF needs for water of drinking quality are provided within the limits of the industrial complex «Vektor», the feasibility study report provides for arrangement of an additional artesian well with an assumed flow rate of 8 m^3/hour at the water-intake station of complex "Vektor";
- For CSFSF construction personnel, catering services in the canteen of complex Vektor need to be arranged in two shifts.

As shown in table 9.9.1, appreciable impact (comparable to the current dose uptakes) on the personnel of neighboring facilities to CSFSF is possible only in the case of a beyond design basis accident during construction of storage facilities (local forest fire). However, even in this case, impacts will be much less than the specified CL.

Therefore, planned CSFSF construction activity, taking into account accepted measures, does not render essential impact on the man-made environment.

9.10 Measures for Maintenance of Normative Conditions of the Environment During Construction

9.10.1 Security Measures

Within the framework of a feasibility study the following safety measures are envisaged:

- Arrangement of radiation monitoring system;
- Arrangement of physical protection system.

9.10.1.1 Radiation Monitoring

The RMS during the construction stage solves the tasks which are related to measurement of parameters used for estimation of:

- Impact of construction on the personnel;
- Impact of construction on the environment.

The RMS provides:

- Radiation monitoring;
- Environment radiation monitoring;
- Radiation monitoring due to non-distribution of radioactive contamination.

For the decisions of the above mentioned tasks the following is envisaged:

- Continuous remote monitoring;
- Monitoring by permanently installed local means;
- Monitoring by portable devices;
- Sampling using media with subsequent processing and measurement in laboratories.

The control of radiation conditions over the CSFSF construction site is carried out by dose rates using portable gamma-radiation means.

The control of activity of liquid discharges is carried out by a sampling method with the subsequent laboratory analysis conducted by existing radiation monitoring laboratories in the exclusion zone.

The control of skin contaminations and IPE beta - active radionuclides is carried out by stationary or portable monitor installations on entry and exit of portable sanitary locks.

The control of surface contamination levels of vehicles is carried out by portable radiometers.

The control of soil contamination is carried out by a sampling method with the subsequent laboratory analysis using existing radiation monitoring laboratories in the exclusion zone and operational control of dose rate by portable means.

The control of ground concentration of the air is carried out periodically during work by a sampling method with the subsequent laboratory analysis using existing radiation monitoring laboratories in the exclusion zone.

The control of individual doses of external irradiation of construction personnel is carried out by direct reading individual thermoluminescent dosimeters.

The control of individual doses of internal exposure of the construction personnel is carried out in the existing laboratories of the exclusion zone. Corresponding contracts will be signed for this purpose.

9.10.1.2 Physical Protection System

Commissioning of a physical protection system is envisaged to provide conditions which make it impossible to carry out an act of nuclear terrorism on the CSFSF territory at the stage of operation or construction, according to the requirements of Law on physical protection,. The specific scope of measures of physical protection maintenance at the CSFSF construction stage will be developed in the construction plan at the CSFSF design stage.

The main directions which require development of specific measures are the following:

- Measures on access restriction;
- Measures for incoming loads control;
- Measures on maintenance of participation in erection of physical protection means only by licensed personnel.

9.10.2 Protective measures

Within the framework feasibility study the following protective measures are envisaged:

- Decontamination of contaminated technical equipment;
- Sanitary treatment of personnel;
- Protection of the construction site;
- Construction of an access control point with permanently manned for guarding the construction yard;
- Normative fire breaks between temporary buildings and structures are envisaged at the construction site and stroybaza areas in order to increase their fire resistance;
- At the moment of commissioning of all temporary buildings and structures, the motorways and fire entrances will be routed to them;
- Specially allocated places with signs indicating "Smoking area", equipped with urns for stubs and drums with water will be arranged;
- At entry to the construction territory, as well as inside where smoking is prohibited, it is assumed posters will be installed with precautionary inscriptions “Smoke is forbidden”;
- After completion of work on a daily basis, construction waste (scraps of forest products, chips, bark, shavings, sawdust) will be removed from the construction site to places specified by the fire department;

- Fire water supply of the construction site will be provided taking into account the requirements of normative-legal reports. At night, it is assumed to cover sources of fire prevention water supply;
- The cables connected to welding devices and welded structures will have reliable isolation and shall be protected in necessary places against the impact of high temperature and mechanical damage;
- Cables with index "NG" will be used for power supply of welding devices and lighting of workplaces;
- The power and lighting wiring, as well as temporary electrical installations for construction will meet the requirements for permanent installations;
- The construction site will be equipped with fire boards with primary fire extinguishing means;
- Work areas will be equipped with powder fire extinguishers;
- Buildings, temporary facilities, as well as utility rooms will be provided with primary fire extinguishing means;
- Paint and varnish substances and other explosive or harmful components will be kept in special durable containers or packing; name of the material, number of batch, date of manufacture, name of the manufacturer, and methods of safe storage, transportation, application and storage life will be designated on the container. The weight of amounts coming to the construction site will not exceed 15 kg. The volumes of paint and varnish substances supplied to the workplace will not exceed shift needs.
- Places of electrical welding will be cleared of combustible and inflammable materials to a radius not less than 5,0 m (places where sparks and splashes of fused steel may fall), and from explosive materials and installations – 10,0 m. The welding transformer will be located at distance of not less than 10,0 m from the place of welding;
- Personnel on the construction site will be provided with protective helmets and overalls;
- Persons that passed training and examination of the instruction on occupational health safety and having a record in the certificate of examination and admission to work performance with application of electric tools will be admitted to work with electric tools. These persons will have group 1 by electrical safety;
- Normative level of light exposure will be provided at workplaces;
- Welding equipment installed in the open area will be protected from atmospheric precipitation and mechanical damage;
- Interdiction of installation and movement of construction machinery and vehicles within the limits of sloped sides of soil will be introduced;
- Bridges in width not less than 0,7 m. with a handrail will be arranged for passing over ditches and trenches;
- Ladders in width not less than 0,75 m. with a handrail will be installed for descent of workers into foundation pits and wide trenches;
- Excavation of foundation pits and trenches without walls will be made with sloped sides;
- Storage of large quantities of materials or soil is assumed only outside of sloped areas;
- Regular observation over edge condition will be specified;
- Before the beginning of concrete placement a check of the correctness of installation and reliability of formwork fastening is assumed;
- Handles of the electric vibrator used will be supplied with shock-absorbers; the case shall be grounded prior to the beginning of work. During vibrating of concrete mix, every 30-35 minutes the vibrator will be switched off for 5-6 minutes for cooling;
- Prior to the beginning of work performance the order of exchange of prearranged signals between the person supervising erection and the crane operator shall be specified;

- Prior to the beginning of work all load handling tools will be preliminarily examined, load tested, and the survey results shall be registered in the log-book;
- Lifting of structures shall be carried out in two steps: first to the height of 20-30 cm, then, after checking the reliability of the slinging, further lifting shall be made.

9.10.3 Reconditioning Measures

During CSFSF construction the following reconditioning measures are envisaged:

- Removal of radioactively contaminated soil with export to RWDF "Buryakovka";
- Leveling work improving existing conditions of relief and reducing exogenic processes in CSFSF site;
- Arrangement of the temporary motorways which reduce the probability and/or exclude penetration of radioactive substances into the soil;
- Decontamination of an area of approximately 18 hectares (approximate area of the construction facilities) of the exclusion zone during construction.

9.10.4 Compensation Measures

During CSFSF construction the following compensating measures are envisaged:

- For assessment of expenses for CSFSF construction, the additional payment, extra charges and premiums to tariff salaries of the personnel are taken into account according to the valid legislation of Ukraine;
- For estimation of the cost of construction, additional means for compensation of expenses for work at shift operation and operating conditions in ChNPP exclusion zone regulated by the valid legislation are taken into account;

9.10.5 Resource-saving Measures

During CSFSF construction the following resource-saving measures are envisaged:

- Storing construction waste on the construction site is not envisaged. As it is accumulated, the waste shall be taken out periodically from the territory of construction to specially allocated dumps;
- After carrying out of radiation monitoring, construction waste can be used at performance of other works or taken outside the limits of the construction site;
- Household waste shall be utilized with observance of the corresponding rules;
- Obligatory observance of boundaries of territories which are allocated under construction;
- Equipping construction sites and workplaces with inventoried containers for construction and household waste;
- Combustive-lubricating materials in places specially allocated and equipped for these purposes;
- Leveling the elevation of the CSFSF site (138,5 m) allowing minimizing the scope of ground work is chosen;
- CSFSF site leveling excluding additional backfilling of the "cold" ground for normalized water table provision is chosen.

9.11 Comprehensive Assessment of the Impact of CSFSF Construction under Normal Conditions

Assessments performed in subsections 9.1-9.9 EIA have shown that under conditions of normal construction the main type of CSFSF impact on components of the environment is radiation (selection of components is made in conformity with DBN A. 2.2-1-2003[1]).

The relatively small scope of civil work, their short duration and lack of a population near work areas make it possible to consider the impacts of noise and vibration on the environment as insignificant. During construction, use of technologies causing intensive electromagnetic radiation and ultrasound is not assumed.

The air, water media (surface and ground waters), topsoil, flora and fauna, social and man-made environment are related to components of the environment to which radiation impacts are distributed. Results of an assessment of CSFSF impact during normal operation on these components are given below.

Currently and during the CSFSF operation period, man-made changes of the condition of the geological environment resulting from impact of the ISF facilities are not predicted. The geological environment of the industrial site and Item CSFSF is characterized by sufficient stability and does not render negative influence on the functioning of CSFSF structures.

Negative CSFSF impact on facilities of the social environment is not forecast also, due to lack of the population in ChNPP exclusion zone, however ISF impact outside the exclusion zone is considered.

9.11.1 Assessment of Impacts on the Air Ambient

The main sources of impact on the air ambient during CSFSF construction are the work which is related to preparation of the area, as well as the work related to construction of access roads to the site.

Work performance on preparation of the area will result in $2{,}1 \cdot 10^6$ Bq of radioactive substances in the air, including: $1{,}4 \cdot 10^6$ Bq 137Cs, $6{,}5 \cdot 10^5$ Bq 90Sr, $3{,}0 \cdot 10^4$ Bq α radiating TUE.

On the nearest boundary of the EZ and OEA (12 km in "south-west" direction) volumetric air pollutionunder typical weather conditions will not exceed $AC_в^{inhal}$ (admissible concentration for inhalation) (0,8 Bq/m^3 for ^{137}Cs). So, ^{137}Cs values of volumetric activity will vary within the limits of $5*10^{-5}$ Bq/m^3. The value of volumetric activity of ^{90}Sr at such a distance will be ~ $1*10^{-5}$ Bq/m^3, at 0,2 Bq/m^3 $ДК_в^{inhal}$ specified for the given nuclide. For alpha-emitting TUE ($AC_в^{inhal} = 4*10^{-4}$ Bq/m^3), volumetric concentration in the air on the nearest boundary of the EZ and OEA (12 km in "south-west" direction) will reach ~ 6·10-7 Bq/m^3.

For the construction period, the individual effective equivalent dose on the boundary of the 10-km zone of ChNPP will be about $1*10^{-3}$ mSv, and on the nearest boundary of the EZ and OEA (12 km to the southwest) – about $4*10^{-5}$ mSv.

Therefore, the maximum design concentration of ^{137}Cs, ^{90}Sr, making radioactive emissions alpha-emitting TUE main part in the air, under normal conditions of ISF construction is $10^3 – 10^4$ times below the maximum allowed concentration.

9.11.2 Assessment of Impact on Water Media

During CSFSF construction, impact on water objects of the area of impact is possible only by the air way due to direct sedimentation of polluting substances on water surfaces from the atmosphere, or washout and/or filtrations of these substances from the surface of topsoil.

The analysis of spreading of radioactive emissions in the air has shown that under normal conditions of CSFSF construction, surface contamination of territories (at distances more than 1 km) will be the 100-th fractions of percent from the existing contamination, caused by emergency emission from ChNPP. Based on data results and taking into account that surface reservoirs are located at a great distance from CSFSF (river Uzh – 6-8 km, river Sakhan about 7 km, river Pripyat – 12 km), the volumetric concentration of radioactive substances in water of the specified reservoirs caused by CSFSF will be lower than the reliably detectable levels.

Thus it is necessary to take into account that water collecting territories of the rivers Uzh and Sakhan nearest to CSFSF are mainly relatively leveled and forest-covered territories, which practically have no surface effluent to cause a main source of intake of radioactive substances from water collecting territories. A significant part of water collecting territories are boggy, and, as a matter of fact, are the natural biogeochemical barriers to spreading of radioactive substances.

Taking into account the aforesaid, it is possible to conclude that under normal conditions of CSFSF construction, radiation impact on surface waters will be practically imperceptible.

Radionuclide contamination of ground water during CSFSF construction is caused exclusively due to vertical migration of radionuclides deposited on the topsoil surface. At current

levels of radioactive contamination of adjoining areas, the impact of additional contamination on ground waters in space and in time will be insignificant.

9.11.3 Assessment of Impact on Topsoil

The main sources of impact on topsoil during construction are:

- Earthwork during construction;
- Dust release from earthwork during construction and preparation of the site.

During construction it is assumed 61,5 thousand m^3 (73,8 thousand tons) of soil will be removed. Specific β activity of the top layer of soil (up to 10 cm thickness) is up to 7 kBq/kg, α activity - up to 0.1 kBq/kg. Taking into account that it is assumed to remove 50 cm soil on the average (for performance of site leveling), its specific activity as a result of mixing will decrease to 1.4 kBq/kg and 0.02 kBq/kg for β - and α contaminated soil respectively. In conformity with SPORO – 85, radioactively contaminated materials with specific β activity more than 74 kBq/kg or more than 0,37kBq/kg for αActive transuranium elements are considered RAW. Therefore, RAW generation during civil work at the CSFSF industrial site is not expected.

During construction of the access railway which crosses the "western" trace of fallout generated after the ChNPP accident, RAW generation is possible. During development of main decisions on construction management, it is accepted that the layer of contaminated soil in the area from 300 up to 600 m should be removed and taken out for disposal. The estimated volume of possible RAW – up to 50,0 thousand m^3. Backfilling of “cold” instead of the soil removed is planned

The analysis of results of calculations of additional impact on topsoil during construction performed in subsection 9.7 of the entire EIA has shown that the value of the maximum surface topsoil contamination in immediate proximity to places of work will be approximately 0,2-0,3 % of existing topsoil contamination (irrespective of the current meteorological parameters). At greater distance, for example on the boundary of the 10-km zone of ChNPP (2 km in southerly direction), levels of additional surface contamination will not exceed 0,01 % of the existing contamination.

Therefore, the impact on topsoil during construction is insignificant.

Therefore, impact on topsoil areas of ChNPP will not be an obstacle to possible change of the EZ and OEA configuration up to boundaries of the10-km zone and will not result in restriction of economic activities in territories which can be removed from the EZ and OEA structure.

9.11.4 Assessment of Impact on Flora and Fauna

The major factor of impact of CSFSF construction on flora and fauna is deforestation directly on construction sites (area – 11,33 hectares) and at routing of the railway track to the facility (area – 7 hectares). Specified areas of forest – the unproductive artificial pine plantings created in the 60’s of the last century on poor dry sandy soils which are unsuitable for agriculture. By forest vegetative conditions they are considered dry coniferous forest and have the least class growth class among forests on the EZ and OEA territory. In this connection, deforestation of specified areas of forest does not render appreciable impact on the specific variety of phytocenosises and, accordingly, faunistic complexes of adjoining areas.

Deforestation of the railway track with a length of 6,4 km may appreciably limit movement of wild hoof animals due to infringement of historically developed migration paths. However, taking into account the high local population of these animals, increased percentage of forest land adjoining areas, and practically reserved mode of the territory, essential increase of number and specific variety of animals is not expected.

9.11.5 Assessment of Impacts on Man-caused Environment

EIA, subsection 9.9, considers the following facilities as the facilities of ISF impact on man-caused environment:

- main buildings of Chernobyl NPP;
- LRTF;
- ISF - 2 CHNPP;

- complex Vektor;
- Chernobyl enterprises;
- RWDF "Buryakovka".

Activity during CSFSF construction does not assume change of the existing conditions of operation of the enterprises located nearby (Complex "Vektor", ChNPP, etc.). The unique factor of impact is use of the RWDF "Buryakovka" infrastructure, as well as increase of dose uptakes of the personnel of the enterprises related to CSFSF construction.

In section of this EIA it is shown that RWDF "Buryakovka" can receive possible radwaste during CSFSF construction. The volume of RAW and concurrence of RAW reception to RWDF "Buryakovka" shall be specified at the following design stages after additional radiation surveys of the area.

As a result of calculations of dose uptakes for the personnel of the above facilities as a result of normal conditions of CSFSF construction, in section 6 of the EIA it is shown that additional dose uptakes of the personnel of these facilities taking into account existing dose uptakes do not exceed controlled levels for the specified personnel. Results of calculations are represented in table 9.11.1.

Table 9.11.1 – Dose uptakes for the personnel of facilities during construction

Facility	**Controlled levels, mSv / year**	**Existing dose uptakes, mSv / year**	**Additional dose uptakes during construction, mSv / year**
Main buildings of Chernobyl	17	3,01	$3{,}15 \times 10^{-5}$
LRTF	17	3,01	$3{,}04 \times 10^{-5}$
ISF - 2	17	3,01	$2{,}9 \times 10^{-5}$
complex Vektor	18	0,14	$0{,}7 \times 10^{-1}$
Chernobyl enterprises	2,3-15	0,1-3,9	$1{,}48 \times 10^{-5}$
RWDF "Buryakovka"	18	1,64	$2{,}7 \times 10^{-3}$

9.11.6 Assessment of Impacts on Social Environment

As a result of calculations of dose uptakes of the population outside the exclusion zone during CSFSF construction the present EIA shows that additional dose uptakes of the population do not exceed the limits specified in NRBU - 97. Results of calculations are represented in table 9.10.2.

Table 9.11.2 – Dose uptakes on the population during construction

Distance from CSFSF, km	**Exposure dose limits, regulated by NRBU - 97, mSv / year**	**Dose uptakes on the population during construction, mSv / year**
30	1	1×10^{-5}
40	1	$6{,}3 \times 10^{-6}$
100	1	$2{,}7 \times 10^{-6}$

9.12 Comprehensive Assessment of CSFSF Impact During Accidents

9.12.1 Considered accidents

The only accident that can render essential radiation impact on the air medium during CSFSF construction is a local forest fire at the moment of work on preparation of the construction site (up to the full removal of wood vegetation).

In the process of propagation of such a fire, the radionuclides released into the atmosphere with smoke and soot and deposited in wood and vegetation cover will be distributed in the atmosphere which will result in additional topsoil contamination and increase of concentration of radionuclides in the ground layer of the air. As a result of this process, there occurs concentrating of

radionuclides in ashes of forest underlayer and release of radioactive aerosols of various dispersive degree in the air.

9.12.2 Assessment of Impact on the Air Ambient

Calculations of impact of a local forest fire on the air ambient carried out in section 9.4 of the entire EIA have shown that the maximum volumetric activity of isotopes ^{134}Cs, ^{90}Sr and alpha-emitting TUE in the air is observed at distances 4-5 km from the place of the fire and add up to 15 Bq/m^3, $8Bq/m^3$, and $2Bq/m^3$ respectively.

On the nearest boundary of the EZ and OEA (12 km in "south-west" direction) the volumetric activity of air for isotopes ^{134}Cs, ^{90}Sr and alpha-emitting TUE will be respectively 8 Bq/m^3, $4Bq/m^3$, and $1Bq/m^3$.

Therefore, for a local fire during ISF construction, exceedance of controlled levels is possible. Taking into account that forest fires in the exclusion zone can be not related to ISF construction, and that within the framework of the construction plan measures on prevention of ignitions of wood and forest cover will be envisaged, the impact on the air during construction can be considered as acceptable.

9.12.3 Assessment of Impact on Water Media

The analysis of impacts on surface waters for a local forest fire shows that the greatest contamination of open reservoir will be observed for fallout of radioactive aerosols on the surface of a flood-plain and a mirror of water river Pripyat (distance 12 km from a seat of the fire). Thus additional contamination 137Cs, 90Sr and TUE, deposited as aerosols directly on the water surface and washed off by hollow waters from a coastal flood-plain, will be respectively - 0,30, 0,15 and 0,03 Ci. Taking into account that annual values of activity carried away by the river Pripyat including the most mobile radionuclide ^{90}Sr is 314-165 Ci/year, it is possible to draw a conclusion that the impact on surface waters for a possible accident during construction (local forest fire) will be insignificant.

Radionuclide contamination of ground waters during CSFSF operation is caused exclusively due to vertical migration of radionuclides dropped out on the surface of topsoil. At current levels of radioactive contamination of adjoining areas, the impact of additional contamination on ground waters, in space and in time will be insignificant.

9.12.4 Assessment of Impact on Topsoil

The analysis of the impact of a possible local forest fire on concentration of radionuclides in the air given in section 9.7 of the entire EIA has shown that at a reference value of density of surface contamination of ^{137}Cs at the construction site of 230 kBq/m^2, the maximum additional surface topsoil contamination will be observed at a distance of ~ 4000 m from the place of a fire and will not exceed 200 Bq/m^2. On the nearest boundary of the EZ and OEA (12 km in "south-west" direction) additional topsoil contamination by ^{137}Cs will be 100 Bq/m^2 which corresponds ~ 0,1 % of the existing level of topsoil contamination.

The maximum values of additional contamination of ^{90}Sr and TUE also will be observed at a distance of 4000 m from a seat of the fire and will be respectively, 90 and 2 Bq/m^2. Thus on the nearest boundary of the EZ and OEA (12 km in "south-west" direction), additional topsoil contamination by ^{90}Sr will be 50 Bq/m^2 or ~ 0,1 % of background contamination; additional contamination by TUE will be about 1 Bq/m^2 or 0,2 % of background contamination. Therefore, the surface topsoil contamination caused by emission for a possible wood local fire during CSFSF construction, does not render essential impact on topsoil.

9.12.5 Assessment of Impact on Flora and Fauna

The maximum emergency contamination of soil - vegetative cover by radionuclides (^{137}Cs, ^{90}Sr and TUE), in case of occurrence of an accident during construction (local forest fire, ref. section 9.8) will be observed at a distance of 4000 m from a seat of the fire and will not exceed 0,1-

0,2 % of values of background contamination of the area which practically will not result in deterioration of inhabitancy of living organisms.

It is assumed that ignition will take place on the territory of the construction site, where corresponding measures (fire-prevention mineral strips, etc.), preventing fire propagation to the adjoining large forests shall be carried out. Therefore, accident during construction does not render essential impact on flora and fauna.

9.12.6 Assessment of Impact on Man-caused Environment

As the facilities of impact for ISF accidents on man-caused environment, section 9 of the entire EIA considers:

- Main buildings of Chernobyl NPP;
- LRTF;
- ISF - 2 CHNPP;
- Complex Vektor;
- Chernobyl enterprises;
- RWDF "Buryakovka".

As a result of calculations of dose uptakes for the personnel of considered facilities as a result of a local fire during CSFSF construction, it was shown that additional dose uptakes of the personnel of these facilities taking into account existing dose uptakes, do not exceed controlled levels for the specified personnel. Results of calculations are represented in table 9.12.1.

Table 9.12.1 – Dose uptakes on the personnel of facilities at accident during construction

Facility	**Controlled levels, mSv / year**	**Existing dose uptakes, mSv / year**	**Additional dose uptakes in case of a fire, mSv**
Main buildings of Chernobyl	17	3,01	0,05
LRTF	17	3,01	0,049
ISF - 2	17	3,01	0,048
complex Vektor	18	0,14	0,08
Chernobyl enterprises	2,3-15	0,1-3,9	0,031
RWDF "Buryakovka"	18	1,64	0,013

9.12.7 Assessment of Impacts on Social Environment

As a result of calculations of dose uptakes for the population outside the exclusion zone for a local fire during CSFSF construction, it was shown that additional dose uptakes for the population do not exceed the limits specified by NRBU - 97. Results of calculations are represented in table 9.12.2.

Table 9.12.2 – Dose uptakes on the population in case of a fire

Distance from CSFSF, km	**Exposure dose limits, regulated NRBU - 97, mSv / year**	**Dose uptakes on the population in case of a fire, mSv**
30	1	0,022
40	1	0,016
100	1	$7x10^{-3}$

9.13 Description of Residual Impacts

The summary list of residual impacts shown in table 9.13.1 is for CSFSF at normal conditions of construction, as well as for accidents during CSFSF construction. The information is

represented on the basis of data on sources of the impacts contained in section 9.1 of the entire EIA and results of the assessments represented in sections 9.3-9.8 of the EIA taking into account implementation of plan measures stipulated by construction for the maintenance of the ecological safety represented in section 9.11 of the entire EIA.

Table 9.13.1 – List of residual impacts during CSFSF construction

Types and sources of impact	Parameters of emissions and discharges	Description of impacts on components of the environment					
		air	water	soils	flora and fauna	man-made environment	social environment
Normal conditions of construction and operation							
Dust generation for work after preparation of site and during construction	$2{,}1 \cdot 10^6$ Bq of radioactive substances, including: $1{,}4 \cdot 10^6$ Bq of ^{137}Cs, 6,5·105 Bq of ^{90}Sr, $3{,}0 \cdot 10^4$ Bq of α radiating TUE will be emitted in to the air	The maximum design concentration of ^{137}Cs, ^{90}Sr, is 10^3 – 10^4 times below the maximum allowed; The maximum design concentration of alpha-emitting TUE, exceed the maximum allowed values by 10^3 times.	Volumetric concentration of radiation substances in water of reservoirs (river Uzh – 6-8 km, river Sakhan about 7 km, river Pripyat – 12 km), caused by CSFSF, will be lower than levels of reliable detectability	The value of maximum topsoil PSC in immediate proximity to work places will be 0,2-0,3 % of existing topsoil contamination. On the boundary of the 10-km zone of ChNPP PSC levels will not exceed 0,01 % of the existing contamination.	Deforesting of specified areas does not render appreciable impact on specific variety of phytocenosises and, accordingly, on faunistic complexes of adjoining areas Damage for number and specific variety of animals is not expected	Maximum additional radiation doses are expected for the personnel of complex Vektor – 0,07mSv/year that along with existing dose does not exceed 1% of controlled levels	Dose uptakes of the population outside exclusion zone do not exceed 0,001% of limits pre-specified by NRBU - 97 (1 mSv/year)
Final assessments of residual impacts at normal operation		Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible
Emergencies							

Types and sources of impact	Parameters of emissions and discharges	Description of impacts on components of the environment					
		air	water	soils	flora and fauna	man-made environment	social environment
Local forest fire	Activity of expected emission (Bq): ^{137}Cs – $5,4x10^{10}$; ^{90}Sr – $2,9x10^{10}$; alpha-emitting TUE – $5,8x10^{8}$	MDBA of isotopes ^{134}Cs, ^{90}Sr and alpha-emitting TUE in air will be observed at distances of 4-5 km from the place of fire and will be 15 Bq/m^3, $8Bq/m^3$, and $2Bq/m^3$ respectively.	additional contamination by ^{137}Cs, ^{90}Sr and TUE, deposited directly on water surface will be respectively - 0,30, 0,15 and 0,03 Ci, which is less than 314-165 Ci/year of annual carried away by river Pripyat	On the nearest boundary of the EZ and OEA (12 km in "south-west" direction) topsoil PSC ^{90}Sr, ^{137}Cs and alpha-emitting TUE is no more than 0,1-0,2% of background contamination	Maximum emergency PSC of soil - vegetative cover will be observed at a distance of 4000 m from the seat of a fire and will not exceed 0,1-0,2 % of values of background contamination of area	Maximum additional radiation doses are expected for the personnel of complex Vektor – 0,08mSv/year that along with existing dose does not exceed 1,2 % of controlled levels	Additional dose uptakes of the population do not exceed the limits specified in NRBU - 97
Final assessments of residual impacts at accidents		Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible	Impacts do not exceed permissible

10 IMPACT OF CSFSF CONSTRUCTION, OPERATION AND ACCIDENTS ON TERRITORY OF THE ADJACENT STATES

Planned activity on construction and operation of the storage facility for the spent nuclear fuel of WWER nuclear reactors of nuclear power plants of Ukraine (CSFSF), according to Conventions on environment impact assessment in transboundary context (item 3, Attachment 1) is subjected to an obligatory assessment concerning possible impacts in transboundary aspect.

According to item 1.11 of normative document DBN 2.2-1-2003 for presence of impacts of planned activity on territory of adjacent states, the EIA is performed taking into account requirements of the Convention on environment impact assessment in transboundary context which was ratified by Ukraine on March 19, 1999.

The purpose of the present section is the preliminary proof of the lack of transboundary impacts during construction, operation, accidents and decommissioning of CSFSF on the territory of Ukraine.

The nearest adjacent states whose territory may be impacted by CSFSF, are Byelorussia (distance – 13 km) and Russian Federation (distance - 220 km).

Due to the fact that the Convention on environment impact assessment in transboundary context is not ratified by the corresponding state bodies of the Russian Federation, impacts on the territory of this state are not considered.

The convention on environment impact assessment in transboundary context is ratified by Byelorussia (the Decree of the President of Byelorussia №487 dated October 20, 2005).

The shortest distance from the CSFSF site to the frontier of Ukraine with Byelorussia is 13 km in a northern direction (area of uninhabited settlement Khutor Les). From the perspective of Byelorussia, this area is part of the Polesskiy state radiation - ecological reserve whose territory does not contain permanent population due to the result of the Chernobyl accident in 1986. Lands of the reserve are removed from economic use by significant radioactive contamination of the grounds. The personnel of the reserve work by in a shift operation method.

The nearest areas of the frontier of Ukraine on the Byelorussia side of the border where the population lives constantly, are at a distance of 31 km in the north-west direction (settlement Aleksandrovka) and 31 km in the east direction (settlement Gden). Therefore, the assessment of impacts of construction and CSFSF operation on the territory of Byelorussia will be provided for two areas at the distance 13 and 31 km from the storage facility.

The main type of CSFSF impacts are radiation, therefore the analysis of condition of the environment on Byelorussia territory will be carried out by three key parameters characterizing radiation conditions:

- volumetric concentration of radionuclides in the air;
- additional surface contamination of soils;
- additional exposure of the population.

Due to the fact that during CSFSF construction a local forest fire is accepted as the accident – an event which is not the direct consequence of construction of the storage facility, therefore the impact of this accident on territory of Byelorussia is not considered.

Modeling of the spread of radionuclides in the atmosphere for emissions which will be generated under normal conditions of civil work being carrying out, normal operation and for possible accidents, was carried out with use of the modified Gauss procedure recommended by IAEA (Attachment A).

10.1 Impact under Normal Construction Conditions

During preparation of the construction site of the storage facility, earthworks will be carried out, which probably result in radioactive air pollution due to dust generation.

For calculations the following input data were accepted:

- Character of emission – short-term;
- Factor of dust release (k) - 0,0001 m^{-1};
- Height of point of emission – 0 m;
- Total emission of ^{137}Cs - $1{,}4 \cdot 10^{6}$ Bq;
- Total emission of ^{90}Sr - $6{,}5 \cdot 10^{5}$ Bq;
- Total emission ά active TUE - $3 \cdot 10^{4}$ Bq.

10.1.1 Air Pollution

Parameters of the volumetric activity of air during civil work at the distances of 13 and 31 km from CSFSF site are represented in figures 10.1.1 – 10.1.3 and in table 10.1.1.

Table 10.1.1-Average volumetric concentration (Bq/m^3) of radionuclides in the air during civil work on CSFSF site

Radionuclide	**Distance from CSFSF**	
	13 km	31 km
^{137}Cs	$4{,}0 \cdot 10^{-5}$	$1{,}3 \cdot 10^{-5}$
^{90}Sr	$9{,}0 \cdot 10^{-6}$	$3{,}0 \cdot 10^{-6}$
ά active TUE	$5{,}0 \cdot 10^{-7}$	$1{,}5 \cdot 10^{-7}$

10.1.2 Contamination of Surface Topsoil and Additional Exposure of the Population

Due to the short time of emission (only for the period of carrying out of earthwork) and relatively small concentration of radionuclides in the air, radioactive contamination of soils and additional radiation doses of the population are not presented in view of their small values.

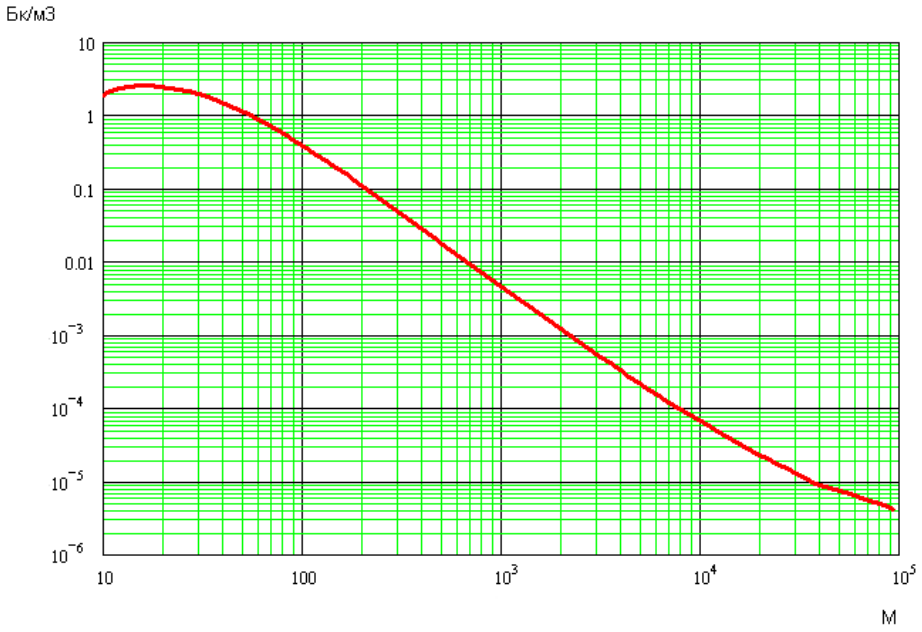

Figure 10.1.1-Dependence of volumetric concentration of ^{137}Cs in the air (Bq/m^3) during earthwork at distance (m) to emission source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

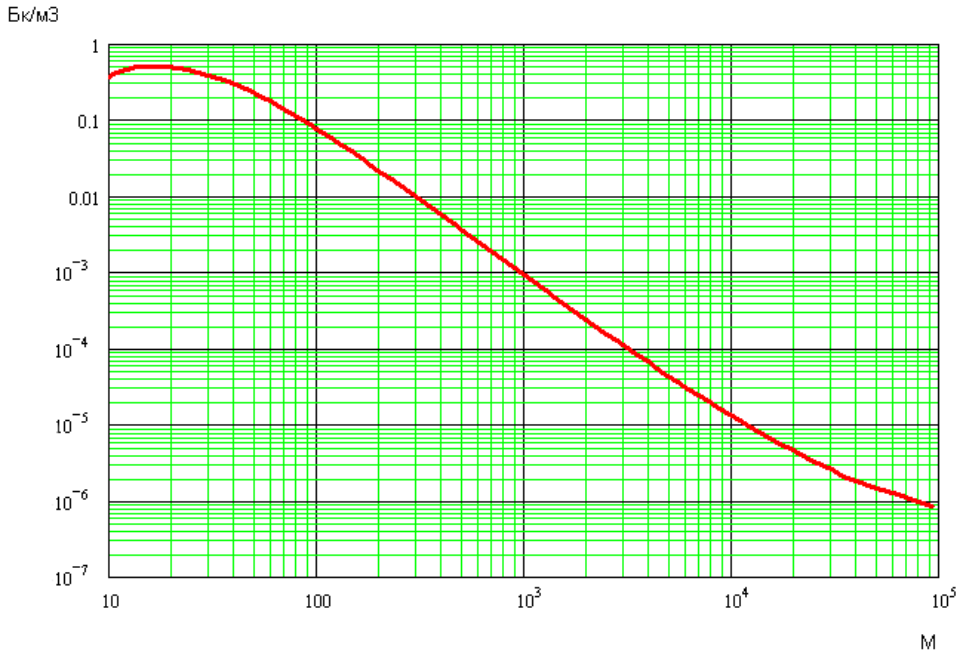

Figure 10.1.2-Dependence of volumetric concentration ^{90}Sr in the air (Bq/m^3) during earthwork at distance (m) to emission source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

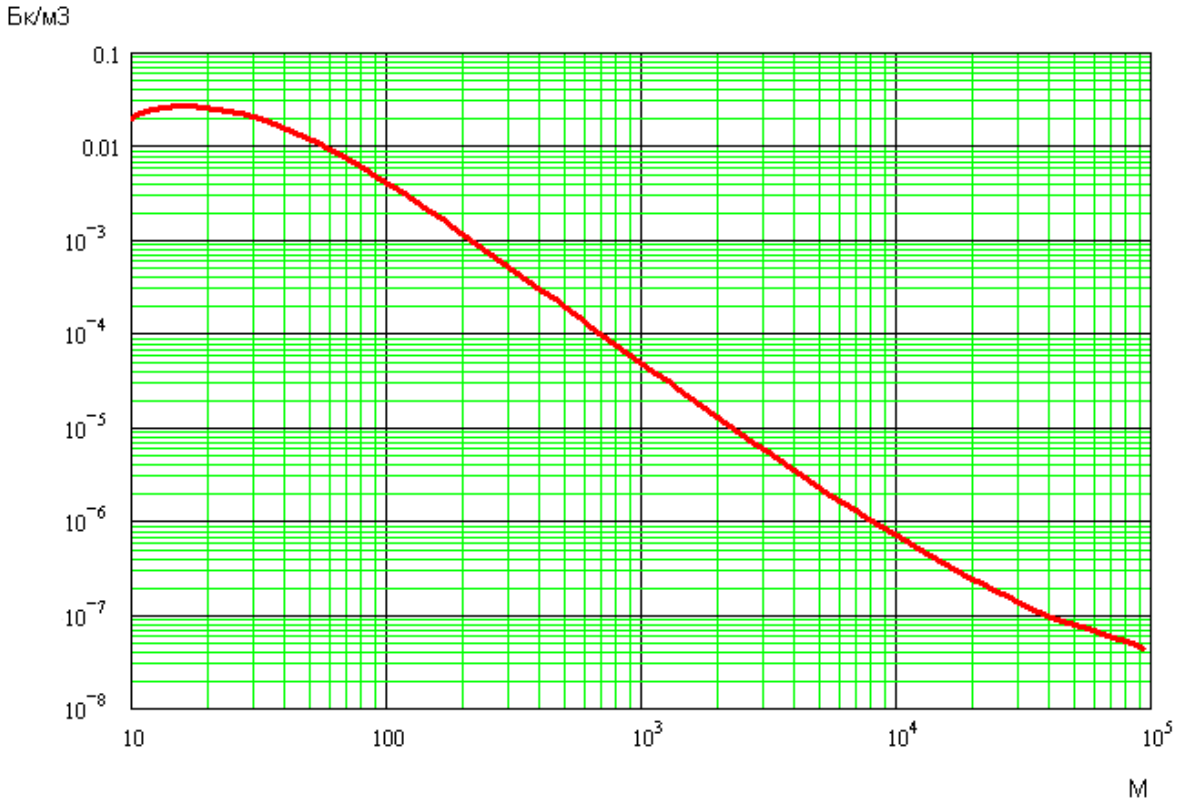

Figure 10.1.3 - Dependence of volumetric concentration of alpha - active transuranium elements in the air (Bq/m^3) during earthwork at distance (m) to emission source

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

10.2 Impacts During CSFSF Normal Operation

Radiation impacts during normal operation are possible due to radioactive contamination of the external surface of the tight container with spent nuclear fuel.

It is considered that at storage of the container, surface contamination as radioactive aerosols affects the environment for 1 year. It is conservatively assumed that surface contamination of the container with spent nuclear fuel is represented by the most dangerous radionuclide in the radioecological relation, ^{60}Co.

The following input data were assumed for the calculations:

- Total annual emission of ^{60}Co from storage facility - 16,1 MBq;
- Height of emission point – 6 m (height of the module of storage);
- Category of atmospheric stability - D (by Pascwill);
- Direction of wind – permanent, average speed – 2,1 km/s.;
- Inhalation dose factor ^{60}Co - $1{,}02 \cdot 10^{-8}$ Sv/Bq;
- Dose factor of radionuclide ^{60}Co (taking into account all ways of impact of emission) - $1{,}1 \cdot 10^{-1}$ (Sv/year) / (Bq/m^3) [30].

10.2.1 Air pollution

Calculations show that volumetric concentration of ^{60}Co at the distances of 13 and 31 km from storage facility will not exceed, accordingly - $8 \cdot 10^{-9}$ and $2 \cdot 10^{-9}$ Bq/m^3 (fig. 10.2.1).

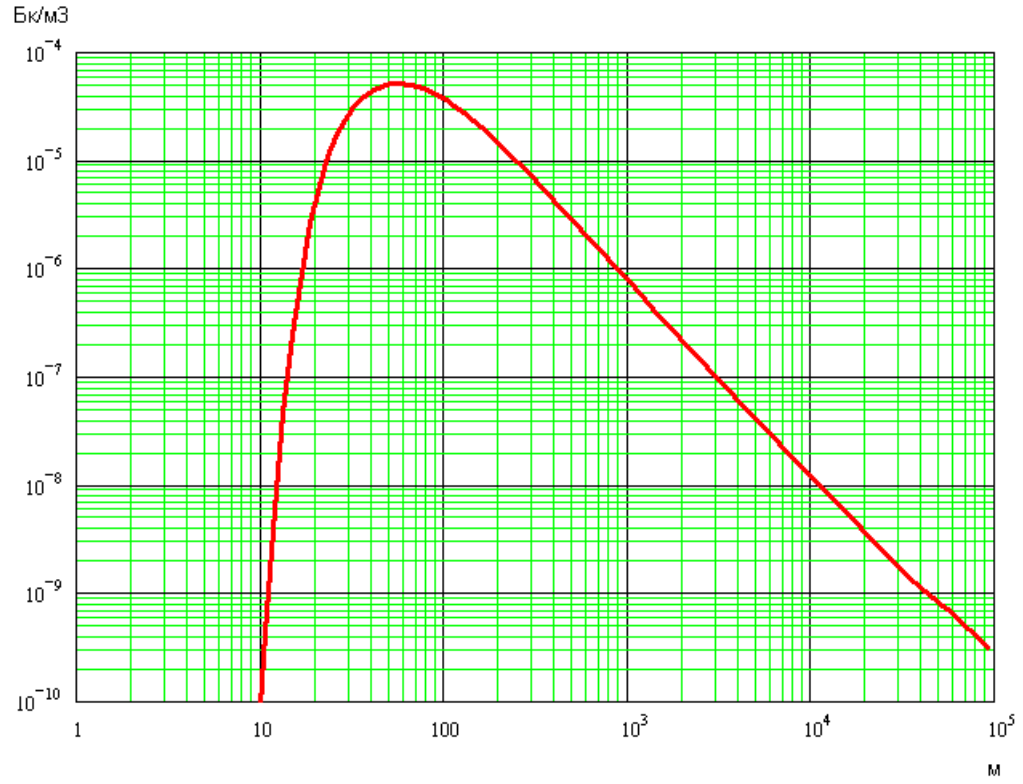

Figure 10.2.1 - Dependence of volumetric concentration of ^{60}Co (Bq/m^3) in the air at distance (m) to the CSFSF under normal operation conditions

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

According to Attachment 3 of state normative document GN 2..6.1.8-127-2000 [29] valid in Byelorussia, permissible average annual volumetric activity of ^{60}Co for the population is equal to 11

Bq/m^3. Accordingly, volumetric concentration of ^{60}Co in the air on Byelorussia territory during CSFSF normal operation is approximately 10^9 less than the permissible limit.

10.2.2 Contamination of Surface of Topsoil

Calculations show that additional surface topsoil contamination by ^{60}Co, due to deposition of radioactive aerosols during normal operation of the storage facility, at the distances of 13 and 31 km will not exceed, respectively - $2 \cdot 10^{-3}$ and $5 \cdot 10^{-3}$ Bq/m^2 (fig. 10.2.2). Topsoil contamination by radionuclides of such low level is not detected by the majority of modern devices, minimum detected activity (MDBA) which is not less than 1 Bq per 1 kg of topsoil.

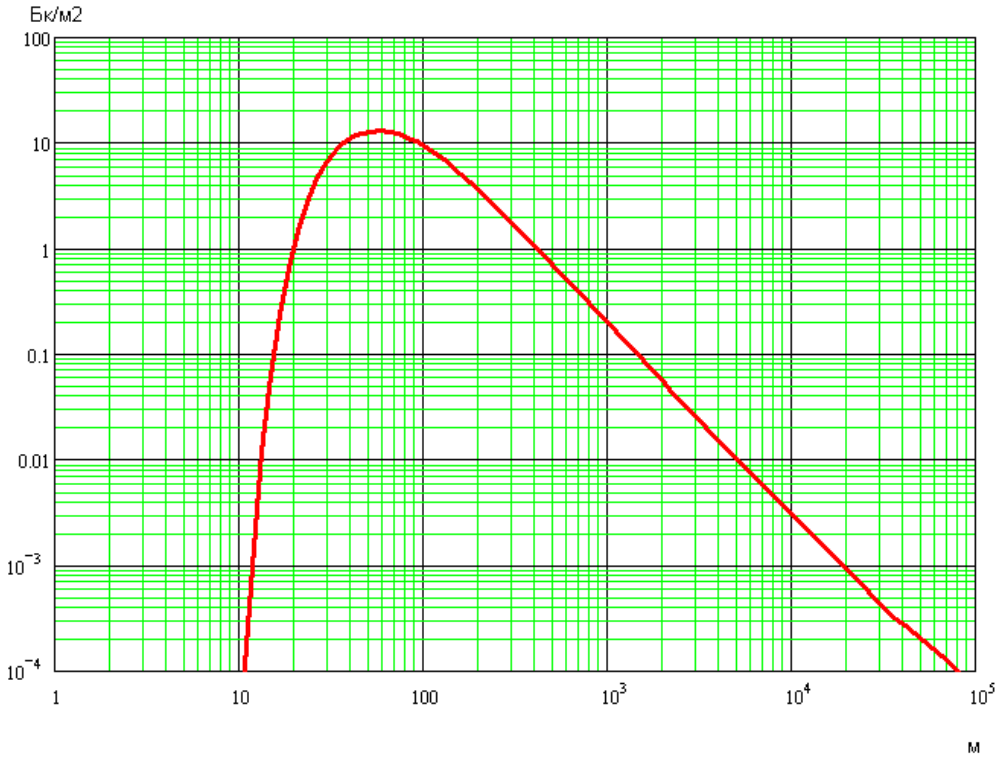

Figure 10.2.2 - Dependence of density of contamination of surface soils by ^{60}Co (Bq/m^2) at distance (m) to the CSFSF during normal operation in the course of the year

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

10.2.3 Additional Personnel and Population Exposure

At normal operation of the storage facility, additional exposure of people (personnel) due to inhalations of radionuclides of emission at the distances of 13 and 31 km will be respectively - $2 \cdot 10^{-9}$ and $5 \cdot 10^{-10}$ mSv / year (fig. 10.2.3).

Considering all ways of released radionuclides impact during normal operation of the storage facility (for 30 years) on human organism, the value of additional individual effective dose of exposure at the distances of 13 and 31 km will be respectively – $1{,}5 \cdot 10^{-6}$ and $4{,}0 \cdot 10^{-7}$ mSv / year (fig. 10.2.4) which certainly is an insignificant impact.

Taking into account current weather conditions (average annual frequencies of winds of different directions), the value of additional individual effective dose of exposure, due to 30-years

operation of the storage facility, at the distances of 13 and 31 km, will be respectively – $9{,}4 \cdot 10^{-7}$ and $6{,}3 \cdot 10^{-7}$ mSv / year (fig. 10.2.5).

According to Attachment 1 of state normative document GN 2..6.1.8-127-2000 [29] valid in Byelorussia, the limit of annual radiation dose of the population is 1 mSv. Accordingly, the value of the additional individual effective dose of exposure due to CSFSF normal operation, is approximately 10^6 times less than the permissible limit for the population of Byelorussia.

Taking into account the fact that radioactive emissions of the storage facility are possible only during filling, i.e. during the first 50 years of operation, as well as the relatively short half-life period of ^{60}Co (5,27 years), it is possible to draw a conclusion that CSFSF normal operation **will not result in essential negative impacts** on condition of the air, topsoil and health of the population of boundary territories of Byelorussia.

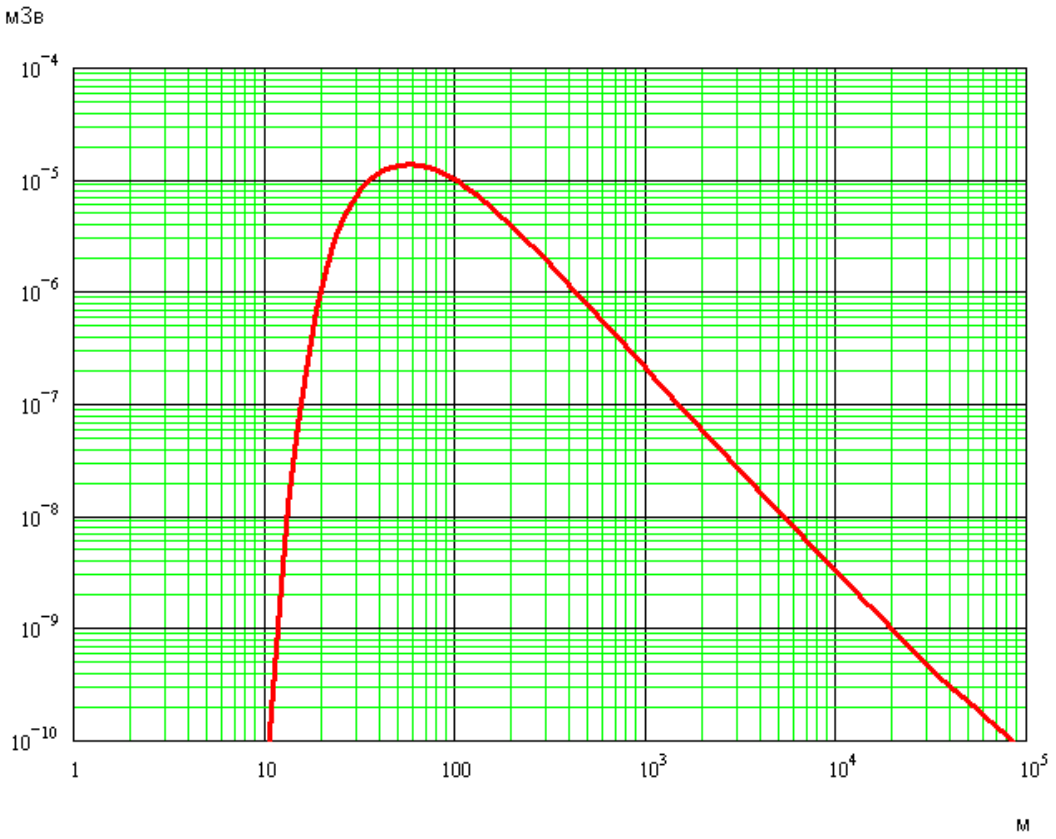

Figure 10.2.3-Dependence of value of individual effective dose (mSv / year) due to inhalation of ^{60}Co at distance (m) to CSFSF during normal operation

Legend: X-coordinate – m; Y-coordinate –mSv.

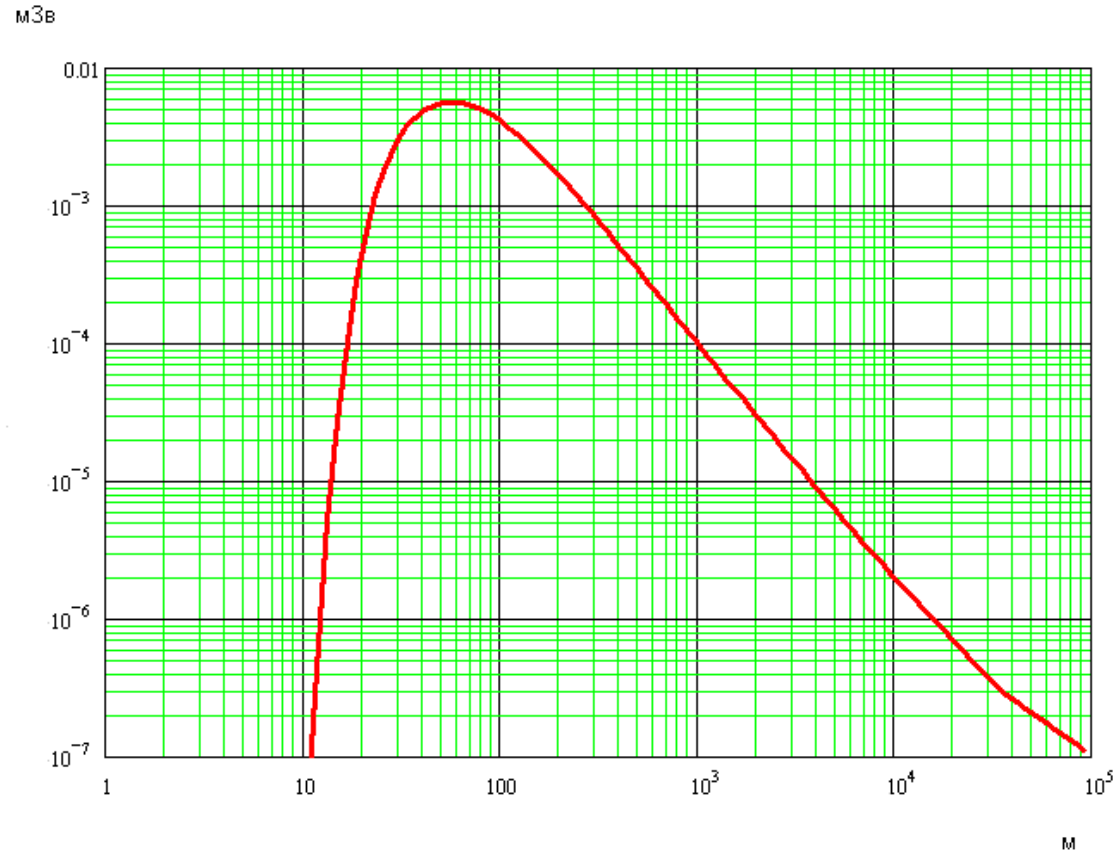

Figure 10.2.4-Dependence of value of individual effective dose (mSv / year) due to all ways of impact of emission ^{60}Co at distance (m) to CSFSF during normal operation for 30 years

Legend: X-coordinate – m; Y-coordinate –mSv.

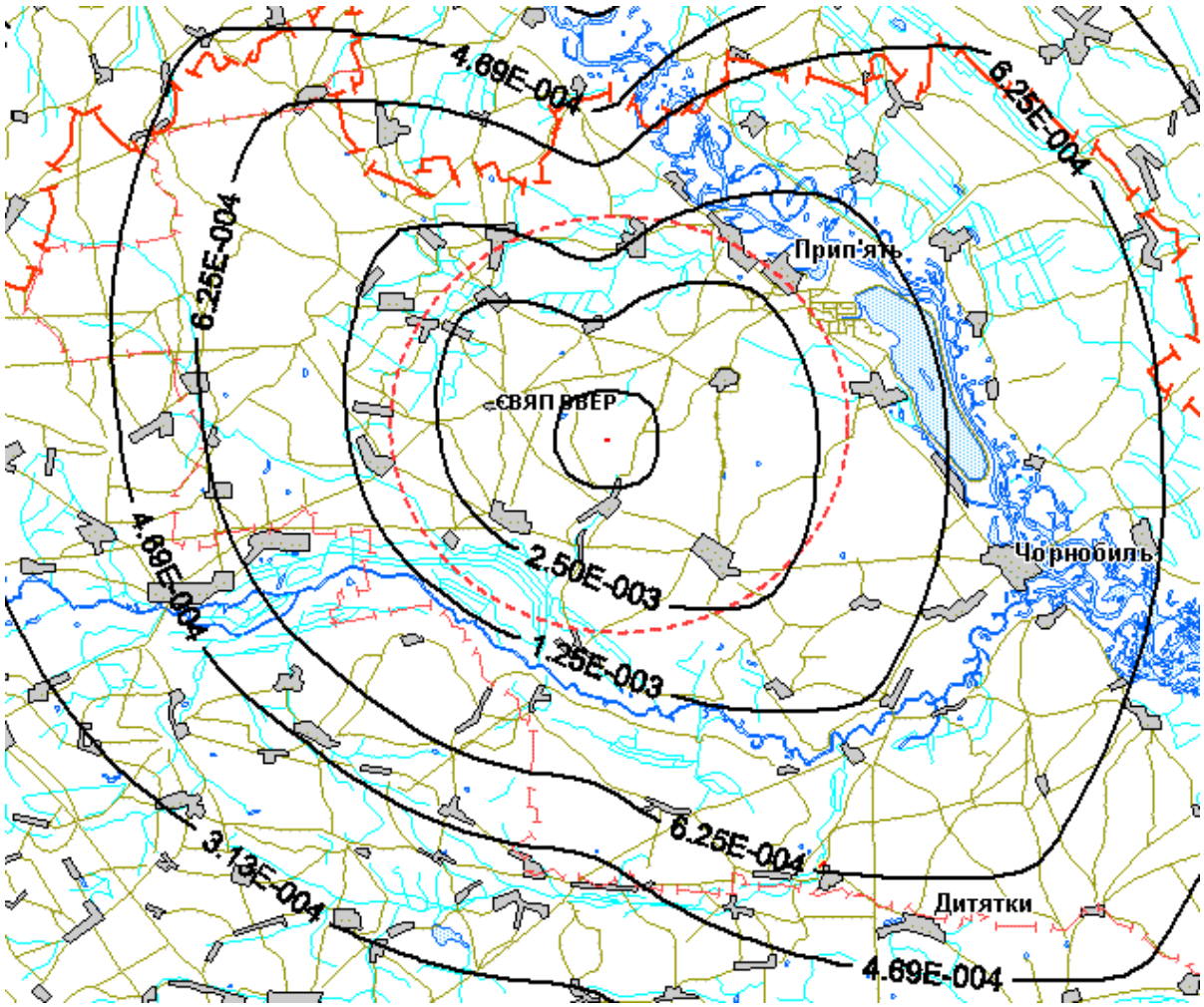

Figure 10.2.5 - Individual effective exposure dose for the population (mkSv/year) due to all ways of impact of emission ^{60}Co during CSFSF normal operation taking into account the average annual indexes of current weather conditions. Calculation is given for the date: 30 years after the beginning of CSFSF operation. Fat red dotted line indicates the boundary of Byelorussia

10.3 Impact during the MDBA

Engineering decisions on technology of spent nuclear fuel storage are developed in such a manner that excludes possible occurrence of significant design basis accidents in the CSFSF. Therefore, the most representative design accident (MDBA) is represented by possible loading of an individual HI-STORM multi-purpose canister having surface radioactive contamination exceeding the specified permissible limits.

It is assumed that following storage of such a container, its surface contamination releases as radioactive aerosols to the environment for 1 year. It is conservatively assumed that surface contamination of the container with spent nuclear fuel is represented by the most dangerous radionuclide, ^{60}Co.

For calculations, 2 options of input data were used.

The 1-st option (annual emission from the module of storage):

- Total annual emission of ^{60}Co from the emergency module of storage - $2{,}67 \cdot 10^{9}$ Bq;
- Height of point of emission – 6 m (height of HI-STORM);
- Category of atmospheric stability - D (by Pascwill);

- Direction of wind – permanent, average speed – 2,1 km/s.;
- Inhalation dose factor ^{60}Co - $1{,}02 \cdot 10^{-8}$ Sv/Bq.

The 2-nd option (instant emission from pipe of reception building):

- Emission of ^{60}Co - $2{,}67 \cdot 10^{9}$ Bq;
- Height of point of emission – 21 m (pipe of reception building);
- Category of atmospheric stability - F (by Pascwill);
- Direction of wind – permanent, average speed – 1 km/s.;
- Inhalation dose factor ^{60}Co - $1{,}02 \cdot 10^{-8}$ Sv/Bq.

10.3.1 Air Pollution

Calculations show that the volumetric concentration of ^{60}Co due to possible MDBA at the distances of 13 and 31 km from the storage facility will not exceed, respectively – $1{,}5 \cdot 10^{-6}$ and $3 \cdot 10^{-7}$ Bq/m^3 (fig. 10.3.1).

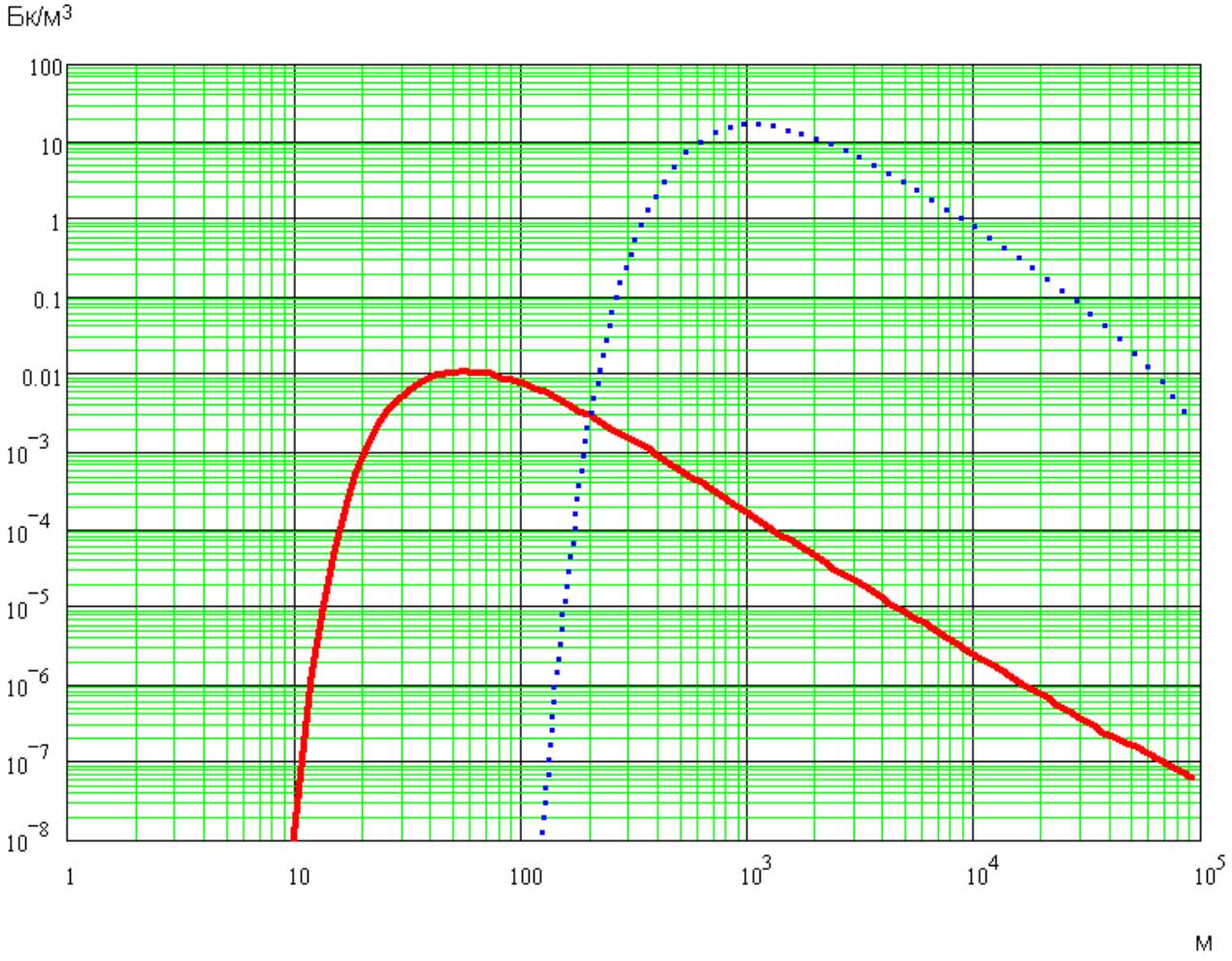

Figure 10.3.1 - Dependence of volumetric activity of ^{60}Co (Bq/m^3) in the air at distance (m) to the CSFSF in case of MDBA. Red continuous line indicates emission from HI-STORM for 1 year, dark blue (dot) line represents the volumetric activity averaged over 5 hours at instant emission from the reception building.

Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

According to Attachment 3 of the state normative document GN 2..6.1.8-127-2000 [29] valid in Byelorussia, permissible average annual volumetric activity of ^{60}Co for the population does not exceed 11 Bq/m^3. Accordingly, volumetric concentration of ^{60}Co in the air on territory of Byelorussia for a possible MDBA in the CSFSF is approximately 15 - 10^5 times less the permissible limit.

10.3.2 Contamination of Surface of Topsoil

Calculations show that additional surface topsoil contamination by ^{60}Co due to deposition of radioactive aerosols in case of MDBA, at the distances of 13 and 31 km will not exceed, respectively – 68 and 10 Bq/m^2 (fig. 10.3.2)..

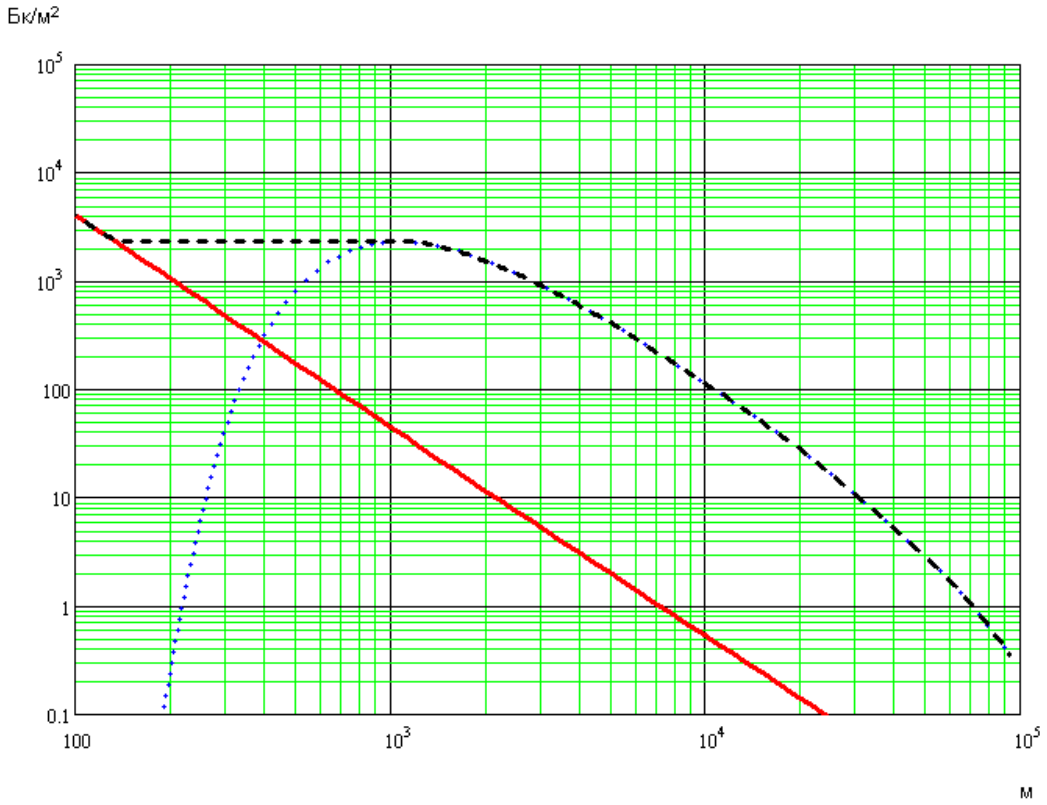

Figure 10.3.2 - Dependence of density of contamination of soil surface by ^{60}Co (Bq/m^3) at distance (m) to the CSFSF in case of MDBA. Red continuous line shows emission from HI-STORM for 1 year, dark blue (dot) line indicates instant emission from reception building, black (dotted) line indicates the maximum values for all distances from point of emission.

Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

10.3.3 Additional Exposure of the Population

For a possible MDBA, additional exposure of people due to inhalation of ^{60}Co, at the distances of 13 and 31 km from the storage facility will not exceed, respectively – $3{,}6 \cdot 10^{-5}$ and $5{,}3 \cdot 10^{-6}$ mSv (fig. 10.3.3).

According to Attachment 1 of the state normative document GN 2..6.1.8-127-2000 [29] valid in Byelorussia, the limit of annual radiation dose for the population is equal to 1 mSv. Accordingly, the value of additional individual effective dose of exposure in case of a MDBA in the CSFSF is approximately $2{,}8 \cdot 10^4$ times less than the permissible limit for the population of Byelorussia.

Considering the calculation of individual effective radiation dose from all ways of radiation impact due to a MDBA is unreasonable. Due to the fact that for such calculations intake of ^{60}Co through the food chain shall be considered, the impact should be considered during the long period of time after the accident. Taking into account the fact that insignificant quantity of fallout of ^{60}Co and it's relatively short half-life period (5,27 years), such calculations will be non-informative.

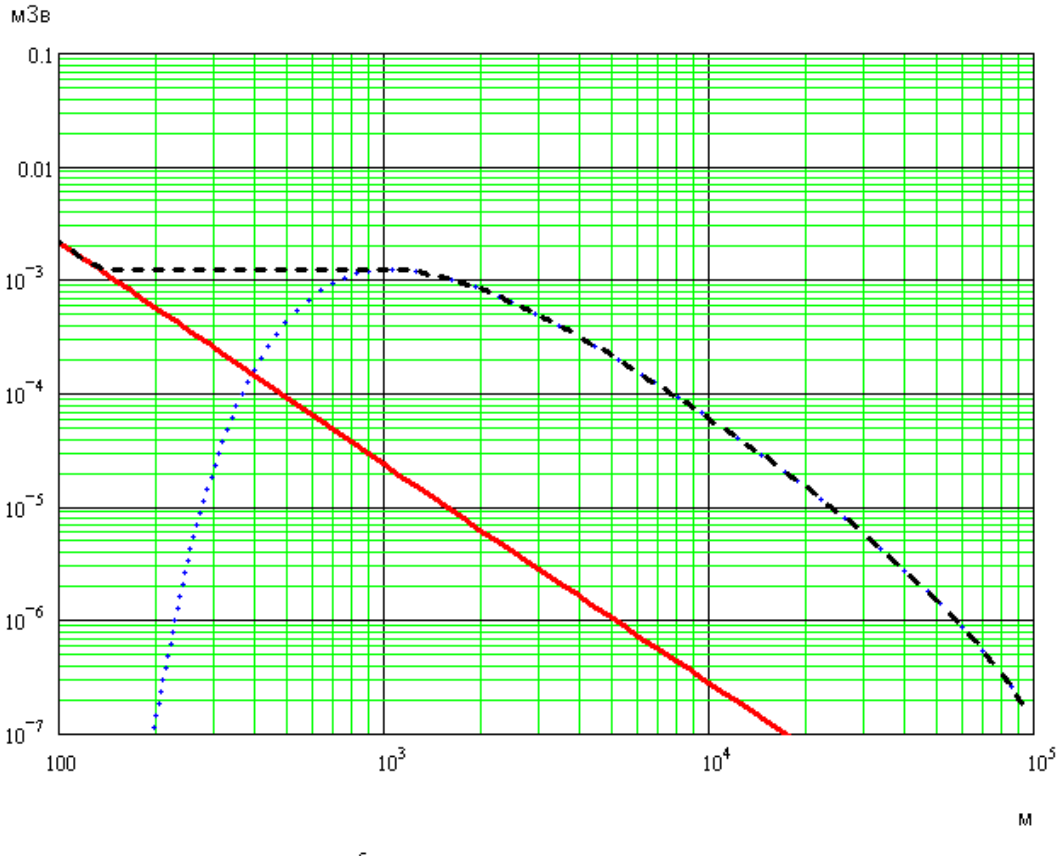

Figure 10.3.3 – Dependence of effective dose (mSv, due to inhalation of ^{60}Co) at distance (m) to the CSFSF in case of a MDBA. Red continuous line represents emission from HI-STORM for 1 year, dark blue (dot) line shows instant emission from the reception building, black (dotted) line indicates the maximum values for all distances.

Legend: X-coordinate – m; Y-coordinate – mSv.

10.4 Impacts during the BDBA

The accident related to 100% depressurization of all fuel rods in a MPC-31 containing 31 spent WWER-1000 fuel assemblies and leakage of radioactive substances due to failure of a weld (barrier of air-tightness) of the multi-purpose container is considered as the beyond design basis (hypothetical) accident with the maximum consequences. It is impossible to determine any actual initial events whose direct consequences would entail simultaneous damage of a multi-purpose container and all fuel assemblies inside. Unique type of impacts on the HI-STORM storage module which can result in simultaneous damage of the multi-purpose container and all fuel assemblies is a significant external dynamic impact (for example, as a result of application of special ammunition, etc.). The given accident is considered for the purpose of demonstration of the relatively insignificant radiation consequences of accidents in the CSFSF (even taking into account hypothetical accidents). The probability of such event is less than $10^{-6} \cdot year^{-1}$.

For calculations the following input data have been used:

- Height of emission point– 0 m;
- Duration of emission – 720 hours (30 day);
- Category of atmospheric stability - F (by Pascwill);
- Direction of wind – permanent, average speed – 1 km/s;
- Total emission of activity – $1{,}8 \cdot 10^{10}$ Bq.

10.4.1 Air Pollution

The total volumetric concentration of radionuclides in the air due to the Beyond-Design-Basis Accident (within 30 days) at the distances of 13 and 31 km from the storage facility will not exceed, respectively – 0,06 and 0,02 Bq/m^3 (fig. 10.3.4). Volumetric activity of separate, most significant nuclides in the radiological relation is represented in figures 10.3.5 - 10.3.7.

As one can see from the data of table 10.4.1, volumetric concentration of various radionuclides in surface air is 1930 - 45000 times less than the admissible limit of their average annual volumetric activity for the population of Byelorussia (ADA_{pop}), specified in the document NRB- 2000 [29].

Table 10.4.1 - Assessment of radiation impact on the air of Byelorussia territory due to a beyond design basis (hypothetical) accident in the CSFSF

Radionuclide	Allowable average annual volumetric activity (ADA_{po})*, Bq/m^3	Design volumetric activity of air for the period of 30 days from the moment of accident, Bq/m^3	
		Nearest boundary of Byelorussia (distance – 13 km)	Nearest settlement on territory Byelorussia (distance – 31 km)
^{137}Cs	27	$6{,}0\cdot10^{-4}$	$2{,}0\cdot10^{-4}$
^{90}Sr	2,7	$4{,}0\cdot10^{-4}$	$1{,}3\cdot10^{-4}$
TUE **	$2{,}7\cdot10^{-3}$	$1{,}4\cdot10^{-6}$	$6{,}0\cdot10^{-7}$
Sum of radionuclides	not regulated	0,06	0,02

Notes: * - according to Attachment 3 of normative document GN 2.6.1.8-127-2000 "Codes of radiation safety " (NRB - 2000) [29], valid in Byelorussia;
** - conservatively it is assumed that all emission of TUE is represented by the most dangerous radionuclide, ^{238}Pu.

Therefore, taking into account the small probability of the accident, radiation impact on the air on Republic the Byelorussia territory due to a BDBA in the CSFSF is considered as acceptable.

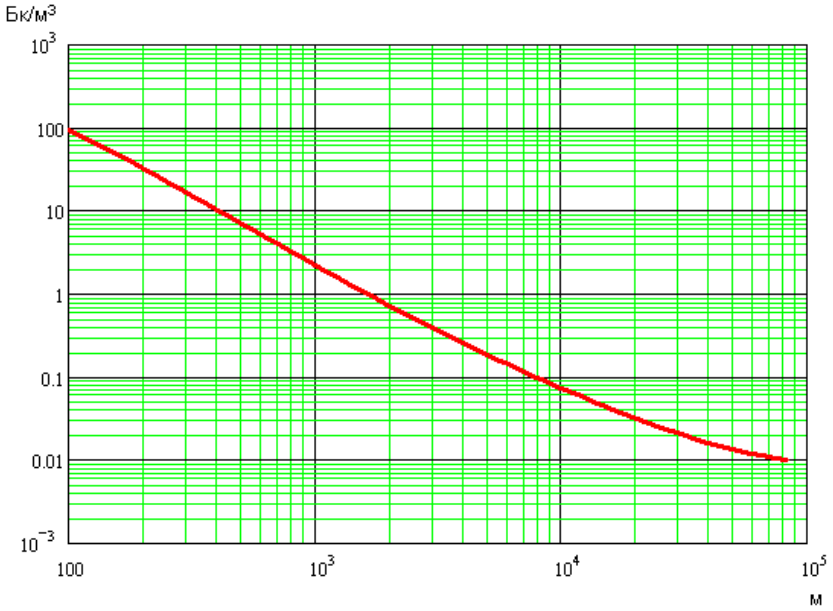

Figure 10.3.4 - Dependence of volumetric total activity of radionuclides in the air (Bq/m^3), generated due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF
Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

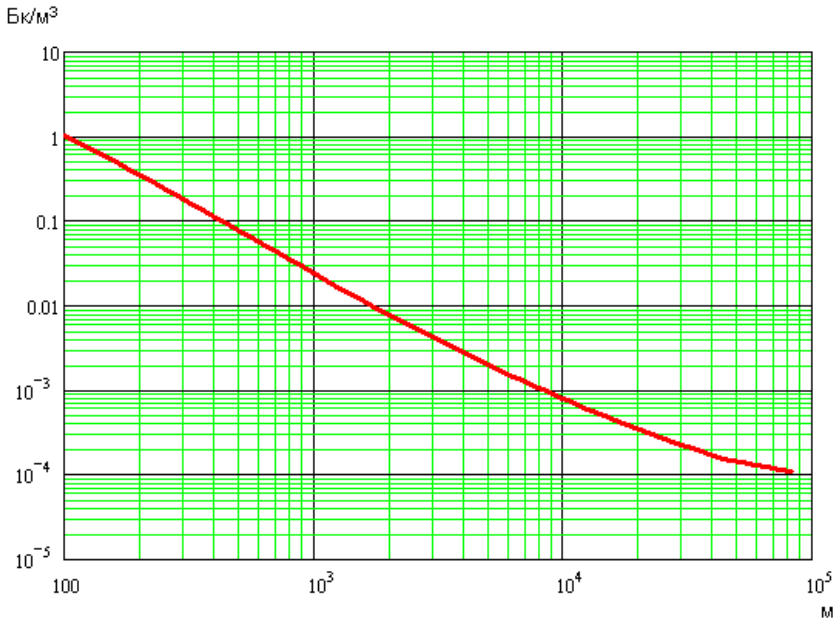

Figure 10.3.5 - Dependence of volumetric activity ^{137}Cs in the air (Bq/m^3), generated due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

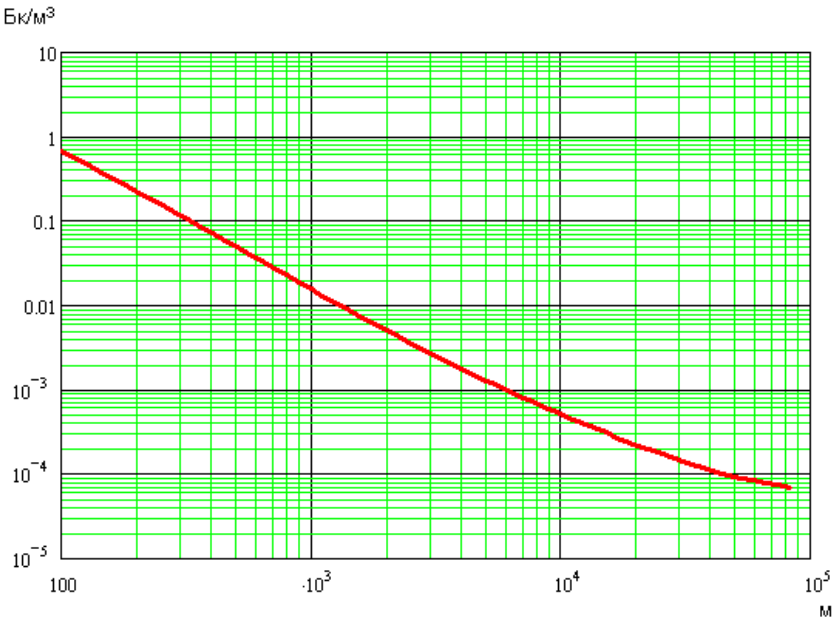

Figure 10.3.6 - Dependence of volumetric activity ^{90}Sr in the air (Bq/m^3), generated due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

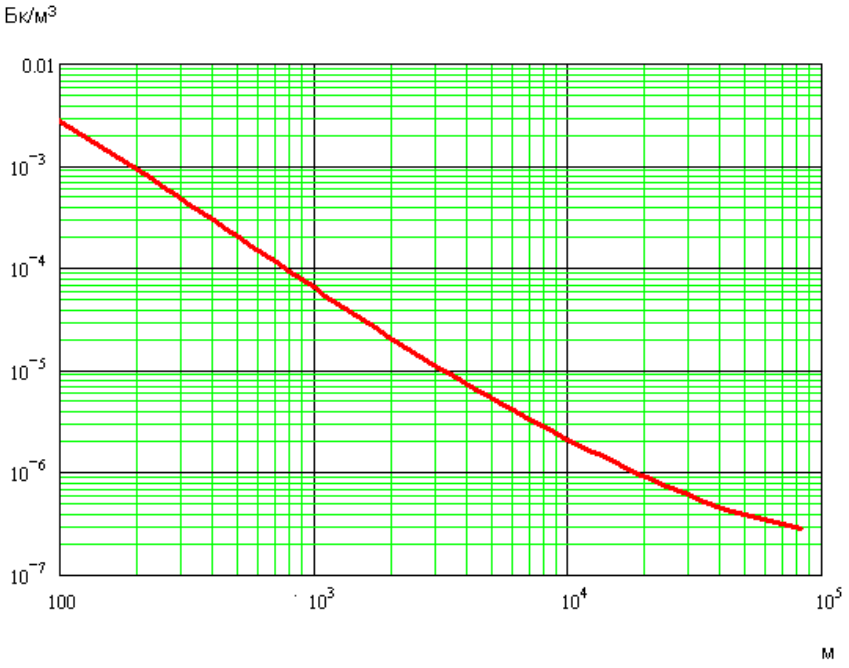

Figure 10.3.7 - Dependence of volumetric activity of transuranium elements in the air (Bq/m^3), generated due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^3.

10.4.1.1 Contamination of topsoil surface

In case of a BDBA the radioactive emission will be represented by a gas-aerosol mix of radionuclides. From them ^{137}Cs, ^{90}Sr and transuranium elements (TUE) have the greatest radiological value fortopsoil contamination.

Calculations show that on the nearest boundary with Byelorussia (distance 13 km from the CSFSF), the density of additional topsoil contamination by ^{137}Cs will not exceed 12 Bq/m^2 (figure 10.3.8), ^{90}Sr - 8 Bq/m^2 (figure 10.3.9) and TUE - 0,03 Bq/m^2 (figure 10.3.10). Such additional contamination will be less than 0,1 % of the existing background contamination of this territory.

Therefore, at a distance of 31 km (nearest settlement), additional topsoil contamination will be smaller and will not exceed for ^{137}Cs - 7 Bq/m^2, for ^{90}Sr - 3 Bq/m^2 and for TUE - 0,015 Bq/m^2 which also will not result in essential changes of radiation conditions.

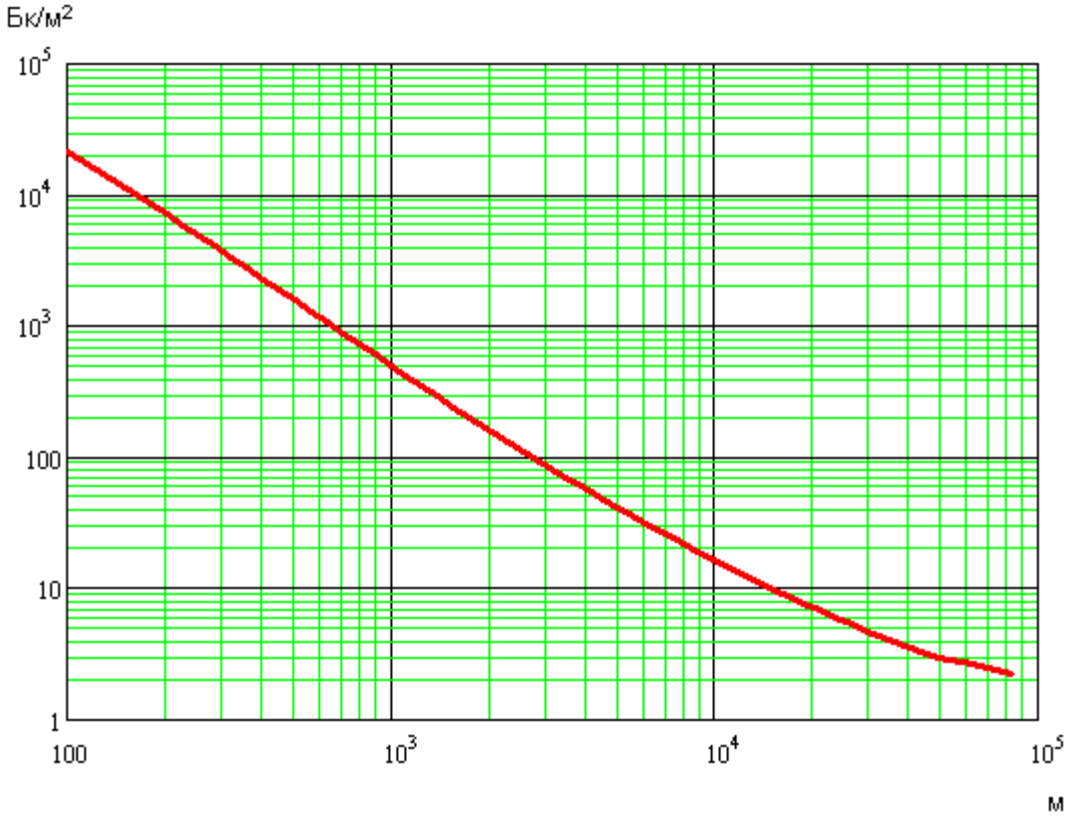

Figure 10.3.8 - Dependence of density of total surface contamination ^{137}Cs (Bq/m^2), due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

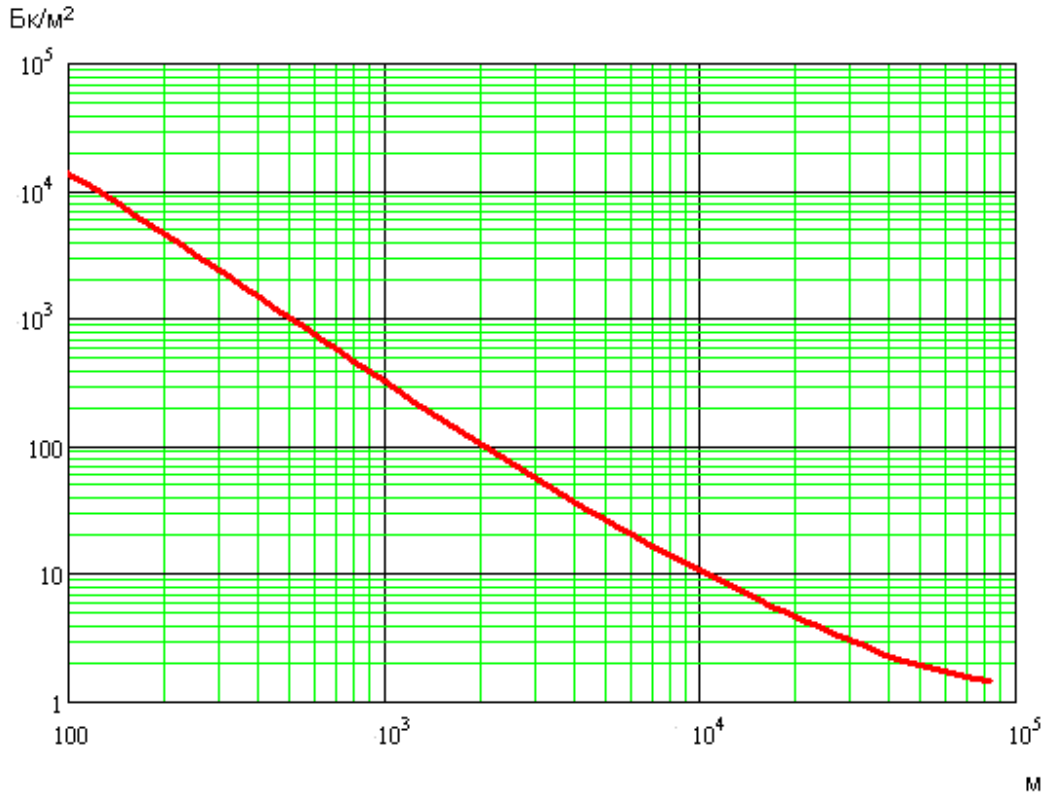

Figure 10.3.9 - Dependence of density of surface contamination 90Sr (Bq/m^2), due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

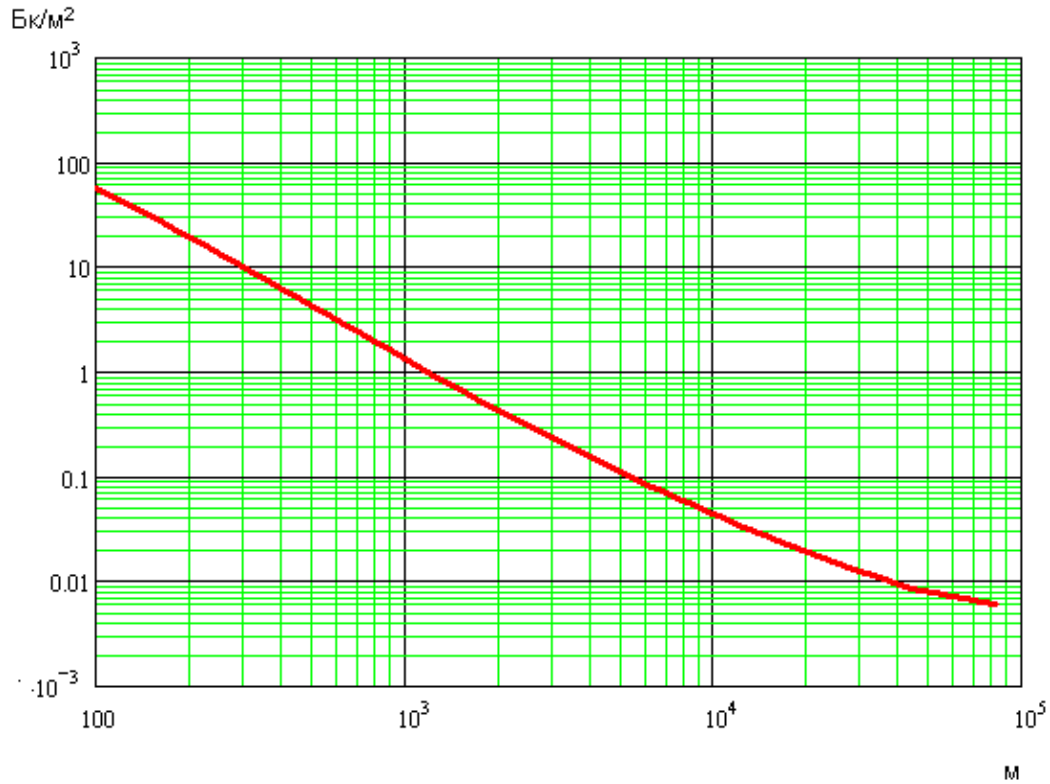

Figure 10.3.10 - Dependence of density of surface contamination by transuranium elements (Bq/m^2), due to a Beyond-Design-Basis Accident, at distance (m) to the CSFSF. Legend: X-coordinate – m; Y-coordinate – Bq/m^2.

Therefore, taking into account the low probability of the accident, it is necessary to consider acceptable the radiation impacts on topsoil of Byelorussia due to a Beyond-Design-Basis Accident in CSFSF,.

10.4.1.2 Additional exposure of the population

For the forecast of radiation impacts for the population it was conservatively assumed that radiation dose of the population in case of the BDBA in the CSFSF was generated for round-the-clock presence on open space during the entire emergency period (30 days).

Calculations show that individual effective exposure dose from inhalation of a mix of radionuclides (total for 30 days), at the distances of 13 and 31 km from the CSFSF will not exceed, respectively, $4{,}0 \cdot 10^{-4}$ and $1{,}5 \cdot 10^{-4}$ mSv (figure 10.3.11).

According to Attachment 1 of the state normative document GN 2..6.1.8-127-2000 [29] valid in Byelorussia, the limit of annual radiation dose of the population is equal to 1 mSv. Accordingly, the value of additional individual effective exposure dose (total for 30 days) in case of a BDBA in the CSFSF is 2500 times less than the permissible limit specified for the population of Byelorussia.

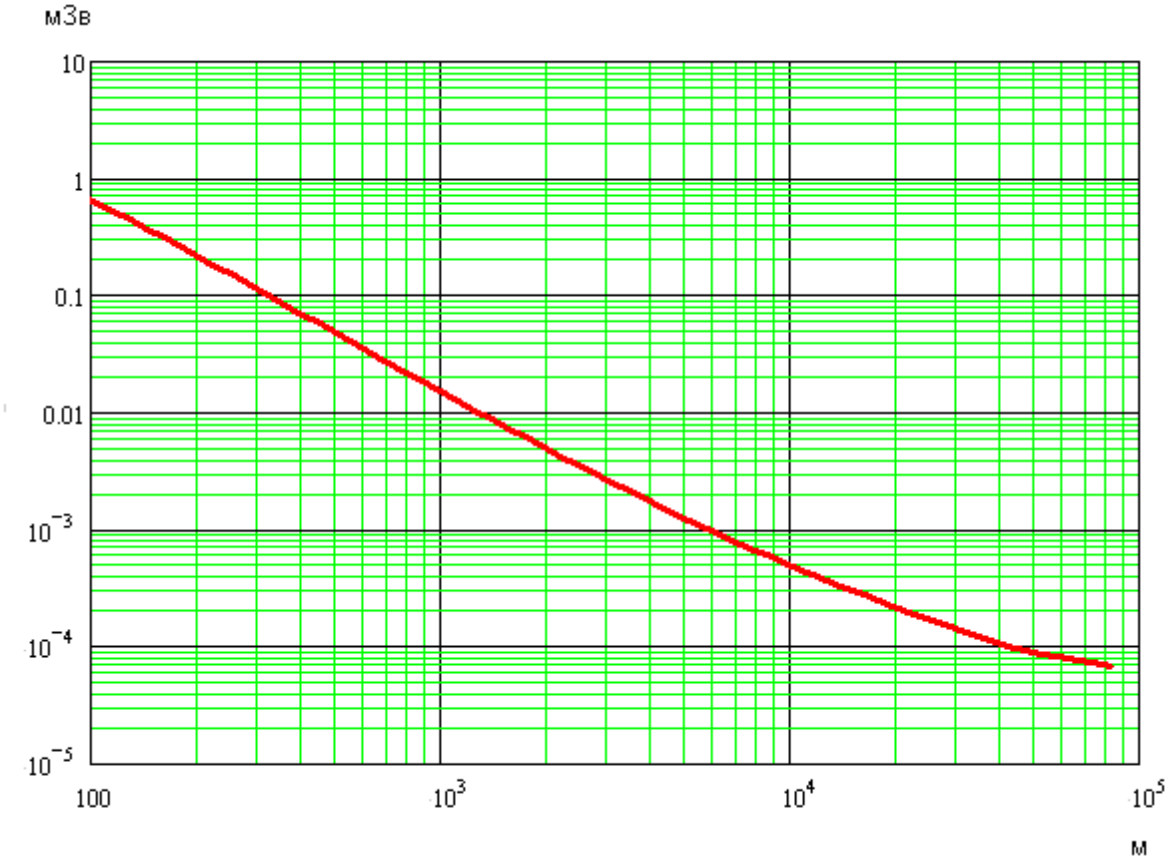

Figure 10.3.8 – Dependence of individual effective dose (mSv) at distance (m) to the CSFSF for a beyond design basis accident. Legend: X-coordinate – m; Y-coordinate – mSv.

Considering the calculation of individual effective radiation dose from all ways of radiation impact due to the BDBA is unreasonable. Due to the fact that for such calculations incoming radionuclides along the food chain are taken into account, the impact should be considered during the long period of time after the accident. Taking into account the low probability of occurrence of the BDBA in the CSFSF such data will be non-informative.

10.5 Conclusions on CSFSF Trans-border Impact

The analysis of design indexes of radiation impacts on components of the environment in boundary areas of Byelorussia during construction, normal operation and in case of accidents in the CSFSF shows:

1) Construction and normal operation of CSFSF **will not result in essential negative impacts** on content of the air, topsoil and health of the population on boundary territories of Byelorussia during the CSFSF life-time (100 years).
2) In case of a design accident with the maximum consequences during CSFSF operation, contamination of the air medium and topsoil, as well as additional exposure of the population on the boundary territories of Byelorussia **will be insignificant** due to significant distance of these territories from the storage facility;
3) In case of a Beyond Design Basis (hypothetical) Accident in the CSFSF, contamination of air medium and topsoil as well as additional exposure of the population on boundary territories of Byelorussia **will not result in essential changes of radiation conditions** which **is acceptable** taking into account the small probability of accident.

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Attachment A – Report on interdepartmental meeting

Refer to Vol.1, part 4.

Attachment B –Calculation procedure of impacts of radioactive emissions

The probability of emissions of gas-aerosol radioactive substances in the atmosphere under CSFSF construction and normal operation is high. Release of radioactive substances results in environmental contamination and increases the danger of exposure of the personnel working in immediate proximity to ISF and staying in the exclusion zone.

Transfer of gas-aerosol impurity are resulted by wind and atmospheric diffusion.

According to recommendations of IAEA and the World meteorological organization the Pascwill model of diffusion which is based on statistical (Gaussian) distribution of impurity in the atmosphere is selected as the model of diffusion.

The emissions are distinguished by duration of radioactive aerosols emission in the atmosphere:

- Short-term,
- Long-term.

By arrangement of emission source it is possible to distinguish:

- Emissions from high pipe,
- Emissions at level of building roofs.

Short-term emission

Emission can be defined as short-term in case when its duration is comparable to the time of movement of the released impurity to place of its fall-out with remaining the direction of wind.

Emissions from vent stack

Let us consider emission of gas-aerosol radioactive substances through the ISF vent stack. We shall assume that behavior of the radioactive substances through-out the vent stack are the same as for emission from high stask, i.e. the jet of emission will get in area of non indignant stream.

Let us enter a rectangular system of coordinates (x, y, z) with center in the basis of stack (emission sources). In the given system of coordinates the axis x coincides with direction of the accumulating wind stream, coordinates y and z – distances in horizontal and vertical directions up to the detecting point. It is assumed that at the moment of time t=0 in point with coordinates x=0, y=0, z=h there was an emission of radioactive aerosols Q_0 (Bq) with the capacity Q (Bq/SEC) in time $T_{release}$ (SEC). Thus $Q_0 = Q \cdot T_{release}$ at the moment of time t of volumetric concentration of radioactive impurity will be equal A_v (x, y, z, t). By integrating of value A_v on time and neglecting diffusion of impurity in direction of axes x, volumetric concentration radioactive impurity A_v (Bq/m^3) it is calculated by formula [1]

$$A_v(x,y,z) = \frac{QF(x)}{2\pi\sigma_y\sigma_z u(h)} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left\{\exp\left(-\frac{(z-h)^2}{2\sigma_z^2}\right)+\exp\left(-\frac{(z+h)^2}{2\sigma_z^2}\right)\right\}. \qquad \text{(B1)}$$

Here h – effective height of emission, (m);

$u(h)$ horizontal component of wind speed depending on effective height of emission, (km/s);

σ_y, σ_z - mean square deviation of distribution of impurity in cloud of emission due to turbulent diffusion in direction axes y and z, accordingly (m);

F (x) - function of exhaustion of radioactive cloud as a result of dry deposition, precipitation scavenging ("wet" deposition) and radioactive decay.

Effective height of emission calculated as follows [5]:

$$h = h_0 + \frac{6 \cdot w0 \cdot r}{u(h_0)}$$

where h_0 - geometrical height of vent stack, m;

w0 - speed of release of impurity from vent stack, m/s;

r - radius of vent stack, m.

Function of exhaustion of radioactive cloud as a result of dry deposition, precipitation scavenging ("wet" deposition) and radioactive decay:

$$F(x) = \exp\left[-\sqrt{\frac{2}{\pi}} \cdot \frac{v_g}{u(h)} \cdot \int_0^x \frac{1}{\sigma_z} \cdot \exp(-\frac{h}{2 \cdot \sigma^2 z}^2) dx \right];$$

where v_g - speed of dry deposition, m/s.

$$u(h) = u(2) \cdot (\frac{h}{2})^p ;$$

where *u (2)* - wind speed at height of 2 m;

p - factor from table B1.

Table B1 Exponential factor *p* for calculation of wind speed [5]

Standard conditions					
Category of atmospheric stability by Pascwil					
A	B	C	D	E	F
0,07	0,07	0,10	0,15	0,35	0,55
City conditions					
Category of atmospheric stability by Pascwil					
A	B	C	D	E	F
0,15	0,15	0,20	0,25	0,40	0,60

Factors of dispersion σ_y, σ_z are determined depending on weather conditions under Smith - Hoker formulas [1]:

$$\sigma_y(x) = c_3 \, x / (1+0.0001x)^{1/2} ; \quad \text{(B2)}$$

$$\sigma_z(x) = \begin{cases} f(z_0,x)g(x) & npu \quad f(z_0,x)g(x) \le \sigma_z^{\max}; \\ \sigma_z^{\max} & npu \quad f(z_0,x)g(x) > \sigma_z^{\max}, \end{cases} \quad \text{(B3)}$$

where c_3 – the factor dependent on category of atmospheric stability; $\sigma_z^{\max}$ – Limiting value of σ_z for the given category of atmospheric stability; z_0 – height of roughness of underlying surface (cm); x – distance from emission sources (m); functions g (x) and f (z_0, x) are calculated depending on categories of atmospheric stability under formulas [1]:

$$g(x) = a_1 x^{b_1} / \left(1 + a_2 x^{b_2}\right); \quad \text{(B4)}$$

$$f(z_0,x) = \begin{cases} \ln\left[c_1 x^{d_1}\left(1 + c_2 x^{d_2}\right)\right] & npu \; z_0 > 10см; \\ \ln\left[c_1 x^{d_1} / \left(1 + c_2 x^{d_2}\right)\right] & npu \; z_0 \le 10см. \end{cases} \quad \text{(B5)}$$

The factors necessary for calculations are given in tables B2-B4.

Table B2. Factors used for calculation of cross dispersion of jet σ_y and functions g (x) [1]

Category of atmospheric stability by Pascwill	$\sigma_z^{\max}$ **m**	c_3	a_1	B_1	a_2	B_2
A (extremely unstable)	1600	0,22	0,112	1,06	5,38(-4)	0,815
B (moderately unstable)	920	0,16	0,130	0,950	6,52(-4)	0,750
C (slightly unstable)	640	0,11	0,112	0,920	9,05(-4)	0,718
D (neutral)	400	0,08	0,098	0,889	1,35(-3)	0,688

Category of atmospheric stability by Pascwill	σ_z^{max} **m**	c_3	a_1	B_1	a_2	B_2
E (slightly steady)	220	0,06	0,0609	0,895	1,96(-3)	0,684
F (moderately steady)	100	0,04	0,0638	0,783	1,36(-3)	0,672

Table B3. Factors of function f (z_0, x), modifying σ_z for various height of roughness of z_0 [1]

Height of roughness z_0, cm	c_1	d_1	c_2	d_2
1	1,56	0,0480	6,25(-4)	0,45
4	2,02	0,0269	7,76(-4)	0,37
10	2,73	0	0	0
40	5,16	-0,098	5,38(-2)	0,225
100	7,37	-0,00957	2,33(-4)	0,6
400	11,7	-0,128	2,18(-5)	0,78

Table B4 Height of a roughness z_0 for various types of a microrelief of surface [1]

Micro relief	z_0, cm
Snow, lawn with height 1 cm	0,1
Cut and low grass up to 15 cm	0,6-2
High grass up to 60 cm	4-9
Non-uniform surface with alternating areas of grass, bushes, etc.	10-20
Park, forest with height up to 10 m	20-100
City constructions	100

As emission cloud moves there is fallout of radioactive aerosols on the surface of the ground and a surface source of external irradiation is formed. The density of fallout of radionuclides on topsoil A_s (Bq/m^2) after short-term emission Q_0 (Bq) determined by formula

$$A_{s0}(x, y) = Q_0 (G_0 v_g + G^z \Lambda) \quad \text{(B6)}$$

Here $Q_0 = Q^* T_{release}$;

G_0 (x, y, 0) – factor of meteorological dilutions (c/m^3) which is understood as relation of volumetric activity of radionuclide in the atmosphere to emission per a unit of time $G_0 = A_{v0} / Q_0$ at z = 0, where A_{v0} is calculated by formula (A1) in which value Q_0 (Bq) is substituted instead of Q (Bq/sec);

$$G^z(x, y) = \int_0^{H_z} G(x, y, z)\, dz \quad \text{(B7)}$$

, where H_z – height of the bottom boundary of cloud – source of precipitation (m);

v_g – speed of dry fallout (m/s).

Speed of dry fallout v_g is not a speed in the kinematic sense and is identified by the ratio:

$$V_g = \frac{\text{Fallout intensity, Bq/(m}^2 \cdot \text{sec)}}{\text{Concentration in air surface layer}} \quad ; \quad \text{(B8)}$$

Λ – Constant value of scavenging (1/sec), dependent on of type precipitation, spectrum of rain drops and intensity of precipitation.

The constant value of scavenging is calculated by formula [1]

$$\Lambda = k_r k_0 I , \qquad \text{(B9)}$$

where I – intensity of precipitation (mm / hour);

k_r = 10-5 hour/(mm*sec) – standard value of absolute scavenging ability of rain (for all nuclides, except for noble gases), intensity I typical for rain = 1 mm / hour;

k_0 – relative scavenging ability for various types of fallouts (ref. table B. 5)

Table B. 5 Relative scavenging ability for various types of fallouts [1]

Type of fallouts	K_0
Rain	1,0
Rain with thunder-storm	1,1
Snow with thunder-storm	2,4
Downpour	2,8
Snow	3,0
Drizzle	4,5
Fog	5,0

Emissions at level of roof of buildings

In case when an emission of radioactive aerosols by intensity Q (Bq/sec) per time $T_{release}$ (sec) at level of roof of buildings, aerosols will get in the area of aerodynamic shadow upon the leeward of building, mix in turbulent jet created by the air stream at flow of building, and quickly reach the surface of the ground. Thus in an area of steady air circulation the source of radioactive impurity in volume V (m^3) is formed:

$$V = C_R \cdot S_b \cdot u \cdot T_{release} , \qquad \text{(B10)}$$

with concentration A_v (Bq/m^3):

$$A_v = Q / (C_R S_b u). \qquad \text{(B11)}$$

Here u (m/s) – wind speed;

S_b (m^2) – the area of section of building which is perpendicular to direction of wind;

C_R – factor of building shape. During calculations it is accepted that C_R = 0,5 [2,3].

Long-term emission

Emission can be defined as long-term in case when time of emission exceeds time of movement of the released impurity from place og generation to the place of its falls-out or direction of wind is changed for this time.

For long emission Q (Bq/sec) the expression for definition of average (for the determined period of time t) volumetric concentration of radioactive impurity A_v (Bq/m^3) in direction of axis x is obtained based on formula (A1) taking into account distribution of wind speed in direction (wind rose) and value of return period of weather category by Pascwill, as well as in view of quantity of possible precipitation [1]:

$$A_v(x,z) = \frac{Q\eta_x}{(2\pi)^{3/2} x} \sum_i \frac{\omega_i F_i}{\sigma_{z,i}\bar{u}_i} \left\{ \exp\left[-\frac{(z-h)^2}{2\sigma_{z,i}^2} \right] + \exp\left[-\frac{(z+h)^2}{2\sigma_{z,i}^2} \right] \right\} . \qquad \text{(B12)}$$

Here The index i marks the values typical for i category of atmospheric stability by Pascwill;

ω_i - return period i weather category in time t;

η_x - elongation of wind rose in direction of axis x, determined by ratio $\eta_{x} = nx/n0$, where n_x – return period of direction of wind in direction of axes x at actual wind rose, n_0 –ditto, at equiprobable direction of wind.

Intensity of fallout of an impurity on surface of topsoil in time t - $\dot{A}_s \cdot t$ (Bq/(m^2)) in direction of axis x at continuous emission is determined by formula:

$$\dot{A}_s(x) \cdot t = \frac{Q\eta_x}{(2\pi)^{3/2} x}\left[2v_g \sum_i \frac{\omega_i F_i}{\sigma_{z,i}\bar{u}_i} \exp\left(-\frac{h^2}{2\sigma_{z,i}^2}\right) + \sqrt{2\pi}\,\Lambda \sum_i \frac{\omega_i F_i}{\bar{u}_i}\right], \quad \text{(B13)}$$

where Q (Bq) – emission per time t.

<u>Calculation of the individual radiation doses formed by radioactive emissions [1]</u>

Individual effective dose which will be taken by the person as a result of emission of radioactive aerosol impurity in the atmosphere consists of two components:

- effective dose of external irradiation;
- effective dose of internal exposure.

These doses are calculated for every specific radionuclide and then summarized.

Equivalent dose rate of external irradiation $\dot{H}_v$ (Sv/sec) due to one nuclide per person who is staying on the ground surface ($z = 0$) caused by cloud of radioactive aerosols which was generated as a result of short-term emission, determined by formula [1]:

$$\dot{H}_v = A_v \, \widetilde{B}_{a\gamma}. \quad \text{(B14)}$$

Here A_v (Bq/m^3) – volumetric activity of radionuclide;

$\widetilde{B}_{a\gamma}$ – transitive dosimetric multiplier (Sv·m^3/(sec·Bq)) which is characterizing equivalent dose rate created by cloud of radioactive aerosols of unit concentration on the open ground surface. This multiplier substantially depends on the shape of a cloud.

At the further calculations the mixed model was used, according to which

$$\widetilde{B}_{a\gamma}(x) = k^2 B_{a\gamma} + [1 - k^2] \, B^{\pi}_{a\gamma}(x). \quad \text{(B15)}$$

Here $B_{a\gamma}$ – transitive multiplier received at modeling of the form of emission by semi-infinite space:

$$B_{a\gamma} = 6{,}810^{-14} E, \quad \text{(B16)}$$

where E (Mev/spread) – full energy of photons on decay;

$B^{\pi}_{a\gamma}$ – transitive multiplier received at modeling of the form of emission by linear extended source of radius R (m) taking place at height h (m) above the flat topsoil surface.

Transitive multiplier $B^{\pi}_{a\gamma}$ is identified by ratio:

$$B^{\pi}_{a\gamma}(x) = r\,\Gamma_\delta R^2 \,[F(\theta,\mu h) + F(\pi/2,\mu h)] / h, \quad \text{(B17)}$$

where r = 1,09 ± 0,002 (Sv/Gr) – transitive multiplier from absorbed dose in the air to the absorbed dose in biological fabric;

Γ_δ (Gr m^2 / (sec Bq)) –kerma - constant of a nuclide;

$F(\theta,\mu h)$ – Sivert function;

μ (1/m) – linear attenuation factor of photons in the air;

$\theta = arctg$ (x/h).

Factor k, characterizing effect of raised jet, looks like

$$k(x) = exp[-h^2 / 2\sigma^2(x)], \quad \sigma^2(x) = \sigma_y^2(x) + \sigma_z^2(x). \quad \text{(B18)}$$

Equivalent dose rate of external irradiation $\dot{H}_v$ (Sv/sec) for case of continuous emission is under the above-stated formulas, which accept k (x) ≡ 1.

Expected equivalent dose H_s^c (Sv) to whole body from photon radiation for surface topsoil contamination Q_0 (Bq) generated as a result of short-term emission is identified as follows:

$$H_s^c = A_{s0}\, B_{s\gamma}^c . \qquad \text{(B19)}$$

Here A_{s0} (Bq/m^2) – surface contamination from short-term emission;

$B_{s\gamma}^c$ (Sv m^2 / Bq) – expected dose from surface topsoil contamination for initial surface activity A_{s0} = 1 Bq/m^2.

Expected dose from surface topsoil contamination $B_{s\gamma}^c$ is identified by ratio

$$B_{s\gamma}^c = B_{S\gamma}\, t , \qquad \text{(B20)}$$

where $B_{S\gamma}$ (Sv m^2 / sec Bq) – transitive the dosimetric multiplier characterizing dose rate in the air at height 1m from the polluting surface;

t (c) – time of exposure.

Expected equivalent annual dose $\dot{H}_s$ (Sv / year) from surface contamination as a result of continuous emission of intensity Q (Bq/year) is calculated by formula:

$$\dot{H}_s = \dot{A}_s\, B_{s\gamma}^c , \qquad \text{(B21)}$$

where $\dot{A}_s$ (Bq/m^2 year) – intensity of surface contamination.

Calculation of dose from external β-radiation of a cloud of radioactive emission is made by immersing method, simulating source in the shape of semi-infinite space. In this case the equivalent dose rate $\dot{H}_\beta$ (Зв/с) looks like:

$$\dot{H}_\beta = A_v\, B_{a\beta} , \qquad \text{(B22)}$$

where A_v (Bq/m^3) – volumetric activity of radionuclide;

$b_{a\beta}$ (Sv m^3 / (sec Bq)) – dose factor in basal layer of the skin, created by β-radiation.

Effective dose H_{int} (Sv) caused by inhalation intake of radioactive aerosol is calculated by formula:

$$H_{int} = V\, k_u\, k_{сиз}\, T\, e_\tau\, A_v , \qquad \text{(B23)}$$

where V (m^3 / hour) – breathing rate;

k_u – the factor which is taking into account intensity of work;

$k_{сиз}$ – the factor which is taking into account intensity of work;

T (hour) – time of stay in a cloud of an aerosol;

e_τ (Sv/Bq) – dose on unit of intake of activity in the inhalation way (ref. table B. 5);

A_v (Bq/m3) – volumetric activity.

Dose factors and other input data which have been used at calculations are given in [1].

Data given in table A. 6 makes possible to estimate category of atmospheric stability by Pascwill for carrying out of conservative assessments of relocation of activity in the atmosphere and its dispersion. Average annual wind speed at the SO site makes 3,3m/s. Therefore, the category of stability in the afternoon will be B or C (depending on insolation), and at night – D or E (depending on cloudiness).

Table B. 7 Interconnection of category of atmospheric stability by Pascwill with average wind speed in the air ground layer [1]

Wind speed at height 10m, m/s	Afternoon, insulation			Night	
	strong	moderate	weak	Thin continuous clouds or 4/8 cloudy covers at least	3/8 cloudy covers at least
less 2	A	A-B	B	F	F
from 2 to 3	A-B	B	C	E	F
from 3 to 5	B	B-C	C	D	E
from 5 to 6	C	C-D	D	D	D
more 6	C	D	D	D	D

The radioactive emissions can be both short-term and long-term under emergency conditions. The represented calculation procedure for radioactive emissions under normal conditions of works can be also used for calculation of radioactive emissions for accidents taking into account that emissions will be much more intensive in the latter case.

Calculation of dose from intake through food chains

According to [1], the individual average capacity of annual dose caused by intake of radioactive substances in human organism with food stuffs is determined as follows:

$$\dot{H} = \dot{A}_s \cdot K_{FD}, \tag{B24}$$

where $\dot{H}$ – individual average capacity of annual dose, Sv/sec,

$\dot{A}_s$ – intensity of contamination, Bq / (m^2·sec),

$$K_{FD} = K_{FI} \cdot B_{ig}, \tag{B25}$$

where K_{FI} –factor connecting level of fallout with intake of radionuclide in organism, m^2;

B_{ig} –factor connecting activity incoming with food with effective dose (depends on age) [6], Sv/Bq.

Calculation of permissible release

For calculation of permissible release the PRC-1 code was developed which makes it possible to calculate PR taking into account all described ways of dose generation from emissions. Possibilities of the code make it possible to work with all input data, change them in MS Excel, as well as output any required information in graphic or tabulated type.

For the greater presentation and simplification of work with the code, it is made as follows. In the beginning the impact of individual emission on the population is calculated on the basis of the above mentioned formulas, then by iterations with indicated accuracy the selection of emission is made with for achievement required NRBU - 97 quotas of dose (40 mkSv).

Input data, used in calculations

The given section contains input data which were accepted during calculations of emissions of radioactive substances in the atmosphere which can occur during construction and CSFSF operation, as well as a result of occurrence of emergencies.

Civil work

For assessment of ground concentration of radioactive substances in the air, as well as expected additional surface contamination the following input data were used:

- density of volumetric contamination of soil: ^{137}Cs - 2,67·10^4 Bq/kg, ^{90}Sr - 5,33·10^3 Bq/kg, 238-240Pu - 280 Bq/kg, ^{241}Am - 36 Bq/kg (received by recalculation from activity $^{238-240}$Pu taking into account radionuclide content of fuel of destroyed 4-th power unit at the moment of accident in 1986; bulldozer properties: speed of movement - 1 m/s, width of a bucket - 2 m; meteorological conditions:
  - 1) category of atmospheric stability by Pascwill - D, wind speed - 3,3 km/s (95 % of time);
  - 2) category of atmospheric stability by Pascwill - F, wind speed - 1 km/s (5 % of time);
  - speed of sedimentation of aerosols - 0,8 cm/sec, precipitations are unavailable, thickness of topsoil layer contaminated with radionuclides - 10 cm.
  - topsoil: it was conservatively assumed that the topsoil is represented by sand, humidity of material is not taken into account. Bulk emission of dust at loading, unloading and storing of sand is calculated by formula:

$$M_c = \beta \cdot \Pi \cdot Q \cdot K_{1w} \cdot K_{2w} \cdot 10^{-2}$$

where β - factor which is taking into account loss of material as dust, fractions of unit [β of sand = 0.05]

Π - loss of material, % (at unloading 0.4 %, at loading 0.4 %, at storing 0.5 %)

Q - weight of construction material, t/year

K1w - factor which takes into account humidity of material

K2w - factor which takes into account conditions of storage

CSFSF normal operation

During CSFSF normal operation emission of radioactive aerosols in the environment due to contaminations of external surface of MPC is possible.

During loading of MPC with SFA (in pre-design fuel pool on NPP) various measures are envisaged for decrease of radioactive contamination of its external surface which occurs due to ingresses and evaporation of water solution from the fuel pool. According to input data, the maximum permissible residual radioactive contamination of external surface of the MPC which is ready for sending for storage will not be more than 10^{-4} mcCi / cm^2 for β emitters and 10^{-5} mcCi / cm^2 for ά emitters [7].

Taking into account such a fact that release of activity directly from the container is impossible under normal operation conditions of the storage facility, , emission of radioactive substances in the environment is expected only during dust release from the contaminated external surface of MPC.

The dust release is possible in two cases: at the moment of overloading the MPC from HI-STAR to HI-STORM in the reception building of the storage facility and, directly, during storage. In the first case, generated radioactive aerosols enter to the active ventilating system of the CSFSF reception building and released to the environment through the vent stack. In the second case, aerosols enter to the passive ventilating system of HI-STORM, installed on the storage area and can dissipate in the atmosphere outside the limits of the storage facility territory.

For the analysis of radiation impacts of emissions from the vent stack and from HI-STORM, and for final assessment of impacts under normal operation, the worst values were conservatively selected from the received results.

Emission of radioactive aerosols from reception building. Applying the conservative approach for calculations it was accepted that the surface of MPC arriving for storage at CSFSF has the maximum permissible contamination which completely passes into the environment. Taking into account the greatest possible quantity of spent nuclear fuel annually incoming in the storage facility –

12 MPC-31 and 3 MPC-85 [8], during the active operation period (filling) of CSFSF, emission of radioactive aerosols in the environment will not exceed 16,1 MBq a year or 44 kBq a day.

The radionuclide content of surface contamination of MPC with the greatest probability will be represented by corrosion products of structural elements of spent fuel assemblies - ^{51}Cr, ^{54}Mn, ^{55,59}Fe, ^{58,60}Co and ^{65}Zn available in water solution of a near-reactor fuel pool. For calculation of individual effective equivalent radiation dose from emissions at CSFSF normal operation, it was conservatively supposed that the radionuclide content of surface contamination of MPC is represented exclusively with ^{60}Co which has the greatest dose factor and half-life period (5,27 years).

For calculation of radiation impacts of the CSFSF on the environment for normal operation, the following input data were used:

- quantity of railroad platforms with HI-STAR accepted in the course of a year – 15 pcs;
- total surface contamination of all railroad platforms by ^{137}Cs after their travel to the EZ and OEA territory is conservatively 190 Bq;
- maximum permissible surface contamination by ^{60}Co of MPC-31 - 1,13 MBq;
- maximum permissible surface contamination by ^{60}Co of MPC - 85 - 0,86 MBq;
- dose factor of radionuclide ^{60}Co – $1{,}02 \cdot 10^{-8}$ Sv/Bq;
- height of point of emission (vent stack of reception building) - 21 m;
- speed of emission – 6,95 m^3/sec;
- category of atmospheric stability (by Pascwill) – D;
- wind speed – 2,1 km/s;
- duration of emission – 1 year.

Emission of radioactive aerosols during storage of spent nuclear fuel. Emission of radioactive substances from HI-STORM is possible due to contamination of the external surface of MPC that results in generation and release of radioactive aerosols in the environment.

For calculations of radiation impacts for CSFSF normal operation it was conservatively assumed that the multi-purpose container incoming for storage has the maximum permissible level of contamination of external surface. Also it is accepted that after installation of HI-STORM to the storage area, all surface contamination of the multi-purpose container releases into the environment over one year.

For calculation of radiation impacts on the environment for storage of spent nuclear fuel in HI-STORM, the following input data were used:

- maximum permissible surface contamination by ^{60}Co of MPC-31 - 1,13 MBq;
- maximum permissible surface contamination by ^{60}Co of MPC - 85 - 0,86 MBq;
- quantity of HI-STORM 100 with MPC-31, installed in the course of the year – 12 pieces;
- quantity of HI-STORM 100 with MPC-85, installed in the course of the year – 3 pieces;
- height of emission point (height of HI-STORM 100) - 6 m;
- atmospheric stability – category D (by Pascwill);
- wind of permanent direction, average speed – 2,1 km/s;
- dose factor of radionuclide ^{60}Co – $1{,}02 \cdot 10^{-8}$ Sv/Bq;
- duration of emission – 1 year.

Accident during construction (local forest fire)

The speed of fire propagation is 1 m/min., direction of wind in the direction ChNPP and the point of occurrence of a fire - on a trace axis. In 4 hours the forest will burn out a total area of about 72 thousand m^2, total activity of emission will be about $5.4 \cdot 10^{10}$ Bq of ^{137}Cs, $2.9 \cdot 10^{10}$ Bq of ^{90}Sr and $5.8 \cdot 10^{8}$ Bq of α - active TUE. The time t is time when full combustion of the forest underlayer in

condition of dynamic balance about 1000, the area of intensive burning - about 5 thousand m^2, speed of emission - about $3.8 \cdot 10^6$ Bq/sec of ^{137}Cs, $2.0 \cdot 10^6$ Bq/sec of 90^{Sr} and $4.0 \cdot 10^4$ Bq/sec of α-active TUE.

Maximum Design Basis Accident

Emergency emission from vent stack of the reception building. Such emergency emission is possible at the moment of opening of HI-STAR and withdrawing of MPC from it. Thus radioactive aerosols get into the active ventilating system of the reception building of the storage facility and are released through the vent stack into the environment. For calculations the following input data were used:

- height of emission - 21 m (vent stack in reception building);
- atmospheric stability - the worst, category F (by Pascwill);
- direction of wind is permanent, average speed - 1 km/s;
- dose factor ^{60}Co - $3{,}1 \cdot 10^{-8}$ Sv/Bq [12];
- character of emission duration – short-term.

Emergency emission from a HI-STORM storage module at the storage area. Such emergency emission is possible from a single HI-STORM during loading of MPC with surface contamination which exceeds the maximum permissible value. Radioactive aerosols generated inside HI-STORM, due to thermosiphon effect, leave through the passive ventilation system into the environment. It was conservatively considered that all activity from surface contamination of the multi-purpose container in regular intervals is released from the HI-STORM over 1 year.

Foe calculations the following input data were used:

- emission source – dot, height - 0 m;
- atmospheric stability – worst, category D (by Pascwill);
- direction of wind is permanent, average speed - 2,1 km/s;
- dose factor ^{60}Co - $3.1 \cdot 10^{-8}$ Sv/Bq [12];
- time of emission - 1 year.

Beyond DesignBbasis Accident

As the Beyond Design Basis Accident (BDBA) is considered an accident by analogy with [10]. For licensing the technology of HI-STORM storage in the USA according to NUREG/CR-6487 [11], the emission of radionuclides from depressurized MPC is considered. For assessment of consequences of the accident, spent nuclear fuel of USA PWR reactors with the maximum burn-up of 70,000 MW-day/kgU, stored in a fuel pool for 5 years and having initial enrichment 4,8 % of 235U. The radionuclides content is given in table B8. Within the framework of considerations of accident influence, the increase of pressure inside of the MPC due to decay heat generated by spent nuclear fuel stored in the MPC on value of leakage MPC was assessed according to the requirements of ASME section III, subsection NB, taking into account performance of welds according to the regulations.

For assessment of accident an increase of internal pressure in the MPC up to 1,4 MPa, the leakage from the MPC related to such pressure was considered. As the criterion of leakage at normal operation, leakage in $5x10^{-6}$ atm-cm^3/sec at internal pressure up to 0,69MPa which meets the requirements of the Data sheet of the storage facility in the USA is accepted. Further increase of internal pressure up to 1,6 MPa is considered and the greatest possible leakage in $3{,}3x10^{-4}$ cm^3/sec is estimated. Fractions of emission are regulated by NUREG-6487 [24]:

- ^{85}Kr - 0,3;
- ^{60}Co – 1;
- ^{90}Sr, 134Cs, ^{137}Cs, ^{106}Ru – $2{,}0x10^{-4}$;
- ^{241}Pu, ^{144}Ce and other elements $3{,}0x10^{-5}$.

The quantity of ^{60}Co is caused by the maximum surface activity of spent fuel assemblies. For spent fuel assemblies of PWR reactors in the USA according to NUREG-6487 [11], surface contamination of spent fuel assemblies by ^{60}Co is $5{,}18 \times 10^{6}$ Bq/cm^2.

- According to NUREG-1536 [12], emission over 720 hours (30 days) is considered. Thus it is assumed that the person stays for 24 hours a day for 30 days on the open area. Thus, all fuel assemblies in the multi-purpose container collapse and leakage in the environment $3{,}3 \times 10^{-4}$ cm^3/sec occurs.

Such accident is an absolutely hypothetical case of damage of all fuel assemblies in the MPC with the subsequent release of gaseous fission products. It is impossible to determine actual initial events with direct consequences which would entail simultaneous damage of MPC and all fuel assemblies inside. A unique type of impact on the storage module of HI-STORM which can result in simultaneous damage of the MPC and all fuel assemblies is a significant external dynamic impact (for example, as a result of application of special ammunition, etc.). The given accident is considered for demonstration of the relatively insignificant radiation consequences of accidents in CSFSF even taking into account hypothetical initial events.

From the point of view of radiological consequences the given accident is considered as BDBA with the maximum consequences.

Calculation and analysis of radiation consequences of the BDBA was carried out by calculation procedure of consequences of short-term emissions, using the following assumptions and input data:

- height of emission - 0 m;
- atmospheric stability - category F (by Pascwill);
- direction of wind is permanent, average speed 2 km/s,
- fuel is supplied in ISF after 5 years of endurance
- dose factors of radionuclides are represented in table A8
- gravitational sedimentation was not taken into account

Table B8. Input data for the BDBA

Radionuclide	**Activity per one spent fuel rod**	**Dose factor for inhalation intake, Sv/Bq**
H 3	3,68E+02	1,73E-11
I129	3,31E-02	4,69E-08
KR 85	5,86E+03	0,00E+00
Co-60	2,18E+01	5,91E-08
SR 90	6,32E+04	3,51E-07
RU106	1,59E+04	1,29E-07
CS134	4,04E+04	1,25E-08
CS137	9,82E+04	8,63E-09
PU241	8,53E+04	2,23E-06
Y 90	6,32E+04	2,28E-09
PM147	2,63E+04	1,06E-08
CE144	8,14E+03	1,01E-07
PR144	8,14E+03	1,17E-11
EU154	5,90E+03	7,73E-08
CM244	1,01E+04	6,70E-05

Radionuclide	Activity per one spent fuel rod	Dose factor for inhalation intake, Sv/Bq
PU238	5,81E+03	1,06E-04
SB125	2,30E+03	3,30E-09
EU155	1,65E+03	1,12E-08
AM241	9,00E+02	1,20E-04
TE125M	5,61E+02	1,97E-09
PU240	4,05E+02	1,16E-04
SM151	3,38E+02	8,10E-09
PU239	2,04E+02	1,16E-04
BA137M	9,27E+04	0,00E+00
RH106	1,59E+04	0,00E+00
PR144M	1,14E+02	0,00E+00
AM243	4,87E+01	1,19E-04
CM242	3,23E+01	4,67E-06
CM243	3,63E+01	8,30E-05
NP239	4,87E+01	6,78E-10
NP237	3,88E-01	1,46E-04
PU242	2,85E+00	1,11E-04
AM242	8,72E+00	1,58E-08
AM242M	8,76E+00	1,15E-04

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Appendix C4

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This document is proprietary and is not included in the appendix.

Appendix C5

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Appendix C6

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Appendix C7

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Appendix C8

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Appendix C9

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Appendix C10

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Appendix C11

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Appendix C12

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Appendix C13

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Appendix C14

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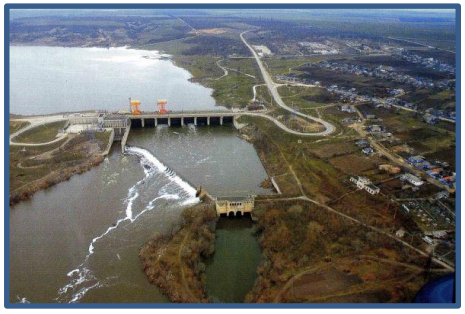
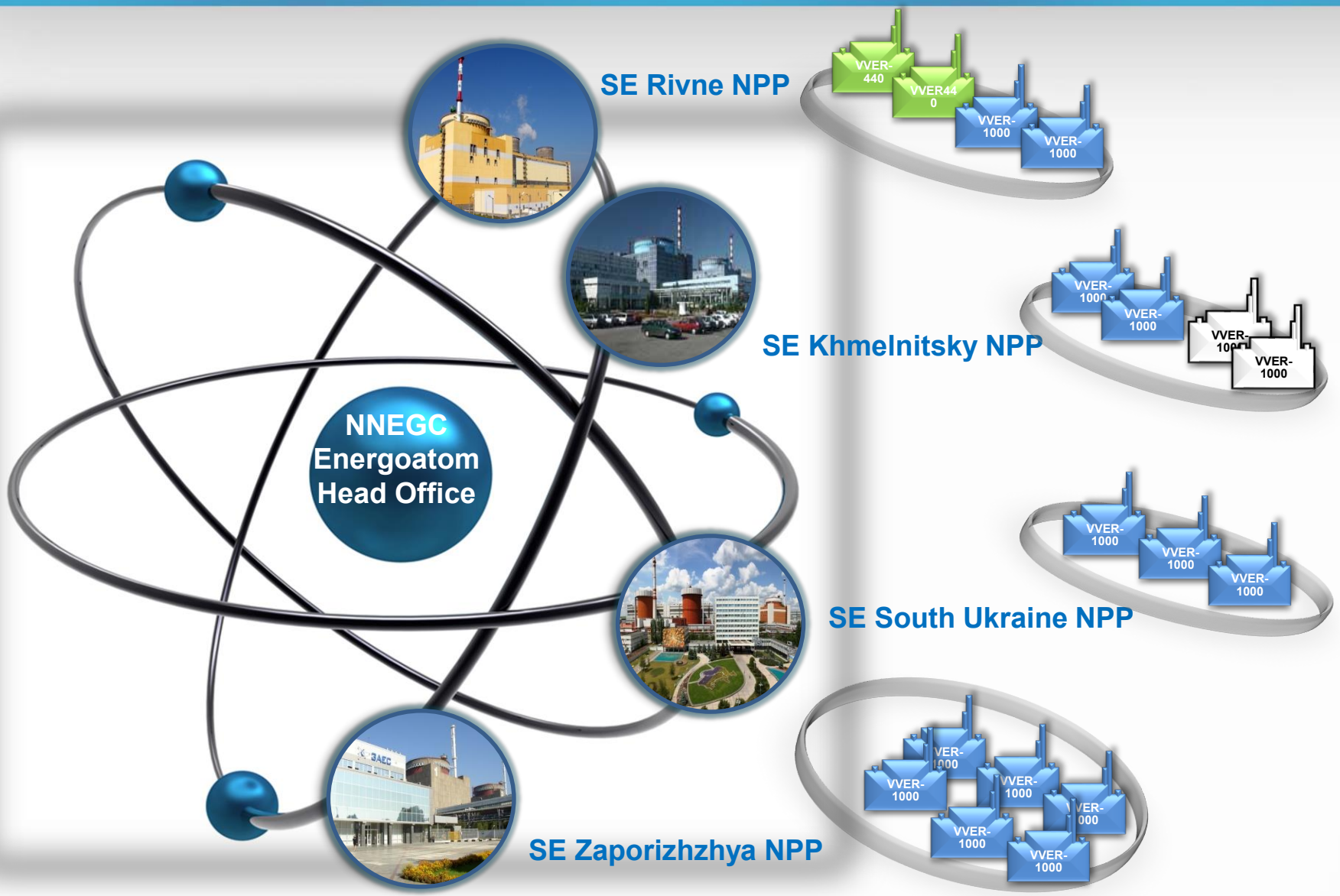
SE NNEGC ENERGOATOM

CENTRAL SPENT NUCLEAR FUEL STORAGE FOR UKRAINE VVER NPP



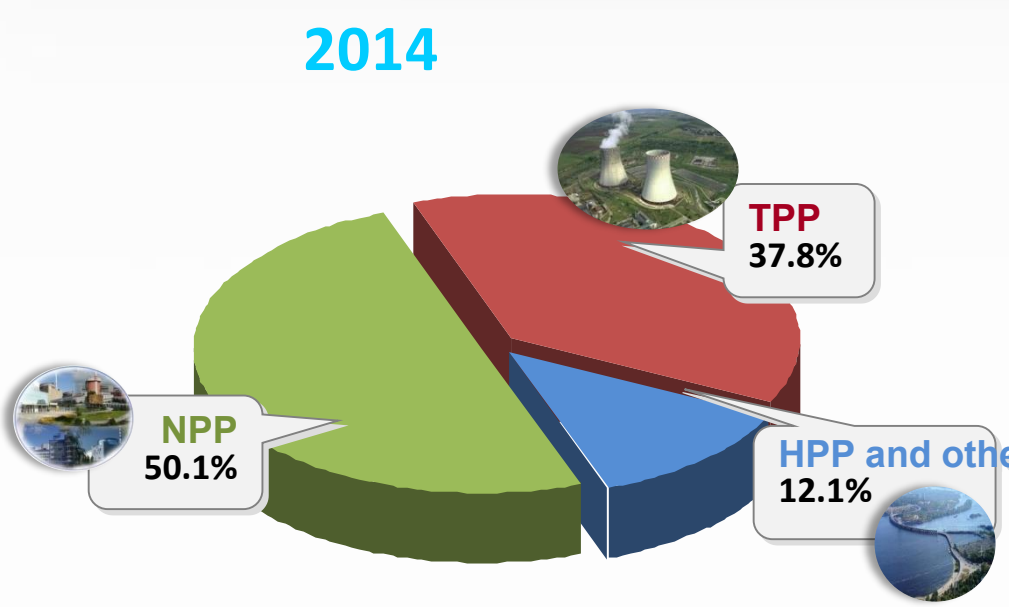
Kyiv- 2015

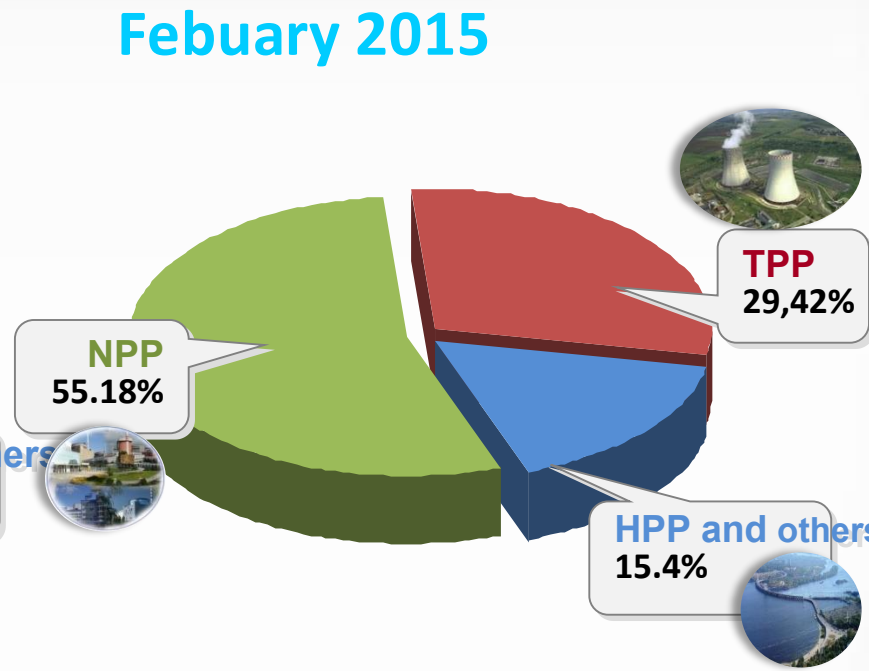
Nuclear Power Industry of Ukraine



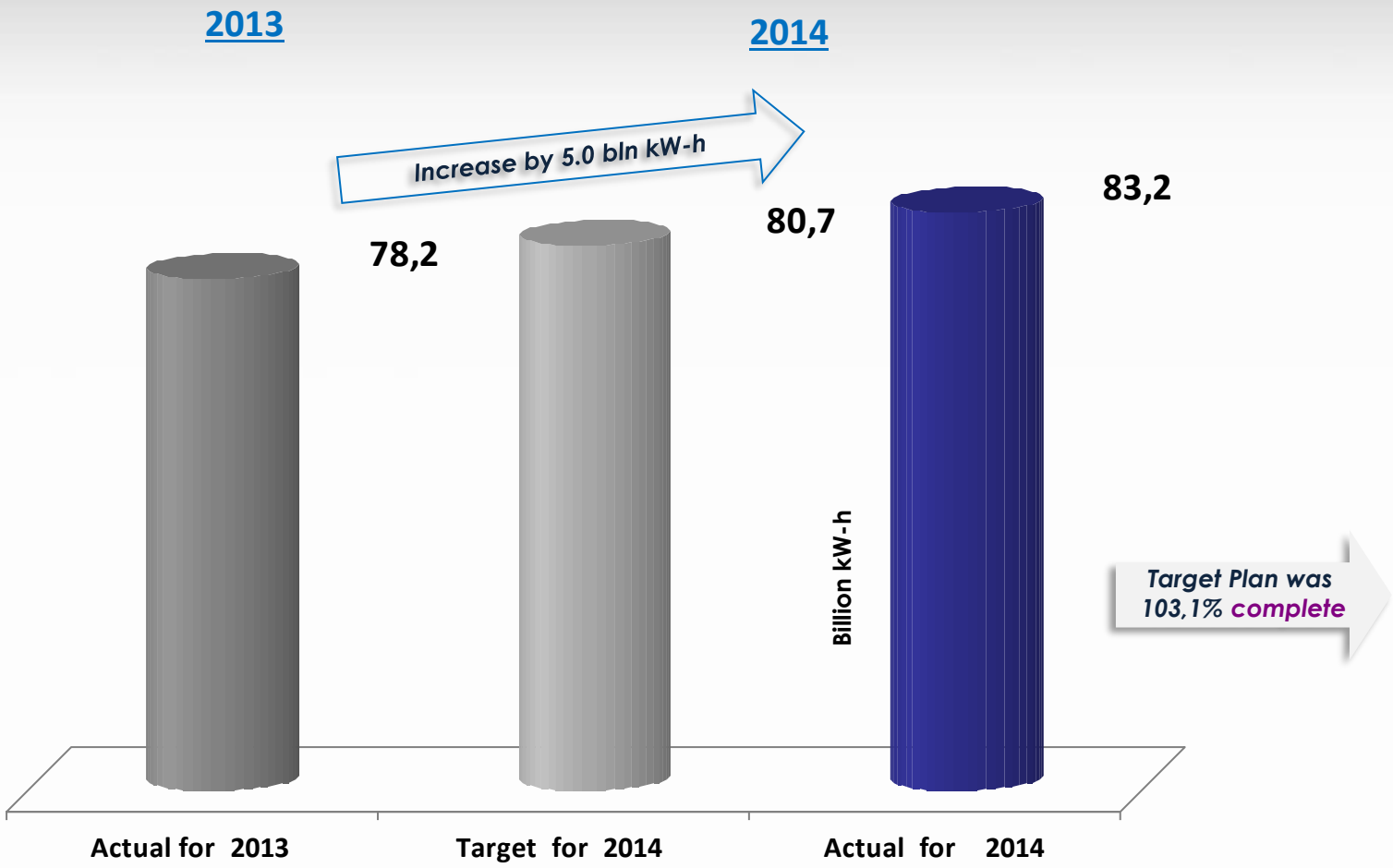
SE NNEC Energoatom in Ukraine's Energy Mix In 2014

Electricity output by NNEGC Energoatom to the Electricity Market of Ukraine

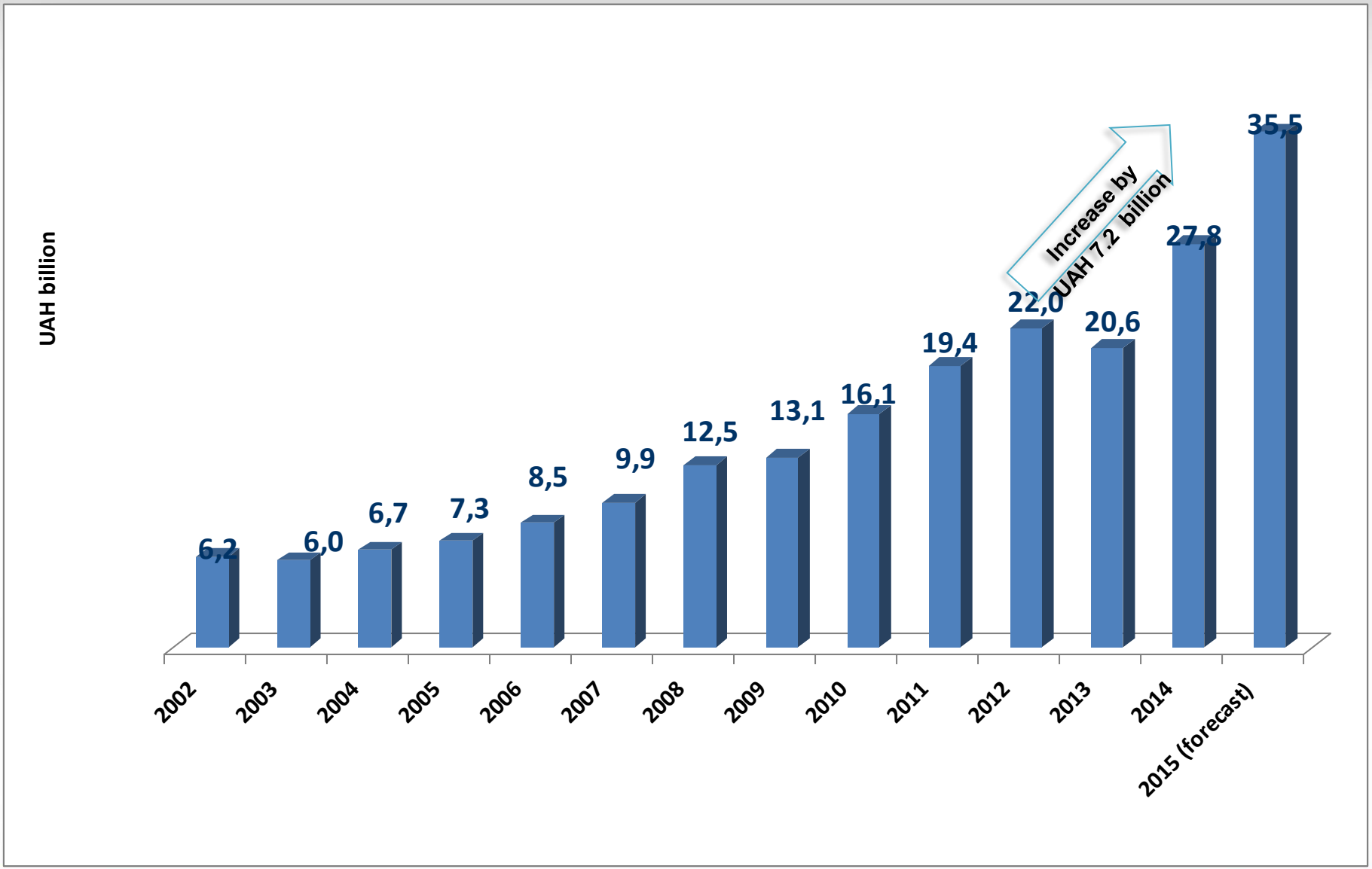




Electricity Output by SE NNEGC Energoatom

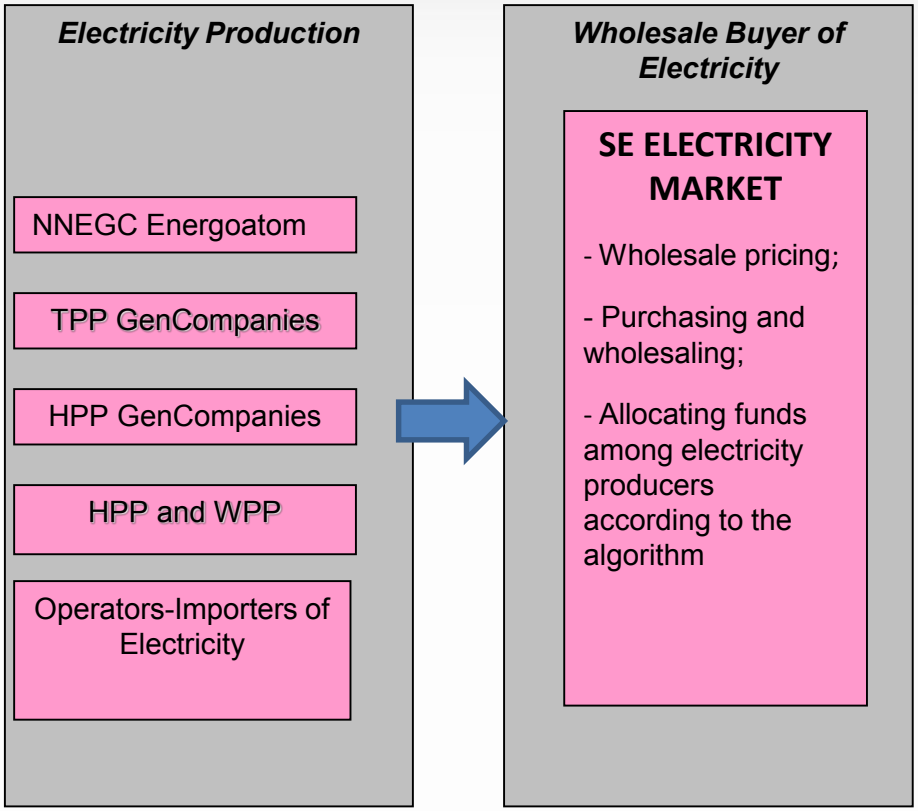


Evolution of SE NNEGC Energoatom 's Commercial Output, (inc.VAT)



Tariff and Electricity Sales

Sale of Electricity



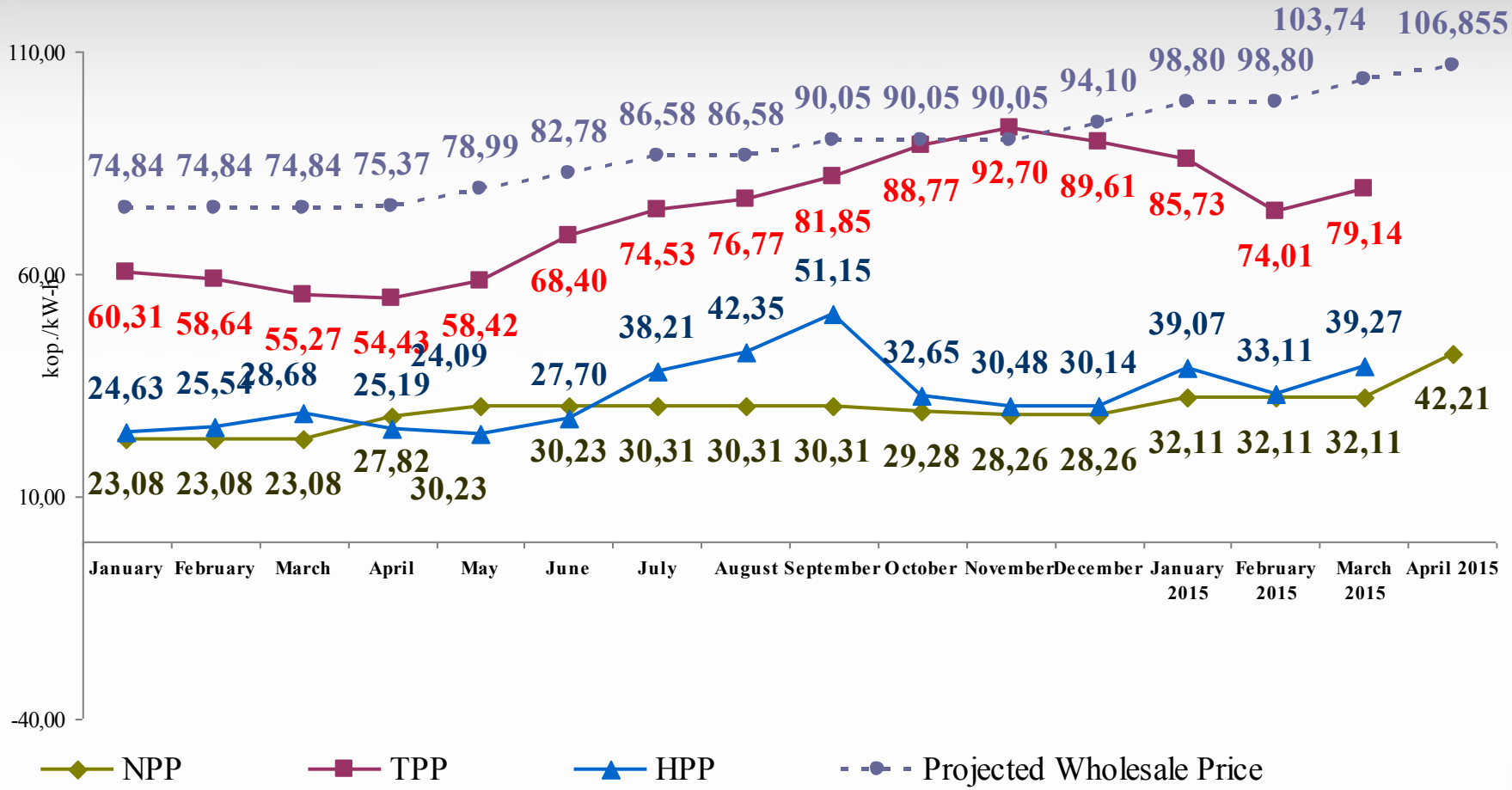
NNEGC Energoatom Tariff

NNEGC Energoatom prepares the substantiation and structure of the tariff to include the required rate of costs, investments and loan repayments of SE NNEGC Energoatom, including CEB' s loans repayments

Tariff is reviewed by the National Commission for State Regulation in Energy and Communal Services

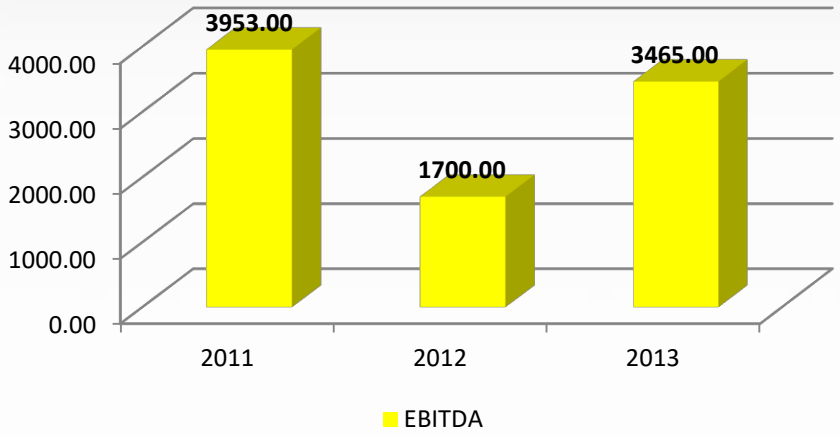
Tariff Structure is approved by the National Commission for State Regulation in Energy and Communal Services

Evolutions of Tariffs for Electricity Delivered to Wholesale Electricity Market over 2014 and 2 month 2015

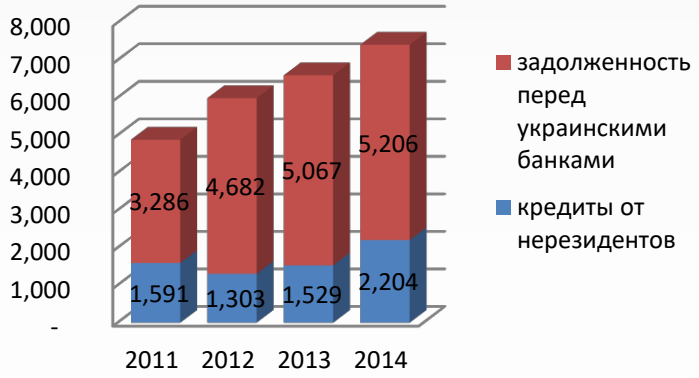


Финансовые показатели НАЭК «Энергоатом»

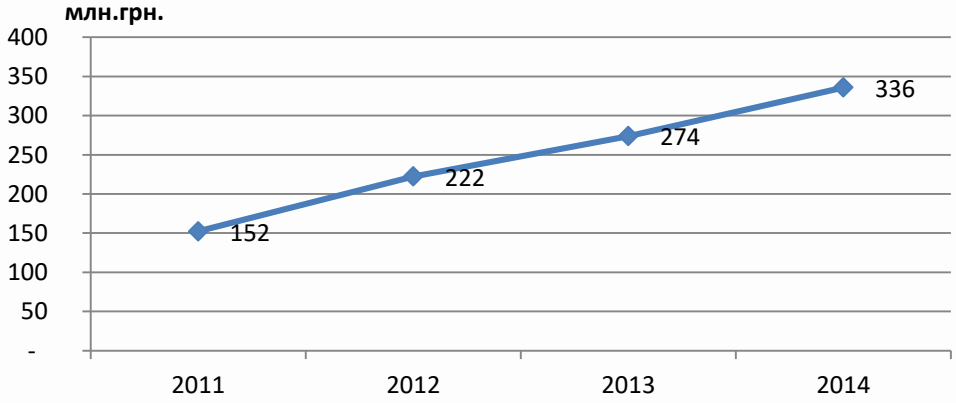
EBITDA



Задолженность по кредитам



Погашение долгосрочных обязательств



Central Storage Facility for Spent Fuel of VVER-type Reactors of Ukraine NPP (CSFSF)

- **CSFSF for reactors of RNPP, KhNPP and SUNPP - a nuclear facility of nation-wide importance**
- **CSFSF is to be located on the site in the Chernobyl Exclusion Zone**

- **CSFSF technology and equipment shall be supplied by the U.S.-based Company Holtec International.** *Total Capacity of the CSFSF - 16529 spent fuel assemblies (SFA) of VVER-440 and VVER-1000-type reactors*
- **On-surface "dry" storage technology is used for the spent fuel storage, deploying a double-barrier system of confinement to be provided by the equipment of specifically designed cask-type engineering systems**
- **Design lifetime of the storage facility is not less than 100 years**
- **In April 2014 the Cabinet of Ministers of Ukraine granted a permit to develop the land-utilization projects allocating two land plots with a total area of 45.2 ha for further construction of the CSFSF in the Exclusion Zone of Chernobyl NPP**

Central Storage Facility for Spent Fuel of VVER-type Reactors of Ukraine NPP (CSFSF)

Project History

Between 2003 and 2004 the International tender for establishing the CSFSF was carried out. By the end of 2004 the offer of Holtec International (tender winner) was accepted.
On December 26, 2005 the Contract was concluded with Holtec International as international tender winner, for establishing of the CSFSF.

Between 2007 and 2011 – equipment designs were developed along with the safety cases
February 9, 2012 – Law of Ukraine No. 4384-VI "On Siting, Designing and Construction of the CSFSF for VVER-type Reactors of Ukrainian NPPs».
2014 saw

- Cabinet of Ministers' Resolution on allocation of land plots for the location of the CSFSF facilities
- Start of designing of the Storage Facility and preparatory works for the CSFSF site

Central Storage Facility for Spent Fuel of VVER-type Reactors of Ukraine NPP (CSFSF)

Current Status of the Contract with Holtec International

In 2015 SE NNEGC Energoatom and Holtec International signed Amendment No. 6 to the Contract whereby:

- Holtec International shall supply the technology of SF management, manufacturing and delivery of equipment required for preparation, transportation and storage of SF;
- SE NNEGC Energoatom provide designing and construction of the CSFSF
- Contract was entirely revised and restated according to the above mentioned approach

Central Storage Facility for Spent Fuel of VVER-type Reactors of Ukraine NPP (CSFSF)

Project Parameters

Cost (capital value) of the overall project - USD 359 M
Including:
1.Construction – USD 59 M.
2. Designing and equipment supply for the CSFSF under the Contract with Holtec– USD 299 M

Stages of the Contract with Holtec International:

- **2015-2017 - Start- up complex - Cost of the Stage is USD 78 M**

- **2018-2020 - Supply of nuclear fuel storage casks by Holtec International – Cost of the Stage is USD 222 M**

Central Storage Facility for Spent Fuel of VVER-type Reactors of Ukraine NPP (CSFSF)

Cost Effectiveness of the Project

	Area for Financing	*Supply of Equipment and 4 casks, construction of the CSFSF, Filling-in of 2 casks 2015–2017*	*Supply of 90 casks and filling-in of 42 casks 2018 - 2020*	*Filling-in of 50 supplied casks , manufacturing in Ukraine 2021 – 2024*
1	*Contract with Holtec International, million USD* *Costs of arranging for the manufacturing in Ukraine, million USD*	*78*	*222*	*40*
2	*Designing, Construction and Operation of the CSFSF Costs in million USD*	*59*	*18*	*29*
3	*Placing the SF for further storage, measured in thousand kg of heavy metal* *Cost of SF removal, USD per kg of heavy metal* *Savings resulted from refusal of SF transportation to Russia, million USD*	*26,78* *1000* *26,78*	*537* *1000* *537*	*650* *1000* *650*
4	*Results as of the end of the period, million USD*	*-111*	*+297*	*+581*

Co-operation with the Regulatory Body in Establishing the CSFSF

2005 – Endorsement of the Technical Specification for the CSFSF Establishing Contract

2008 – Approval of the Feasibility Study for the CSFSF

2009 – Conducting the technical evaluation of the safety-important equipment designs, as well as safety substantiations for that equipment

2011 – Endorsement of the Decision "On Implementing the Spent Fuel Management Technology at "Pilot" Units of NPP

2012 – Endorsement of the Plan of the CSFSF Licensing

2014 – Visit of the Regulatory Body's Chairperson to the Holtec Headquarters

2015 – Endorsement of the Statement on determination of the physical protection level of the CSFSF

Meetings and consultations with the Regulatory Body's experts conducted regularly to address the project implementation issues

Using the Best Practice in Establishing of the CSFSF

Construction of ISF -2 on the Chernobyl NPP site

Contractor (turn-key contract) – Holtec International

Customer : EBRD + Chernobyl NPP

Storage Facility location – site of Chernobyl NPP

Stage of the Project – construction of the Storage Facility and equipment fabrication

Experience of designing, licensing and equipment manufacturing is used in the framework of the CSFSF project

Experience of operating the on-site SF storage at Zaporizhzhya NPP

Operation of the Storage Facility started in 2002

Storage technology provided by DUKE ENGINEERING & SERVICES

Experience of licensing and operating the equipment is used in the framework of the CSFSF project

Meeting the Ecological Requirements for the CSFSF

Environmental Impact Analysis (EIA) for CSFSF

Initially, the CSFSF EIA was developed and approved by the ecological and international expert reviews in 2008

Since 2014 the CSFSF EIA has been updated and the parties concerned have been informed of the safety issues of the CSFSF

Conclusions on environmental impacts

CSFSF's impact on the environment are, for the most part, limited by the boundaries of the site location area

CSFSF site is located in the Exclusion Zone of ChNPP. No public lives in the area of the CSFSF location.

All legislative activities and commitments of fulfilling the international conventions on the interaction with public and neighboring states were implemented during the period between 2007 and 2009.

SE NNEGC ENERGOATOM

•is a guarantor of safe and peaceful use of nuclear power resources

• is an important entity of the market relations

• is a significant contributor to economic, social and geopolitical progress of Ukraine, securing its energy independence

Appendix C15

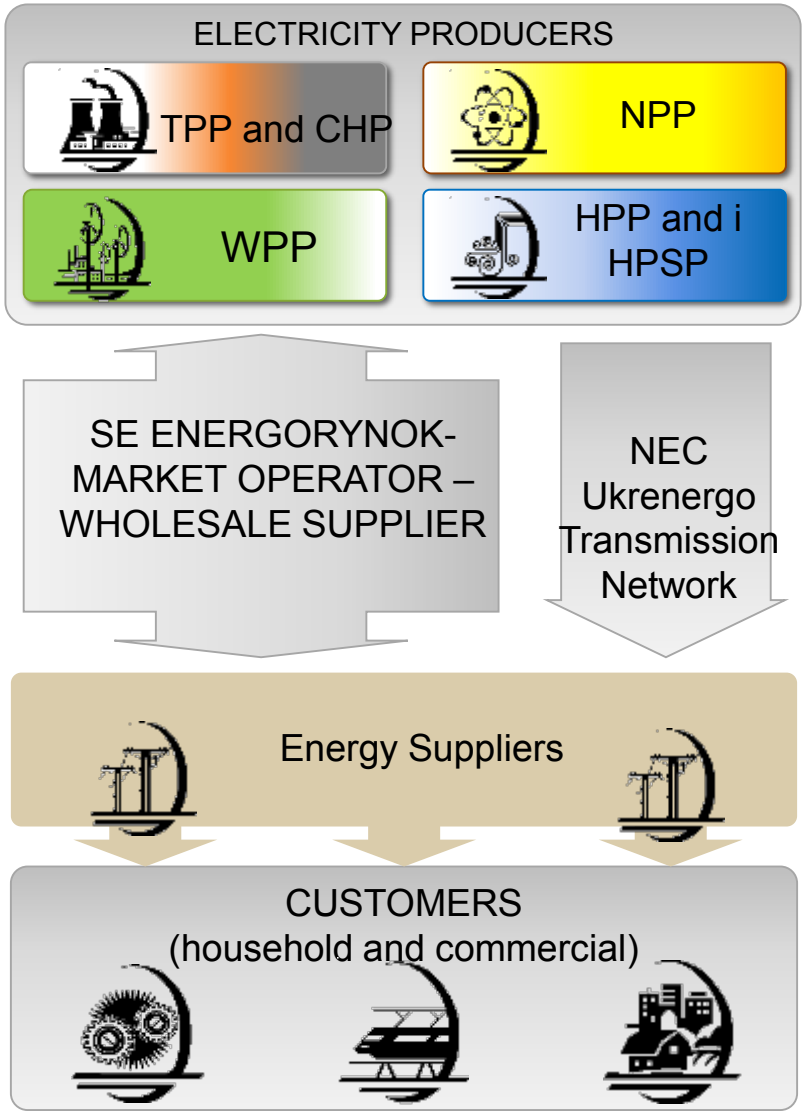
EnergoAtom. 2016. Presentation Slides: Stages of Implementing a New Model of Electricity Market of Ukraine and Activities Performed by SE NNEGC EnergoAtom in Each of these Stages. 142886_9345. November.

STAGES OF IMPLEMENTING A NEW MODEL OF ELECTRICITY MARKET OF UKRAINE AND ACTIVITIES PERFORMED BY SE NNEGC ENERGOATOM' S IN EACH OF THESE STAGES

November 2016

STAGE 1: Before the adoption of the Law of Ukraine "On the Electricity Market of Ukraine"

Existing Market Model



Main Features

The Regulator sets the tariffs for NPP, TPP, CHP and WPP. For TPP, tariffs are set on the basis of price bids in accordance with the costs breakdown approved by the National Commission for State Regulation of Energy and Public Utilities (NCSREPU)

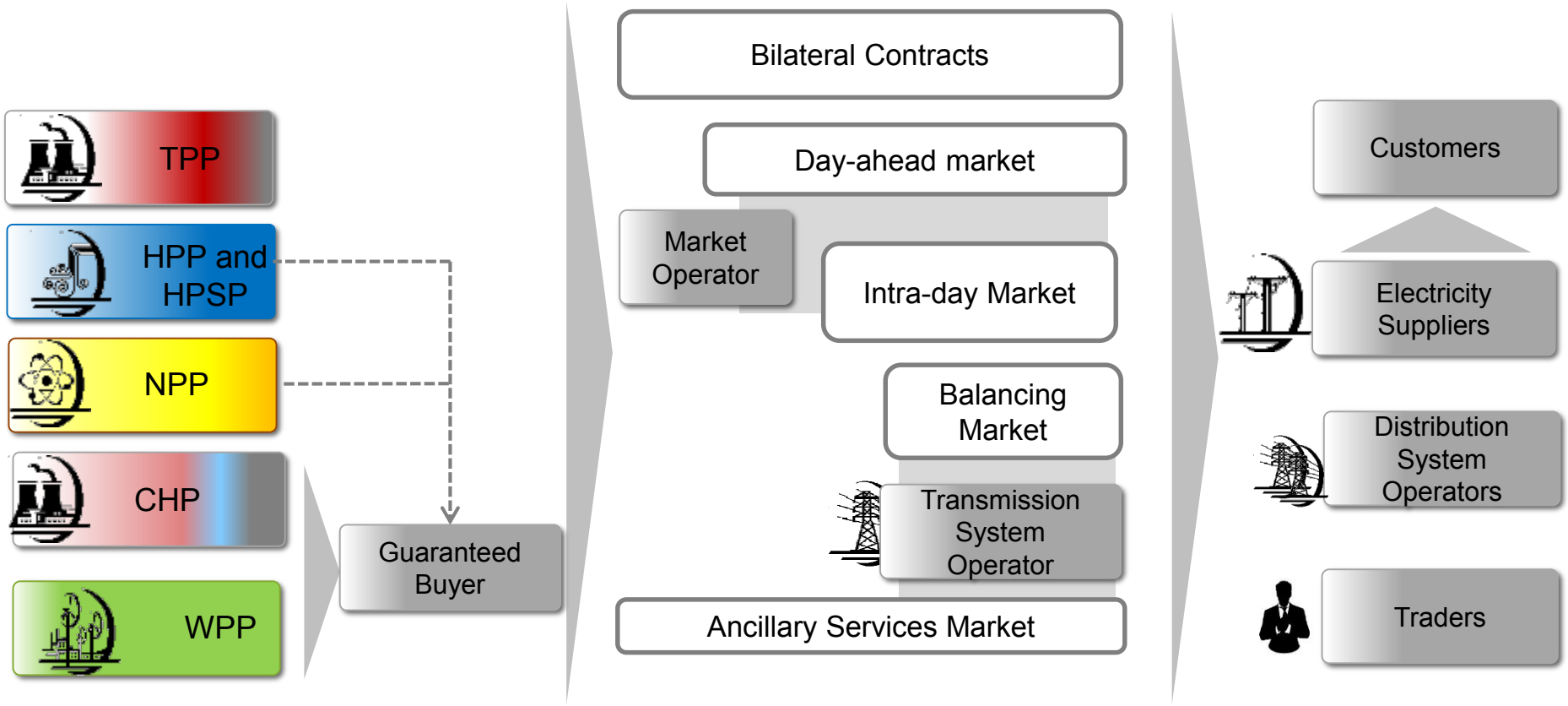
Fully Regulated Pricing

SE NNEGC Energoatom sales electricity to the single buyer, namely, SE Energorynok, at tariffs approved by the Regulator and within the volumes specified in the dispatching schedule.

Note: TPP-thermal power plants, CHP- combined heat and power plant, NPP- nuclear power plants, WPP- wind power plants, HPP-hydro power plants, HPSP- hydroelectric pumped-storage plants

NCSREPU - National Commission for State Regulation of Energy and Public Utilities

STAGE 2: From the beginning of the Transitional Period, as set forth by the Law of Ukraine "On the Electricity Market of Ukraine" adopted as amended by the Verkhovna Rada of Ukraine in the first hearing on 22.09.2016, and until 01.01.2019



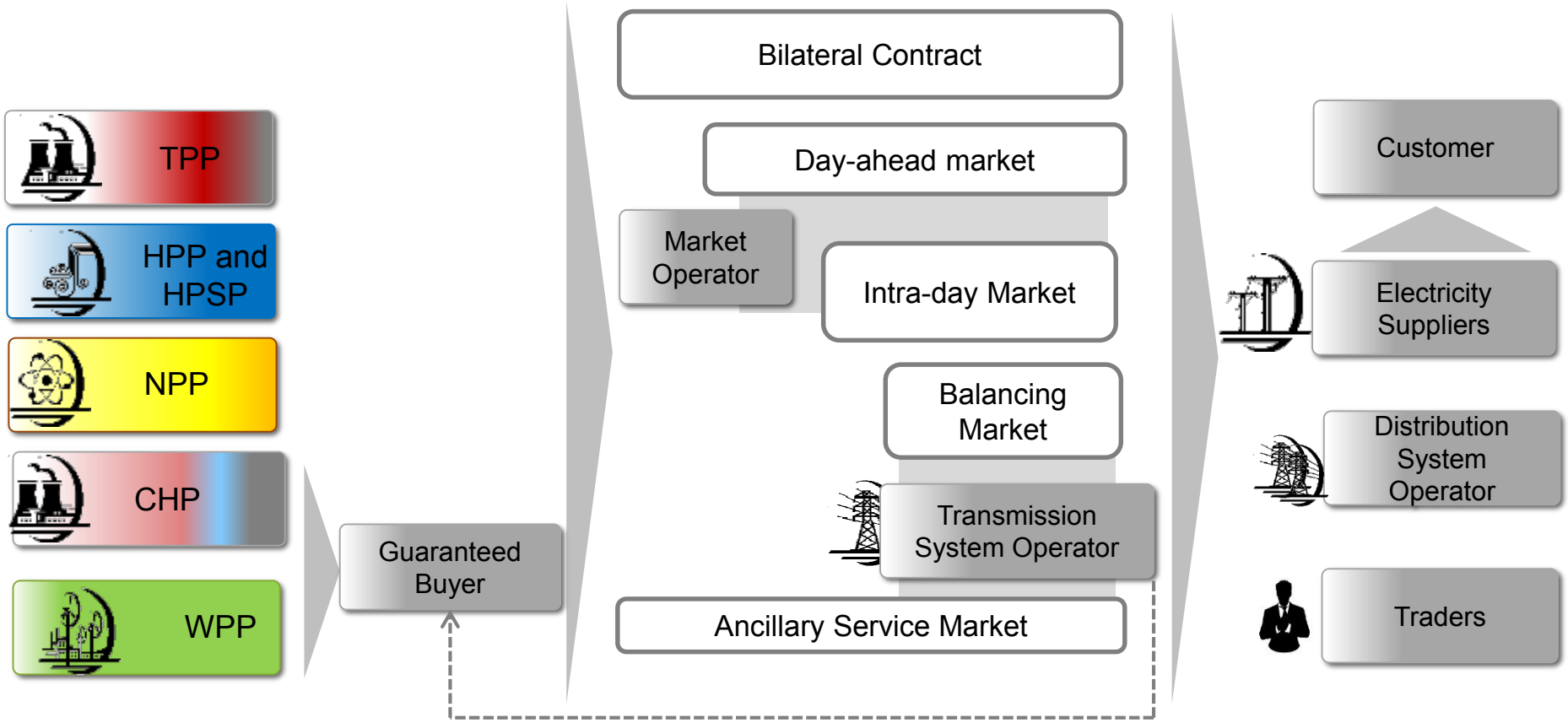
Pricing is partially market-driven and partially regulated

1. SE NNEGC Energoatom shall sell the electricity to SE "Guaranteed Buyer" within the volumes not exceeding 75% of operating capacity, and at prices to be approved by the Regulator.

2. Up to 15% of monthly output of electricity shall be mandatory sold in the day-ahead market. Regulator shall specify the volume of sales, the pricing shall be market driven.

3. Remaining volume of electricity may be sold in the following markets: the bilateral contract market, the day-ahead market, the intra-day market, and the balancing market. The price for bilateral contracts will be close to the day-ahead market price. For other markets, the pricing shall be market driven as required by the Market Regulations.

STAGE 3: after 01.01.2019



Pricing is entirely market driven

SE NNEGC Energoatom shall sells the total volume of electricity in competitive markets: the bilateral contract market, the day-ahead market, the intra-day market and the balancing market

The price for bilateral contracts shall be close to the day-ahead market price. For other markets, the pricing shall be market driven as required by the Market Regulations.

THANK YOU FOR YOUR ATTENTION!

Appendix C16

EnergoAtom. No Date. Centralized Storage of Spent Nuclear Fuel. PL-D.0.46. 6.038-16

MINISTRY OF ENERGY AND COAL INDUSTRY OF UKRAINE
State Enterprise
"National Nuclear Energy Generating Company" Energoatom "
EP "Atomproektinzhynirynh"

APPROVED
CEO
EP "Atmproektinzhynirynh"
_____ Oh. M. Rybchuk
«___» _____ 201 6 g.

POSITION

project management group creation
Centrally first storage facility for spent nuclear fuel
(Facility)

PL-D. 0.46. 6 038 -1

The term di th

Inventory number

Date
Validity extended until

Telephone messages

Date

P olozhennya
project management group creation
Centralized storage of spent nuclear fuel
(Facility)

Art at p 1

SHEET IN G ODZHENNYA

Position	Signature	Date	Initials, surname
Deputy General Director - Director of new nuclear plants			AND. F. Orlov
Deputy Director General on the establishment of a single set of Spent Nuclear Fuel			IN. AND. Trouser leg
Deputy Director of the new nuclear facilities - Head of NF, created			IN. D. Medun
Deputy Director of the new nuclear facilities - Head of professionals holvnyh			Y. IN. Cherepanov
Head of Quality and Licensing			JH Mitichkina
Head of Quality Assurance and Licensing			AT. G. Syrotyns cues

CONTENT

Art at p.

ACCEPT REDUCTION

TERMS AND DEFINITIONS

1 TERMS

2 OBJECTIVES AND FUNCTIONS

3 THE ORGANIZATIONAL STRUCTURE

4 RELATIONSHIP 11

SHEET REGISTRATION CHANGES 12

SHEET REVIEW

1 Accept REDUCTION

NPP	nuclear power station
VP	separated subdivision
SNF	spent fuel
SE "" Energoatom "	State Enterprise "National Nuclear Energy Generating Company" Energoatom "
SCNS	State Nuclear Regulatory Inspectorate of Ukraine th us
SSTC	D erzhavne Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety"
CMU	cabinet of Ministers of Ukraine
CD	K ontseptualne decision "On Introduction to" pylotnыh "unit AES Ukraine modyfytsyrovannoy circulation technology with otrabotavshym yadernыm fuel required to implement Sending ego in TSHOYAT"
Minenergouglya	**1.1 Ministry of Energy and Mines Ukraine**
RAPS	Rivne nuclear power plant
FZ	physical protection
KNPP	Khmelnytsky nuclear power plant
Storage Facility	C entralizovane spent nuclear fuel
SUNPP	South Ukrainian nuclear power plant
NM	nuclear material
NRS	nuclear safety
NF	nuclear plant

1.2

2 Terms and definitions

Project	The only process that consists of a set of coordinated and controlled types of work with dates of beginning and end, performed to achieve goals that meet specific requirements and restrictions upon deadline, cost and resources (p. 3.5 of ISO 10006: 2005)
Storage Facility	Centralized storage of spent nuclear fuel
project management	Planning, organizing, monitoring, controlling and reporting on all aspects of the project and stimulate all participants to achieve the project objectives (p. 3.6 of ISO 10006: 2005)
Responsible executor	EP "Atomproektinzhynirynh" SE "" Energoatom "
Group project management	The group set up for the project, which **is implementing the project** (p. 4.1.2 of ISO 10006: 2005)
Project Manager	An official with clear responsibility and authority for managing the project and ensuring rozroblyannya, implement and maintain a quality management system in the project (p. 5.2.3 of ISO 10006: 2005)
Director PMU	The officer responsible for the management of the PMU
The Steering Committee	The collegiate body of technology implementation Holtec of spent nuclear fuel for power units SE "" Energoatom "functionally associated with the project; receives information from PMU and performs supervisory and advisory functions (strategic support project)
Creditors	International financial institutions participating in the co-financing projects
Venues	The territory, a second will be implemented P roekt Facility
Central PMU office	Part of the PMU, formed of managers and specialists EP "Atomproektinzhynirynh." Managed by PMU.
PMU on site	Part PMU formed with unit managers EP NPP. Managed by the PMU on the court.
Director PMU on site	The person appointed by the order of Director General of the EP AES, which is headed by the PMU on the court.

3 1 TERMS

3.1 1.1 This Regulation group project management centralized repository for spent nuclear fuel EP "Atomproe ktinzhynirynh" SE "" Energoatom "(hereinafter - Regulation) is designed for tasks to create a centralized repository for spent nuclear fuel (hereinafter - Project Facility, Draft).

3.2 1.2 Regulations determine the procedure of forming the PMU, its structure, the role of members of the PMU, tasks and functions, as well as interaction with structural divisions of the Company, the Consultant PMU, creditors and other stakeholders.

3.3 1.3 PMU is united group that formed the leaders and specialists of structural units OP "Atomproektinzhynirynh" SE "" Energoatom "(hereinafter - OP IPA) and VP AES.

3.4 1.4 SUE composition and distribution of tasks and responsibilities among the members of the PMU vyznachayet be orders of SS API and this Statute.

3.5 1.5 Location PMU.

3.6 ..... – Central office: Ukraine, 01032, Kyiv, str. Gaidar, 6 room EP "Atomproektinzhynirynh";

3.7 ..... – Sue finds at the site of ARE KhNPP, and RNPP SU NPP idno compliance, and quickly dominate ARE PMU Head Office.

3.8 1.6 Provisions designed to meet the requirements:

3.9 ..... – Law of Ukraine "On the management of spent nuclear fuel on location, design and construction of centralized storage facility for spent nuclear fuel VVER domestic nuclear power"

3.10 ..... – Conceptual solution "Oh Introduction to" pylotnыh "unit AES Ukraine modyfytsyrovannoy circulation technology with otrabotavshym yadernым fuel required to implement Sending ego in TSHOYAT"

3.11 ..... – Cabinet of Ministers of Ukraine of 26.11.2008 number 1027 "On the order initiation, preparation and implementation of economic and social development of Ukraine, supported by international financial organizations";

3.12 ..... – Of the Ministry of Finance of Ukraine, Ministry of Economy and European Integration of Ukraine, Ministry of Labour and Social Policy of Ukraine, Ministry of Ukraine th stytsiyi 29.10.2002 number 905/308/550/93/5 "On approval of the project management group for economic and social development of Ukraine, supported by international financial organizations";

3.13 ..... –

Ukraine National Standard "Quality Management Systems. Guidelines for quality management in projects "(of ISO 10006: 2005);

3.14 1.7 PMU operates in accordance with applicable regulatory acts and regulatory requirements, production, org anizatsiyno-thrust yadchyh and other existing VPD API documents.

3.15 1.8 This Regulation should know leaders who coordinated it, and all persons who are members of PMU.

3.16 1.9 This provision should be aware of all persons involved in the project and have relationships with PMU.

3.17 1.10 This provision should be in the fund documentation productive th VP API (original) EP KNPP EP RAPS, VP NPP (copies included).

4 2 OBJECTIVES AND FUNCTIONS

4.1 2.1 The aim of the PMU is to perform n roektu create a centralized repository for spent nuclear fuel.

4.2 2.2 Implementation of the objectives provided by the staff of structural Mr idrozdiliv VP API's under her jurisdiction and work of PMU staff is Redeemed work in the Project Facility must have high qualifications and experience sufficient to understand their goals, project objectives and ways to achieve them.

4.3 2.3 The task of the PMU:

- Current project management;
- ealizatsiyi development plan, the project and its support to date;
- ensuring use for the current project in the Company's regulatory and industrial dock umentatsiyi, preventing the creation of unnecessary documents (requirements which duplicate existing procedures in force);
- Development and support overall project schedule;
- development and update of detailed schedules for the implementation of each phase of the Facility; Organization of PMU on implementation of K (i) SDS according to the schedule of the Project;
- the conditions for redytnyh agreements;
- effective cooperation with the project, for oordynatsiynym committee structural divisions of the Company's central authorities, for redytoramy within the powers defined in this Regulation.

4.4 2.4 In order to fulfill its tasks central office PMU sells industrial-technical and financial-economic functions are closely and directly linked to each other (but arbitrarily divided in this section for ease of perception):

4.5 2.5 Production and technical features:

- Monitoring of the Project;
- Organization drafting the contract;
- implementation (if necessary) preparation of documents on amendments to the Project;
- preparing reports on the project for submission to the Steering Committee;
- of the final report on the results of the project;
- exercise overall control of the project, including the schedule of the project;
- Risk Management Project;
- the organism uation and holding meetings and negotiations on the Project;
- organization development and approval of documentation for the tender;
- drafting orders, and other documents roses poryadchyh the Project; Organization approval of organizational and administrative documents
- The Licensing;
- CONTROL P roektu implementation of a quality assurance (through self-assessments, internal audits or other posobamy with - the established procedure);

- control use for P roektu active in the Company's regulatory and production documentation uu to avoid creating unnecessary documents;
- Organization of the plan of environmental and social measures;
- providing (for) the reference to the press-center of the Company.

4.1 2.6 **Financial and economic functions:**

- organization of the financial management project;
- drafting of payment documents for application EP - curator agreement (payment orders, statements etc.);
- Dr. accompanied the implementation of payment instruments;
- preparation of financial reporting documents, storage, financial and other reporting docu ing required to audit roektu P;
- training plan in the procurement of goods (works, services) under the Project;
- organization reporting on procurement of the Project;
- diysnennya of training and support competitive bidding for goods and services;
- Monitoring of performance contracts.

4.2 2.7 **PMU on the site:**

- responsible for implementing the project in stages;
- CAP provides professionals involved in nuclear engineering and organizational meetings for the Project;
- prepares reports, reports, reference materials to requests PMU Head Office;
- supervises the development and approval of the relevant technical documents NPP specialists (conceptual solutions, specifications and delivery conditions, technical solution for editing, testing program, etc.);

5 3 THE ORGANIZATIONAL STRUCTURE

5.1 3.1 Personal structure of PMU appointed by order of the President of the Company.

5.2 3.2 Management of all project carries Project Manager - Mr ershyy vice-president - technical director. For this, he has the necessary powers specified in the job description and relevant provisions (of collegial bodies and structural subdivisions of the Company).

5.3 3.3 With Project Leader Om functionally linked Steering Committee on the implementation of technology that gets information from the PMU and performs supervisory and advisory functions (strategic support for the project).

5.4 3.4 The composition of the steering committee:

5.5 ..... Head Steering Committee - President GP "" Energoatom ".

5.6 ..... Members of the governing comitat:

- a singer and dpovidalnyy "Holtec International";
- Head of nuclear energy and atomic complex promysldovoho Minenergouglya;
- deputy director of safety of nuclear installations - Inspector Nuclear Regulatory Committee of Ukraine;
- Director of SSTC;
- First Vice President - Director of tehnchnyy "" Energoatom ", deputy chairman of the committee;
- Vice President GP "" Energoatom ";
- CEO RNPP;
- CEO KhNPP;
- CEO of SU NPP;
- chairman of JSC KIEP;
- Technical Director of HIEP;
- CEO VP API;
- President Head of State Enterprise "" Energoatom ".

4 RELATIONSHIP

4.1 4.1 Director PMU manages the activities of the PMU.

4.2 4.2 Leader in operating SUE SUE Managers are on-site.

4.3 4.3 Personal structure of the PMU in areas relevant orders appointed CEO VP AES.

4.4 4.4 Director PMU is responsible for the Project.

4.5 4.5 Project Manager and Head of PMU appointed President of the Company.

Coordinating Committee and the personal composition of the Group's control pan innya project appoint ARE president of the submission of the project manager.

Director and staff of the PMU orders on platforms appointed CEO VP AES.

Candidates for the posts of specialists SUE SUE submitted to the head manager of the unit VP API.

4.6 4.6 Project Manager provides management and supervision of all work on the project.

4.7 4.7 Director PMU monitors the implementation of the plan procurement action plans to implement the project and financing; cooperates on the project with the lender.

4.8 4.8 First Deputy Head of the PMU interaction with public authorities and creditors has vyschezaznach Annie functions and serves as the K erivnyka PMU in his absence.

4.9 REGISTRATION SHEET CHANGES

change	number of sheets				message		signature	date
	modified	Collapsed	new	canceled	number	Amount sheet		
1	2	3	4	5	6	7	8	9

SHEET REVIEW

Name	Position	Date	Signature

МІНІСТЕРСТВО ЕНЕРГЕТИКИ ТА ВУГІЛЬНОЇ ПРОМИСЛОВОСТІ УКРАЇНИ
державне підприємство
“Національна атомна енергогенеруюча компанія “Енергоатом”
ВП «Атомпроектінжиніринг»

ORIGINAL

ЗАТВЕРДЖУЮ
Генеральний директор
ВП «Атмпроектінжиніринг»
_____ О. М. Рибчук
«___» _____ 2016 р.

ПОЛОЖЕННЯ

про групу управління проектом створення
Централізованого сховища відпрацьованого ядерного палива
(ЦСВЯП)

ПЛ-Д.0.46.038-16

Термін дії	
Інвентарний №	
Дата	

Термін дії продовжено до	
Номер повідомлення	
Дата	

АРКУШ ПОГОДЖЕННЯ

Посада	Підпис	Дата	Ініціали, прізвище
Заступник генерального директора – директор з нових ядерних установок			І. Ф. Орлов
Заступник генерального директора з питань створення єдиного комплексу поводження з відпрацьованим ядерним паливом			В. І. Холоша
Заступник директора з нових ядерних установок – начальник управління ЯУ, що створюються			В. Д. Медун
Заступник директора з нових ядерних установок – начальник управління голвних фахівців			Ю. В. Черепанов
Начальник управління з якості та ліцензування			І. М. Мітічкіна
Начальник відділу забезпечення якості та ліцензування			О. Г. Сиротинський

ЗМІСТ

Стор.

ПРИЙНЯТІ СКОРОЧЕННЯ 19

ТЕРМІНИ ТА ВИЗНАЧЕННЯ 20

1 ЗАГАЛЬНІ ПОЛОЖЕННЯ 21

2 ЗАВДАННЯ ТА ФУНКЦІЇ 23

3 ОРГАНІЗАЦІЙНА СТРУКТУРА 25

4 ВЗАЄМОВІДНОСИНИ 11

АРКУШ РЕЄСТРАЦІЇ ЗМІН 12

АРКУШ ОЗНАЙОМЛЕННЯ 28

ПРИЙНЯТІ СКОРОЧЕННЯ

АЕС	атомна електрична станція
ВП	відокремлений підрозділ
ВЯП	відпрацьоване ядерне паливо
ДП «НАЕК «Енергоатом»	Державне підприємство «Національна атомна енергогенеруюча компанія «Енергоатом»
Держатомрегулювання	Державна інспекція ядерного регулювання України
ДНТЦ ЯРБ	Державне підприємство «Державний науково-технічний центр з ядерної і радіаційної безпеки»
КМУ	Кабінет Міністрів України
КР	Концептуальне рішення "О внедрении на "пилотных" энергоблоках АЭС Украины модифицированной технологии обращения с отработавшим ядерным топливом для обеспечения отправки его в ЦХОЯТ"
Міненерговугілля	Міністерство енергетики та вугільної промисловості України
РАЕС	Рівненська атомна електростанція
ФЗ	фізичний захист
ХАЕС	Хмельницька атомна електростанція
ЦСВЯП	Централізоване сховище відпрацьованого ядерного палива
ЮУ АЕС	Южно-Українська атомна електростанція
ЯМ	ядерний матеріал
ЯРБ	ядерна та радіаційна безпека
ЯУ	ядерна установка

ТЕРМІНИ ТА ВИЗНАЧЕННЯ

Проект	Єдиний процес, який складається із сукупності скоординованих та контрольованих видів робіт з датами початку та закінчення, виконуваний задля досягнення цілі, що відповідає конкретним вимогам, і містить обмеження щодо строку, вартості та ресурсів (п. 3.5 ДСТУ ISO 10006:2005)
ЦСВЯП	Централізоване сховище відпрацьованого ядерного палива
Управління проектом	Планування, організування, моніторинг, контролювання та звітування щодо всіх аспектів проекту, а також стимулювання всіх його учасників для досягнення цілей проекту (п. 3.6 ДСТУ ISO 10006:2005)
Відповідальний виконавець	ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом»
Група управління проектом	Група, створена на період виконання проекту, яка **виконує проект** (п. 4.1.2 ДСТУ ISO 10006:2005)
Керівник проекту	Посадова особа з чітко визначеними відповідальністю та повноваженнями щодо керування проектом і забезпечення розробляння, запроваджування та підтримування системи управління якістю в проекті (п. 5.2.3 ДСТУ ISO 10006:2005)
Керівник ГУП	Посадова особа, відповідальна за керування роботою ГУП
Керівний комітет	Колегіальний орган із впровадження технології Холтек із поводження з відпрацьованим ядерним паливом на енергоблоках АЕС ДП «НАЕК «Енергоатом», функціонально пов'язаний з керівником проекту; отримує інформацію від ГУП і виконує наглядово-дорадчі функції (стратегічна підтримка проекту)
Кредитори	Міжнародні фінансові організації, що приймають участь у співфінансуванні Проекту
Майданчики	Територія, на якій буде реалізовуватись Проект ЦСВЯП
Центральний офіс ГУП	Частина ГУП, сформована з керівників та спеціалістів ВП «Атомпроектінжиніринг». Очолюється керівником ГУП.
ГУП на майданчику	Частина ГУП, сформована з керівників структурних підрозділів ВП АЕС. Очолюється керівником ГУП на майданчику.
Керівник ГУП на майданчику	Особа, призначена наказом генерального директора ВП АЕС, яка очолює ГУП на майданчику.

6 ЗАГАЛЬНІ ПОЛОЖЕННЯ

6.1 Це Положення про групу управління проектом будівництва Централізованого сховища відпрацьованого ядерного палива ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом» (далі – Положення) розроблене для виконання завдань зі створення Централізованого сховища відпрацьованого ядерного палива (далі – Проект ЦСВЯП, Проект).

6.2 Положення визначає порядок формування ГУП, її структуру, ролі членів ГУП, завдання та функції, а також взаємодію з структурними підрозділами Компанії, Консультантом ГУП, Кредиторами та іншими зацікавленими сторонами.

6.3 ГУП є об’єднаною групою, що сформована з керівників та спеціалістів структурних підрозділів ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом» (далі – ВП АПІ) та ВП АЕС.

6.4 Склад ГУП та розподіл завдань і функцій серед членів ГУП визначається наказом ВП АПІ і цим Положенням.

6.5 Місцезнаходження ГУП.

- Центральний офіс: Україна, 01032, Київ, вул. Гайдара, 6, приміщення ВП «Атомпроектінжиніринг»;
- ГУП на Майданчиках знаходяться у ВП ХАЕС, ВП РАЕС та ВП ЮУАЕС відповідно, і оперативно підпорядковуються ГУП Центрального офісу.

6.6 Положення розроблено з урахуванням вимог:

- Закону України «Про поводження з відпрацьованим ядерним паливом щодо розміщення, проектування та будівництва централізованого сховища відпрацьованого ядерного палива реакторів типу ВВЕР вітчизняних атомних електростанцій»
- Концептуального рішення "О внедрении на "пилотных" энергоблоках АЭС Украины модифицированной технологии обращения с отработавшим ядерным топливом для обеспечения отправки его в ЦХОЯТ"
- Постанови Кабінету Міністрів України від 26.11.2008 № 1027 «Про порядок ініціювання, підготовки та реалізації проектів економічного і соціального розвитку України, що підтримуються міжнародними фінансовими організаціями»;

- Наказу Міністерства фінансів України, Міністерства економіки та з питань європейської інтеграції України, Міністерства праці та соціальної політики України, Міністерства юстиції України від 29.10.2002 № 905/308/550/93/5 «Про затвердження Порядку діяльності груп управління проектами економічного і соціального розвитку України, які підтримуються міжнародними фінансовими організаціями»;
- Національного стандарту України «Системи управління якістю. Настанови щодо управління якістю в проектах» (ДСТУ ISO 10006:2005);

6.7 ГУП здійснює свою діяльність згідно з чинними нормативно-правовими актами і вимогами нормативних, виробничих, організаційно-розпорядчих та інших діючих у ВП АПІ документів.

6.8 Це Положення повинні знати керівники, які його погоджували, а також усі особи, що входять до складу ГУП.

6.9 З цим Положенням мають бути ознайомлені всі особи, що залучаються до проекту і матимуть стосунки з ГУП.

6.10 Це Положення повинно знаходитись у фонді виробничої документації ВП АПІ (оригінал), ВП ХАЕС, ВП РАЕС, ВП ЮУАЕС (враховані копії).

7 ЗАВДАННЯ ТА ФУНКЦІЇ

7.1 Метою діяльності ГУП є виконання проекту створення Централізованого сховища відпрацьованого ядерного палива.

7.2 Реалізація завдань Проекту забезпечується персоналом структурних підрозділів ВП АПІ відповідно до їх компетенції та роботою ГУП Працівники залучені до роботи в Проекті ЦСВЯП, повинні мати високу кваліфікацію і досвід, достатні для розуміння ними мети, завдань проекту і шляхів їх досягнення.

7.3 Завдання ГУП:

- поточне управління Проектом;
- розробка Плану реалізації Проекту і його підтримка в актуальному стані;
- забезпечення використання для цілей проекту діючої в Компанії нормативної і виробничої документації, запобігання створенню зайвих документів (вимоги яких дублюють наявні чинні процедури);
- розробка та оновлення загального графіку Проекту;
- розробка та оновлення детальних графіків для реалізації кожного етапу створення ЦСВЯП; організація діяльності ГУП з впровадження заходів К(з)ПБ відповідно до графіку Проекту;
- виконання умов кредитних угод;
- ефективна взаємодія з керівником проекту, координаційним комітетом, структурними підрозділами Компанії, центральними органами виконавчої влади, кредиторами в межах повноважень, визначених цим Положенням.

7.4 З метою виконання покладених на нього завдань Центральний офіс ГУП реалізує виробничо-технічні та фінансово-економічні функції, тісно і безпосередньо повязані між собою (але умовно розділені в цьому розділі для зручності сприйняття):

7.5 Виробничо-технічні функції:

- здійснення моніторингу реалізації Проекту;
- організація підготовки проекту договору;
- здійснення (у разі потреби) підготовки документів про внесення змін до Проекту;
- підготовка звітів щодо Проекту для подання до Керівного комітету;
- підготовка остаточного звіту за результатами реалізації Проекту;
- здійснення загального контролю за реалізацією Проекту, в тому числі дотримання графіку реалізації Проекту;
- управління ризиками Проекту;
- організація і проведення наради та переговори з питань Проекту;
- організація розробки та погодження документації для проведення конкурсних торгів;

- підготовка проектів наказів, розпоряджень та інших розпорядчих документів за Проектом; організація погодження цих організаційно-розпорядчих документів;
- управління ліцензуванням;
- контроль реалізації Проекту в частині забезпечення якості (шляхом проведення самооцінки, внутрішніх аудитів або іншими способами – в установленому порядку);
- контроль використання для цілей Проекту діючої в Компанії нормативної та виробничої документації з метою запобігання створенню зайвих документів;
- організація виконання плану природоохоронних та соціальних заходів;
- надання (за запитом) довідкової інформації до Прес-центру Компанії.

2.6 Фінансово-економічні функції:

- організація діяльності з фінансового управління Проектом;
- підготовка проектів платіжних документів за заявкою ВП – куратора договору (платіжних доручень, заяв тощо);
- здійснення супроводу платіжних документів;
- підготовка звітних фінансових документів, зберігання фінансових та інших звітних документів, необхідних для проведення аудиту Проекту;
- підготовка плану закупівель товарів (робіт, послуг) у рамках Проекту;
- організація підготовки звітів з питань закупівель щодо Проекту;
- здійснення підготовки і супроводження конкурсних торгів на закупівлю товарів, робіт, послуг;
- здійснення моніторингу виконання контрактів.

2.7 ГУП на майданчику:

- відповідає за реалізацію Проекту на майданчиках;
- забезпечує участь спеціалістів ВП АЕС у технічних та організаційних нарадах з питань реалізації Проекту;
- готує звіти, доповіді, довідкові матеріали на запити Центрального офісу ГУП;
- контролює розробку та погодження відповідних технічних документів спеціалістами АЕС (концептуальне рішення, технічні вимоги та умови постачання, технічне рішення на монтаж, програма випробувань та інше);

8 ОРГАНІЗАЦІЙНА СТРУКТУРА

8.1 Персональний склад ГУП призначається наказом президента Компанії.

8.2 Керівництво всім Проектом здійснює Керівник проекту – перший віце-президент – технічний директор. Для цього він має необхідні повноваження, визначені в посадовій інструкції і відповідних положеннях (про колегіальні органи і про структурні підрозділи Компанії).

8.3 З Керівником проекту функціонально пов'язаний керівний комітет із впровадження технології, який отримує інформацію від ГУП і виконує наглядово-дорадчі функції (стратегічна підтримка проекту).

8.4 Склад керівного комітету:

Голова керівного комітету – президент ДП «НАЕК «Енергоатом».

Члени керівного комітату:

- відповідальний виконавець «Холтек Інтернешнл»;
- начальник управління ядерної енергетики та атомно-промислдового комплексу Міненерговугілля;
- заступник директора департаменту з питань безпеки ядерних установок – державний інспектор Держатомрегулювання України;
- директор ДНТЦ ЯРБ;
- перший віце-президент – технчний директор ДП «НАЕК «Енергоатом», заступник голови комітету;
- віце-президент ДП «НАЕК «Енергоатом»;
- генеральний директор ВП РАЕС;
- генеральний директор ВП ХАЕС;
- генеральний директор ВП ЮУАЕС;
- голова правління ПАТ КІЕП;
- технічний директор ВАТ ХІЕП;
- генеральний директор ВП АПІ;
- керівник служби президента ДП «НАЕК «Енергоатом».

4 ВЗАЄМОВІДНОСИНИ

4.1 Керівник ГУП здійснює управління діяльністю ГУП.

4.2 В оперативному управлінні Керівника ГУП перебувають Керівники ГУП на майданчиках.

4.3 Персональний склад ГУП на майданчиках призначається відповідними наказами генеральних директорів ВП АЕС.

4.4 Керівник ГУП відповідає за виконання Проекту.

4.5 Керівник проекту та керівник ГУП призначаються президентом Компанії.
Координаційний комітет та персональний склад Групи управління проектом призначаються президентом Компанії за поданням Керівника проекту.
Керівник та персонал ГУП на майданчиках призначається наказами генеральних директорів ВП АЕС.
Кандидатури на посади спеціалістів ГУП подаються керівнику ГУП керівником відповідного підрозділу ВП АПІ.

4.6 Керівник проекту забезпечує управління і нагляд за всією роботою з реалізації Проекту.

4.7 Керівник ГУП здійснює контроль за виконанням плану закупівель, планів заходів з реалізації Проекту та з фінансування; взаємодіє з питань реалізації проекту з Кредиторами.

4.8 Перший заступник керівника ГУП із взаємодії з органами державної влади та кредиторами здійснює вищезазначені функції та виконує функції Керівника ГУП в разі його відсутності.

АРКУШ РЕЄСТРАЦІЇ ЗМІН

зміни	номери аркушів				повідомлення		підпис	дата
	змінених	замінених	нових	Анульованих	номер	к-сть аркушів		
1	2	3	4	5	6	7	8	9

АРКУШ ОЗНАЙОМЛЕННЯ

П.І.Б.	Посада	Дата	Підпис

Appendix C17

EnergAtom. 2013. General Guidelines for Integrated Management System. IS-M.0.06.145-13.

МІНІСТЕРСТВО ЕНЕРГЕТИКИ ТА ВУГІЛЬНОЇ ПРОМИСЛОВОСТІ УКРАЇНИ
Державне підприємство
«Національна атомна енергогенеруюча компанія «Енергоатом»
ДП «НАЕК «ЕНЕРГОАТОМ»

APPROVED
The Acting President
SE "" Energoatom "
_____ V. Kim
"____" _____ 2013

General guidelines
With integrated management system
SE "" Energoatom "

IS-M.0.06.145-13

Термін дії до:			Термін дії подовжено до:		
Інвентарний №:			№ повідомлення:		
Дата:			Дата:		

LEAF approval
Position Signature Date initials and surname
First Vice-President - Technical Director A. Shavlakov
Inspector General - Director for Security D. white
Vice President V. Magnificent
Vice President AA Aysin
Vice President of VE Ukrainian
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CEO producing VA Tailor
Executive Director to ensure the production of SP Buchko
Deputy Inspector General - director of safety supervision VP Novikov
Director VV repairs Urbanskiy
Director of Physical Protection and NF NM and WB EV Makarenko
Director of the Control and Audit of SM Sidoruk
ZNPP number 81-50 / 9134 of 11/04/2013 PA Puhlyar
RNPP number 031 / F-1221 from 4/11/2013 BG Tour
SU NPP number 45/5773 from 11.04.2013 VA Bohatchuk
KhNPP № 56-13 / 2-139 / 3612 of 10/04/2013 MG Flint

CONTENT

Найменування частин, розділів та підрозділів	Відповідає НП і стандартам				С.
	9001	14001	НП-190	НП-182	

INTRODUCTION 5

1 GENERAL 2.4 1.1-1.3 8

SCOPE 1.1 8

REVIEW PROCEDURES 10 1.2 GUIDELINES

NORMATIVE REFERENCES 2 2 11

ACCEPT TERMS, DEFINITIONS AND ABBREVIATIONS MARCH 3 1.4 1.4 15

INTEGRATED MANAGEMENT SYSTEM 17 2.6 APR. 4

GENERAL REQUIREMENTS 4.1 4.1 2.1 17

PROCESS APPROACH 19

PROCESS CONTROL SYSTEM MANAGEMENT COMPANY 21

4.3.1 LIST OF PROCESSES MANAGEMENT DIRECTORATE 21

4.3.2 IMPLEMENTATION PROCESSES THIRD PARTIES OR OTHER DEPARTMENTS 23

DOCUMENTATION REQUIREMENTS 4.2 4.4.4-4.4.5, 4.5.4 2.3, 4.2, 4.4- 4.11, 7.2-7.4 4.1-4.4, 7.1-7.2 23

RECORDS MANAGEMENT (MINUTES) 27

DOCUMENT 28

MANAGEMENT'S RESPONSIBILITY 5 2.5 29

MANAGEMENT COMMITMENT 5.1 4.1, V (5.1-5.6) V 29

ORIENTATION TO THE CUSTOMER 5.2 7.7 30

SECURITY POLICY, QUALITY AND ENVIRONMENT 5.3 4.2 2.2 4.3 32

PLANNING 5.4 2.1-2.2 33

OBJECTIVES 4.3.2-4.3.3 34

RESPONSIBILITY AND AUTHORITY 4.4.3 5.5 4.13 4.5 35

REPRESENTATIVES OF THE 40

INTERNAL AND EXTERNAL INFORMATION 41

CIVIL PROTECTION AND EMERGENCY RESPONSE 4.4.7 43

MANAGEMENT REVIEW 5.6 4.6 44

HUMAN RESOURCES 6 46

PROVISION OF RESOURCES 6.1 4.4.1 6.1 46

PERSONNEL MANAGEMENT 6.1.1 6.2 4.4.2 6.2-6.6 VI 46

6.1.2 SOCIAL AND MOTIVATION OF STAFF 46

6.1.3 COMPETENCE, AWARENESS AND TRAINING 47

FORMATION AND SUPPORT OF CULTURE AND SAFETY CULTURE PROTECTION 3.1-3.4 III 48

6.2.1 THE PROGRAM MEASURES 48

6.2.2 COLLEGIAL BODY 49

6.2.3 ASSESSMENT 49

INFRASTRUCTURE AND PRODUCTION ENVIRONMENT 6.3 6.4 50

HEALTH, MEDICAL CARE AND CONTROL 50

OUTPUT 7 52

PLANNING OF PRODUCT 7.1 4.3 52

PROCESSES RELATED CUSTOMER 7.2 7.1 52

7.2.1 DETERMINATION OF REQUIREMENTS RELATED TO PRODUCTION 52

7.2.2 REVIEW OF REQUIREMENTS RELATED TO PRODUCTION 54

7.2.3 COMMUNICATION WITH CUSTOMERS 54

DESIGN AND DEVELOPMENT 7.3 7.5 55

PLANNING AND DESIGN 7.3.1 ROZROBLYANNYA 55

7.3.2 INPUT FOR DESIGN AND ROZROBLYANNYA 56

7.3.3 BACKGROUND DESIGN AND ROZROBLYANNYA 57

7.3.4 CRITICAL REVIEWS OF DESIGN AND DEVELOPMENT 57

7.3.5 VERIFICATION OF DESIGN AND DEVELOPMENT 58

PROCUREMENT 7.4 7.5 7.3-7.4 59

PRODUCTION AND SERVICE 62 7.5

7.5.1 VALIDATION OF PROCESSES FOR PRODUCTION AND SERVICE PROVISION 62

7.5.2 IDENTIFICATION AND TRACEABILITY 63

7.5.3 OWNERSHIP OF THE

CUSTOMER 63

7.5.4 SAVING PRODUCTS 64

CONTROL OF MONITORING AND MEASURING DEVICES 64 7.6

MEASUREMENT, ANALYSIS AND IMPROVEMENT 8 4.5 4.12, VIII 66

GENERAL 8.1 66

MONITORING AND MEASUREMENT OF PROCESSES 4.5.1 8.2 7.6 7.6 67

MONITORING, MEASUREMENT AND CONTROL OF NONCONFORMING PRODUCT 68

ANALYSIS OF DATA 8.4 4.6 2.3 72

IMPROVEMENT 72 8.5

CORRECTIVE ACTION 8.5.1 4.4.6 8.3, 4.5.2 7.7 72

8.5.2 PREVENTIVE ACTION 72

REGISTRATION SHEET CHANGES 74

SHEET REVIEW 75

INTRODUCTION

State Enterprise "National Nuclear Energy Generating Company" Energoatom "(hereinafter - SE" "Energoatom") is a legal entity created under the Cabinet of Ministers of Ukraine "On establishment of the National Nuclear Energy Generating Company" Energoatom "of October 17, 1996 № 1268 pursuant Law of Ukraine "On nuclear energy use and radiation safety".

SE "" Energoatom "was established on the basis of property of nuclear power plants and their infrastructures, included in its membership the rights of separated units (IU) as VP" Zaporizhzhya NPP "SE" South-Ukrainian NPP "GC" Chornobyl NPP "EP "Rivne NPP" and SE "Khmelnitsky NPP." In July 2001, the EP "Chornobyl NPP" stood out as an independent state specialized enterprise "Chernobyl NPP" according to the Cabinet of Ministers of Ukraine of 25.04.2001 number 399 "On establishment of the State Specialized Enterprise" Chernobyl NPP ".

SE "" Energoatom "belongs to the Ministry of Energy and Coal Industry of Ukraine - state authority in the sphere of nuclear energy and radiation safety. The purpose, nature of business, assets, rights and obligations, principles of administration SE "" Energoatom "entity as defined by the Statute (CSS-P.0.10.001-13); goals, objectives, basic functions, responsibilities and rights as the operating organization - "Regulations on the operating organizations (operator) of Nuclear Installations SE" "Energoatom" (PL-C 0.06.002-13) (change, change №1).

SE "" Energoatom "the licenses and permits licensing authorities to carry out activities in accordance with the law.

Location SE "" Energoatom "Street. Nazarivska 3, m. Kyiv, 01032, Ukraine. (Change, change №2)

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e.teterina@direkcy.atom.gov.ua

http://www.energoatom.kiev.ua/ua/contact/feedback.html

Separated subdivisions SE "" Energoatom "

	Zaporizhzhya NPP Number of units - 6 Type reactor - VVER-1000 Total capacity - 6000 MW NPP satellite towns - Energodar, Zaporizhia region c. Energodar Zaporozhye region. Ukraine, 71504 tel .: +38 (06139) 3-38-78 Fax: +38 (06139) 5-55-33 Information: +38 (06139) 5-62-09 http://www.npp.zp.ua/	
	Rivne NPP Number of units - 4 Type reactor - VVER-440 (the first and second blocks) -1000 (Third and fourth) Total capacity - 2835 MW NPP satellite towns - Kuznetsovsk, Rivne region m. Kuznetsovsk, Rivne region. 34400, Ukraine Email: pr@rnpp.atom.gov.ua Office@rnpp.atom.gov.ua Admissions Director General: 6-41-74, 3-85-69; General department: 6-43-49, 3-59-17.	
	South Ukrainian NPP Number of units - 3 Type reactor - VVER-1000 Total capacity - 3000 MW NPP satellite towns - Yuzhnoukrainsk, Mykolaiv region c. Yuzhnoukrainsk, Mykolaiv region.	

	55000, Ukraine Tel .: +38 (044) 227-26-61; +38 (05136) 5-13-32, 4-22-22 Fax: +38 (05136) 04.11.70, 2-18-32 E-mail: office@sunpp.atom.gov.ua	
	Alexander GES and GAES included in the energy industry NPP THAPS has 2 units and is designed to cover peak loads in the southwestern part of the unified energy system of Ukraine, as well as to ensure the basic mode of the NPP.	
	Khmelnitsky NPP Number of units - 2 Type reactor - VVER-1000 Total capacity - 2000 MW NPP satellite towns - Netishyn, Netishyn Khmelnytsky region, Khmelnitsky region, 30100 Phone: (+ 380-3842) 33350 Fax: (+ 380-3842) 33360 e-mail: office@khnpp.atom.gov.ua	
	Donuzlavskaya WEIGHT November 14, 2008 the Ministry of Fuel and Energy of Ukraine decided to join SE "Donuzlavskaya WEIGHT" of the "Energoatom". In December 2008, the Company's Board agreed on the creation of a separate division "Donuzlavskaya WEIGHT" "Energoatom".	
	Atomremontservis The main objective of the CAP "Atomremontservis" - safe and efficient execution of complex and pozarehlamentnyh repair work, including work on the construction, repair, reconstruction and modernization of equipment for nuclear power plants. In addition, APC is a member of international projects at Chernobyl. Located in Slavutych.	
	Atomkomplekt EP "Atomkomlekt" created to provide centralized supplies of material and technical resources for nuclear power plants. Located in Kiev on the street. Zhylianska, 108.	

	- Atomenergomash - The structure of the unit consists of three separate plants: - · Special plant constructions (c. Energodar, Zaporizhia region). - · Plant optional equipment and pipelines (c. Energodar, Zaporizhia region). - · Repair and Engineering Works (c. Yuzhnoukrainsk, Mykolaiv region). - OP "Atomenergomash" specializes in: - - The development and manufacture of heat transfer and mechanical equipment, components for NPP pipelines, parts TVS; execution unit repair of heat transfer equipment for nuclear power plants; - - Manufacture of steel structures, containers for radioactive waste and spent nuclear fuel, thermal insulation, doors, Containment Prestressing System for NPP; - - Manufacture of special and building structures.

	Scientific and Technical Center The purpose of in 2003. VP SEC is formation in Ukraine complex and effective system of scientific and technical support for nuclear energy, the optimal use of intellectual and technical potential of scientific and engineering organizations that provide for NPP 01054, m. Kyiv, vul. B. Hmelnyts- who, 63A Phone: +38 (044) 206-97-21, Fax: +38 (044) 206-97-25 e-mail: v.ponomaryova@ntc.atom.gov.ua (assistant director)	
	Atomproektinzhynirynh The purpose of the CAP is the work of new capital construction and completion of current construction of nuclear facilities, and the implementation of investment projects "Energoatom" 01033, Kyiv, st. Gaidar, 6 Admissions Director General: Tel .: (044) 206-97-87 General Department: Tel. / Fax: (044) 201-09-03 E-mail: office_api@direkcy.atom.gov.ua	
	Перевести Аварійно-технічний центр ВП «Аварійно-технічний центр» створений для забезпечення готовності України до швидких та ефективних дій у разі виникнення аварій на підприємствах атомної енергетики і промисловості відповідно до міжнародних зобов'язань МАГАТЕ щодо створення національної системи ліквідації наслідків ядерних катастроф і аварій 08140, вул. Прип'ятська, 1, с.Білогородка, Києво-святошинського р-ну, Київська обл., Україна Телефони: комутатор (044) 406-5670, факс (044) 406-5680, приймальня (044) 406-5652 Електронні пошта: info@atc.gov.ua	

	560/5000 Emergency and Technical Center EP "Emergency and Technical Center" was created to ensure the readiness of Ukraine to rapid and effective action in case of accidents at nuclear power plants and industry in accordance with the international obligations of the IAEA to create a national system of elimination of consequences of nuclear disasters and accidents 08140, st. Pripyat 1, s.Bilohorodka, Kiev Svyatoshinsky district, Kyiv region., Ukraine Phones: switch (044) 406-5670, fax (044) 406-5680, reception (044) 406-5652 Email: info@atc.gov.ua	
Warehousing Separated subdivision "Warehousing" is created to ensure the effective use of stocks of inventory in accordance with the requirements, rules and safety standards Ukraine, 34400 Rivne region., M. Kuznetsovsk, SE "Rivne NPP" Tel. (03636) 3-41-36		
CB "Atomprylad" EP "CB" Atomprylad "was established in June 2010 with the reorganization by joining SE" "Energoatom" State Science and Technology Enterprise "Ukrenerhoefektyvnist" (field of activity - a special power instrumentation) (change, change №2) 01032, m. Kyiv st. Tolstoy, 59. Tel. (044) 277-7914 fax (044) 277-7931 e-mail: ee@eff.atom.gov.ua		
Office of the (added, changing №3) Pursuant to the decision of the Board of the Company on 31.07.2002. №38 in August 2002 established OP "Administrative Department", which aims to increase the economic activity of the service SE "" Energoatom "01032, m. Kyiv, vul. Franko, 31. Tel. (044) 277-7851 fax (044) 277-7866 e-mail: a.osaulenko@direkcy.atom.gov.ua		

Automation and Engineering (uploaded, changing №3) **Pursuant to the decision of the Board of the Company on 14.11.2014 №9 / 14 was created SE "Automation and Engineering", whose goal is the development, modernization, production of special equipment and control systems, control, signaling, communication and process automation 52210, m . Vody, Dnipropetrovsk region., street. Gagarina 4** **Tel. (05652) 9-33-47** **fax (05652) 5-51-33** **e-mail: npkam@ukrpost.net**
Representation "SE" "Energoatom" in Brussels (Belgium) (uploaded, changing №3) **Pursuant to the decision of the Board of the Company of 12.5.2014 p. №3 / 14 set of "SE" "Energoatom" in Brussels (Belgium), which aims to support organizational and representational issues related to the implementation of international projects SE "Energoatom "Energoatom» Royaume de Belgique** **1150 Bruxelles, Avenue de Tervuren, 429** **Tel. +3227625467** **mob. +32485705197** **e-mail: anddii.tiurin@ukr.net**

General organizational structure of "" Energoatom "presented on the website of the Company: http://www.energoatom.kiev.ua/ua/about_nngc/management/structure.htm),

and more - in the "Regulations on the organizational structure" Energoatom "PL-S.0.06.003-10.

TERMS

1.1 Scope

1.1.1 "General guidance on integrated management of SE" "Energoatom" (hereinafter - Guidelines) developed instead of "Guide to Quality, general NNEGC" Energoatom "LCD 0.06.026-06 M and is mandatory for all structural OP units and the Management Company.

1.1.2 The interpretation of the concept of "integrated management system" (or "integrated management system", which is equivalent to the English «integrated management system») listed in section 4 of this guideline.

1.1.3 Guidance is the founding document of a higher level, which integrates the Company established requirements for management systems (sets and / or links to already existing requirements). Scope The guidelines apply to all areas and activities of the Company as defined in the Charter [US-P.0.10.001-13], "Regulations on the operating organization (operator) of Nuclear Installations SE" "Energoatom" PL-C 0.06.002- 13 (change, change №1), standard enterprise "Organization management processes. Klassyfykator directed activities "(STP 0.06.007-2006).

1.1.4 Guidance is a general description of the system of State Enterprise "" Energoatom "developed according to the requirements of section 4 [37] subject to standards [27 - 30] and states:

• The company's management policy in the field of safety, quality and other areas;

• list and general description applicable to the management of process models and core processes (including those that affect the nuclear and radiation safety);

• hierarchical management system documentation.

1.1.5 Software development, implementation and maintenance of an integrated management system aimed at providing the necessary conditions for the proper performance of work the first time, the organization works on the principle of "Plan - Observe - Check - Act", which provides that:

• managers provide planning, management, resources and support staff to achieve the set objectives;

• personnel performing work ensures the quality of the work;

• personnel performing the assessment, analyzes the quality and effectiveness of the management process and monitors compliance of the results of the established quality indicators.

1.1.6 If the certification of integrated management system is the main guidance document confirming compliance with the certification requirements of the ISU.

1.1.7 Withdrawal of claims relating to section 7 standards ISO [27, 28] due to the specific production - and do not affect the company's ability to produce products that meet customer requirements, applicable statutory and regulatory requirements.

1.1.7.1 For requirements of paragraph. 7.3.1 "Design and development planning" is considered not design their own production (electricity and heat), and participated in the design, carried out the modernization, renovation, construction of new facilities, etc. (more - in r.7.3 Guidelines).

1.1.7.2 For requirements of paragraph. 7.5.3 "Identification and traceability" shall not be directly identifying electric (heat) energy as physically possible to identify VP produced nuclear energy after the issuance of its customers. As seen come identification of production facilities, process equipment and documentation.

1.1.7.3 Requirements p.7.5.4 "customer property" is not considered in this guideline because the company does not use in the manufacturing process and does not control any property of the customer.

1.1.7.4 For requirements p.7.5.5 not seen directly saving products (electricity and heat) and storage of inventory used in the process.

1.1.8 In developing the guidelines included requirements:

• NP 306.2.141-2008 "General Safety of Nuclear Power Plants";

• NP 306.1.190-2012 "General requirements for the management activities in the field of nuclear energy";

• NP 306.1.182-2012 "System Requirements management of the operating organization (operator)";

• ISO 9001: 2009 "Quality Management Systems. Requirements" which is identical to ISO 9001: 2008 Quality Management Systems - Requirements;

• of ISO 14001: 2006 "Environmental Management Systems. Requirements and Guidelines for Application", which is the authentic text of ISO 14001: 2004 Environmental Management Systems - Requirements With Guidance For Use;

• ISO ISO / TR 10013: 2003 "Guidelines rozroblyannya quality management system documentation," which is identical to the international standard ISO / TR 10013: 2001 Guidelines For Quality Management System Documentation.

1.1.9 As reference materials used in the design guidelines:

• GS-R-3 "IAEA norms on safety. The system management for installations and activities. Guide to safety";

• GS-G-3.1 "IAEA norms for security. Application management systems for facilities and activities. Guide to safety";

• GS-G-3.5 "IAEA Safety Standards. The Management System for Nuclear Installations. Safety Guide

SE Companies should be developed with the guidance of management (management) separate unit, subject to this guideline, the specifics of their activities and management of relationships with other CAP and the Board of Directors of the Company.

1.1.1 The recorded copy control guidelines of the EP should be sent to the Board of Directors of the Company (in VDYAU).

1.1.2 Adoption and approval of the Guidelines confirms leadership review this document.

1.2 Procedure review guidelines

1.2.1 to review and amend guidelines as is the continued support of the document in the state that meets the current and urgent requirements. Guidelines are subject to review, update (if necessary) periodically once in 5 years.

1.2.2 The guidance is adjusted by changes in the following cases:

• due to changes in applicable law or applicable requirements when entering new regulations;

• the analysis and evaluation of management from the management of SE "" Energoatom ";

• the recommendations of the public administration and regulation;

• the results of certification / surveillance audits management system.

1.2.3 Responsible for the maintenance department are guidelines and quality control VDYAU.

1.2.4 The guidance should be in:

• Fund the production documentation Management of the Company (the original);

• VP of the Company (copies included);

• Management of all structural units of the Company (copies included).

normative References

1 of 08.02.1995 number 39 / 95- Law of Ukraine "On Nuclear Energy Use and Radiation Safety" (amended)

2 of 16.10.1997 number 575/97-BP Law of Ukraine "On Electricity" (amended)

3. The number of 1370 11.01.2000 XIV Law of Ukraine "On licensing activities in the field of nuclear energy" (as amended)

4 from 10.04.2014 number 1197-VII Law of Ukraine "On public procurement" (change, change №2)

5 from 24.05.2012 number 4851-VI Law of Ukraine "On peculiarities procurement in certain sectors of economic activity"

6. from 17.05.2001 number 2406-III Law of Ukraine "On Conformity Assessment" (amended)

7 of 19.10.2000 number 2064-III Law of Ukraine "On the physical protection of nuclear facilities, nuclear materials, radioactive waste and other sources of ionizing radiation" (amended)

8 of 20.03.2003 number 638-IV Law of Ukraine "On Fighting Terrorism"

9 from 13.01.2011 number 2939 VI Law of Ukraine "On Access to Public Information"

10. CMU from 01.02.2012, the number 58 on approval of a plan for conducting educational work with the population living in areas of surveillance of nuclear power plants

11. CMU from 30.03.1998 number 391 on approval of the state system of environmental monitoring (as amended)

12. CMU from 09.03.1999 number 343 on approval of the organization and monitoring in the field of air (as amended)

13. CMU from 01.08.1992 number 442 on the Procedure of certification of workplaces on working conditions (amended)

14. CMU from 30.11.2011 number 1232 Some issues of investigation and registration of accidents, occupational diseases and accidents at work

15. CMU from 22.03.2001 number 270 approving the procedure of investigation and registration of accidents outside work

16. CMU from 26.12.2003 № 2030 On approval of the accounting fires and their consequences (as amended)

17. CMU from 21.07.2005 number 630 on approval of the Rules of provision of central heating, hot and cold water and drainage and a model contract for services of central heating, hot and cold water and sanitation (as amended)

18. NERC number 898 from 12.10.2005 On Approval procedure review and approval of tariffs for licensees for the production of electricity and heat

19. NERC number 896 from 12.10.2005 On Approval of the calculation of tariffs for electric and heat energy produced by TPP, TPP, NPP and on installations using non-conventional or renewable energy sources

20. The State Committee of Statistics of Ukraine of 05.12.2008 №489 On approval of standard forms of primary records of Labor Statistics (as amended)

CMU from 11.05.2011 number 560 approving the procedure approval of construction projects and conduct their examination and recognition as being invalid some decisions of the Cabinet of Ministers of Ukraine

1. Order of the Ministry of Health of Ukraine of 21.05.2007 number 246 on approval of the medical examination of certain categories of workers

2. Order of the Ministry of Health of Ukraine of 27.12.2001 number 528 Hygienic classification of work in terms of hazard and danger environment factors, severity and intensity of the work process

3. Annex 10 to the Agreement between members of the Wholesale Electricity Market of 15.11.1996 Instructions on commercial accounting of electric power

4. GOST 13109-97 Elektrycheskaya energy. Electromagnetic compatibility of technical assets. Norms quality of electrical energy in electric power systems, general purpose

5 of ISO 9000: 2007 Quality Management Systems. Terms and Glossary

6. ISO 9001: 2008 Quality management systems - Requirements

7. ISO 9001: 2009 Quality Management Systems. Requirements

8. ISO 14001: 2004 Environmental management systems - Requirements with guidance for use

9 of ISO 14001: 2006 Environmental Management Systems. Requirements and Guidelines for use

10. Preparation System GATS 95.1.07.04.047-2000 personnel AES Ukraine

11. NRBU- 97

DHN

6.6.1.-6.5.001-98 Radiation Safety Standards of Ukraine. Public hygiene standards

12. NRBU-97 / D-2000

DHN 6.6.1-6.5.061-2000 Radiation Safety Standards of Ukraine. Supplement: Radiation protection from potential exposure. Public hygiene standards

13. NP 306.2.141-2008 General safety of nuclear power stations

14. Requirements for emergency 306.2.106-2005 modifications of nuclear installations and their safety evaluation procedure

15. The state of emergency rules 306.6.124-2006 nuclear safety in Transport of Radioactive Materials (PRM PB-2006)

16. NP 306.1.190-2012 General requirements for management activities in the field of nuclear energy

17.

NP 306.1.182-2012

System Requirements management of the operating organization (operator)

18. 306.1.180-2012 emergency conditions and procedure for issuing licenses for operating activities of officials

19. The state of emergency rules 306.2.103-2004 licensing of personnel with direct control of nuclear reactor

20. The state of emergency rules 306.2.104-2004 licensing of personnel to operate nuclear facilities

21. DSP

6.177-2005-09-02 Basic sanitary rules of radiation safety of Ukraine

Accept Terms, definitions and abbreviations

This document definitions and terms shall have the meanings set out in the Laws of Ukraine [1-3], as well as general requirements [37] and ISO standard [26].

adopted reduction

ISO - International Organization for Standardization (International organization for Standartization)

NPP - nuclear power station

DKSP

- Directorate of Personnel and Social Affairs (change, change №3)

VDYuPtaSPZ - executive management on legal issues and support procurement (change, change №1)

VDYAU - Executive Directorate for Quality and Management

VDYaRBiNTP - Executive management of nuclear and radiation safety and technical support

VP - separate unit

SNF - spent nuclear fuel

SNRCU - State Nuclear Regulatory Inspectorate of Ukraine

DNB - Directorate of safety oversight

SE "" Energoatom "," Energoatom "- State Enterprise" National Nuclear Energy Generating Company "Energoatom"

GOST - State Standard of Ukraine

DYARB - Directorate for Nuclear and Radiation Safety

EO - operating organization

ISU - Integrated management system

KB - safety culture

CMU - Cabinet of Ministers of Ukraine

IAEA - International Atomic Energy Agency

Minenergouglya - Ministry of Energy and Coal Industry of Ukraine

MoF - Ministry of Finance of Ukraine

ND - normative document

SE NEC "Ukrenergo" - The State Enterprise "National Power Company" Ukrenergo "

NKREKP - National Commission for state regulation in the energy and utilities (change, change №2)

CS - rules and regulations

IPS - united energy system

PORP - provisions on the organization of staff

PPR - preventive maintenance

RW - radioactive waste

SB - special security

CSR - systems important to safety

SOU - Standard of Ukraine

TEP - technical and economic indicators

TMC - material assets

NM - nuclear materials

NF - nuclear plant

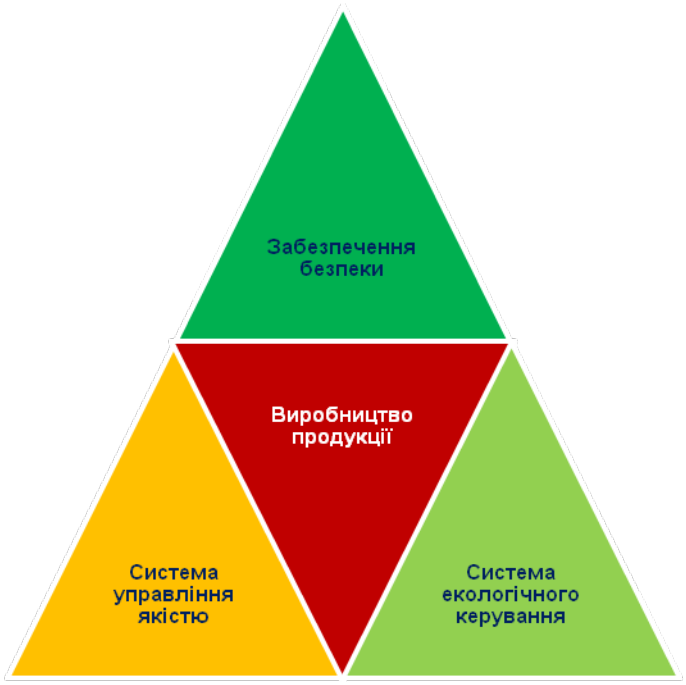
NTEGRATED MANAGEMENT SYSTEM

1.1 General Requirements

1.1.1 The concept of "integrated management system" (or "integrated management system", which is equivalent to the English «integrated management system», as defined in the Glossary IAEA) means a single management system organization in which all the components are combined (integrated) to ensure achievement of the organization (Figure 1). These components include: organizational structure, organizational processes and all types of resources.

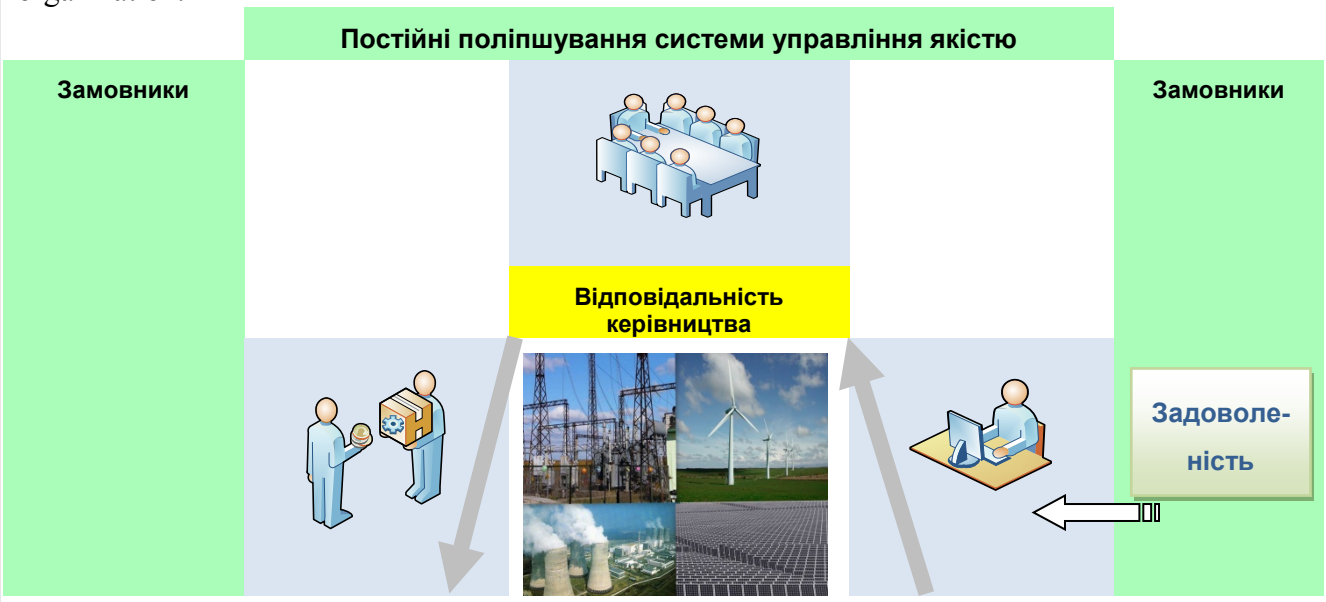
1.1.2 General requirements for management activities in the field of nuclear energy by emergency in [37] and detailed regarding management of the operating organization (operator) in emergency [38].

Figure 1 Conceptual model of integrated management system of the Company



1.1.3 Management of production (electricity and heat) is a network of interconnected processes that create value for customers and of customers, stakeholders and society at large. This activity is based on the observance of the Law of Ukraine rules, regulations and standards on nuclear and radiation safety, technical operation rules and other documents listed in this Guide r2 and "List of existing regulations of the operating organization" PR D.0.06 .555-16 (list of Sun EO) (change, change №2,4).

1.1.4 Production at the plant associated with the creation of untargeted results processes - spent nuclear fuel, radioactive waste and other waste. Therefore, safety, quality management, environmental management and related processes (resource management, infrastructure, economy and finance, etc.) Is also a network of interconnected processes that create added value to the organization.



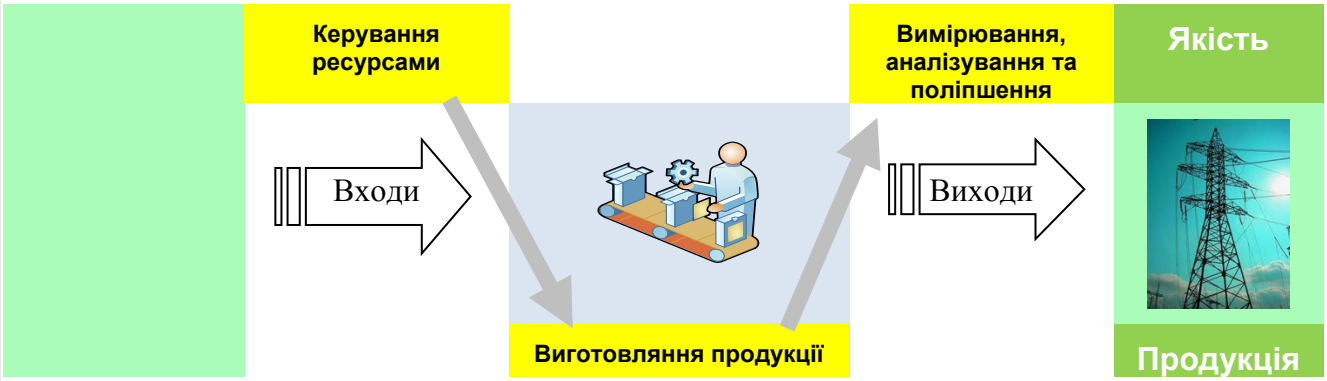


Figure 2 Model of MIS Quality Management Company

1.1.1 Model of Environmental Management of the Company considers MIS requirements of ISO standards [29] and [30] and follows the model recommended by these standards (Figure 3).

1.1.2 MIS Company based on the following principles:

• priority of safety requirements on economic, technical, scientific and other purposes;

• ensuring continuous and systematic monitoring compliance with safety requirements;

• providing planning, management and supervision of affecting the safety in normal, transient and emergency conditions;

• formation and support a culture of safety and security culture;

• establishing personal responsibility of top management priority for the allocation of resources necessary to meet the requirements of safety;

• prevention of violations of safety through constant analysis of its activities and corrective and preventive measures.

Fig.3 Model of Environmental Management MIS Company

1.1 Process approach

1.1.1 One of the principles of construction of MIS Company is process approach - consideration of a set of interconnected and interacting organizational processes undertaken structural units SE "" Energoatom ".

1.1.2 Subject fields, MIS processes can be grouped on the basis of similarity of that role that they play in the management of:

• Group strategic processes / administration;

• Group processes with financial management and economy;

• Group productions and processes to ensure safety;

• Group processes in human resources management;

• Group processes in material management;

• Group process monitoring and control.

1.1.3 Given the accepted model of quality management systems and environmental management, production characteristics and functional relations directorate management structure, composition / decomposition processes in groups and management company VP define yourself.

1.1.4 To demonstrate the relationships in the process of being developed Albums / card processes that are informational and are updated as necessary.

1.1.5 Depending on the level of decision-making in the MIS companies established three levels or more processes (Figure 4)

Figure 4 Levels processes in MIS Company

The first - the strategic level - the top management of SE "" Energoatom "determines the strategy, objectives and policies of the organization in key areas, including safety, quality, environment, human resource management.

For the Board of Directors of the Company, taking into account the distribution of powers in the organizational structure, the first level of senior management defines processes and MIS unit managers - owners of these processes.

Owners processes empowered to set goals, objectives, means and methods of achieving them, identify the necessary resources for its process and must ensure effective process control. The owners of processes, in turn, determine the structural units - members of subprocesses and their leaders (owners processes at the second level). For this directorate level branches and / or departments.

At the third level subprocesses owners determine the stage leaders processes (for directorate - level departments or divisions).

The fourth (or more) levels implemented specific functions and tasks relevant stage of the process and ensures compliance to processes (process steps) in the workplace.

1.1.1 Subdivisions considered as internal customers and consumers at the same time. The result of a structural unit (output) is input for other activities (other) departments. According to this principle are built relationships in the organizational structure of the Company.

Transition from functional to process approach in the management of the Company aims to ensure the effectiveness and efficiency of MIS management by applying the methodology known as "Planning - Implementation - Evaluation - Improvement."

Processes management directorate

Given the large size of the Company as a whole, the complexity of processes and their interactions, high competence of personnel, processes, management systems, implemented with the participation and / or under the supervision of specialized structural units of the Board of Directors of the Company are described in the maps of processes and documentation, links to which are in this guideline.

1.1.1 List of management processes Management of SE "" Energoatom "are shown in Table 1.

1.1 TABLE 1

1.2 GROUP NUMBER / NAME OF DIRECTOR (OWNER) PROCESS

1.3 1. STRATEGIC MANAGEMENT PRESIDENT

1.4 1.1 FORMATION OF POLICIES, GOALS, STRATEGIC OBJECTIVES, ANALYSIS OF THE SENIOR PRESIDENT (TOGETHER WITH COLLECTIVE BODIES OF THE COMPANY DYV.P.5.8.4)

1.5 1.2 MANAGEMENT OF ECONOMY AND FINANCE VICE PRESIDENT / DIRECTOR OF FINANCE AND BUDGETING, DIRECTOR OF ECONOMIC AFFAIRS (CHANGE, CHANGE №1)

1.6 2. ADMINISTRATION OF THE PRESIDENT

1.7 2.1 MANAGEMENT ORGANIZATIONAL STRUCTURE (DISTRIBUTION OF FUNCTIONS, POWERS AND RESPONSIBILITIES) EXECUTIVE DIRECTOR FOR QUALITY AND MANAGEMENT

1.8 2.2 THE SYSTEM OF QUALITY, STANDARDIZATION, LICENSING, INTERNATIONAL COOPERATION EXECUTIVE DIRECTOR FOR QUALITY AND MANAGEMENT

1.9 2.3 MANAGEMENT OF LEGAL ISSUES EXECUTIVE DIRECTOR ON LEGAL ISSUES AND SUPPORT PROCUREMENT (CHANGE, CHANGE №1)

1.10 2.4 MANAGEMENT EXECUTIVE DIRECTOR GENERAL QUESTIONS OF NUCLEAR FUEL PROCUREMENT AND INFORMATION MANAGEMENT (CHANGE, CHANGE №1)

1.11 3. THE PRODUCTION OF PRODUCTS, ENSURING OPERATIONAL SAFETY FIRST VICE-PRESIDENT - TECHNICAL DIRECTOR

1.12 3.1 MANAGEMENT OF MAINTENANCE AND REPAIR OF TECHNOLOGICAL COMPLEX AES VICE PRESIDENT

1.13 3.2 PLANNING ELECTRICITY AND MAINTENANCE MANUAL PROCESSING FACILITY NPP EXECUTIVE DIRECTOR OF PRODUCTION

1.14 3.3 EMERGENCY MANAGEMENT, EMERGENCY PREPAREDNESS EXECUTIVE DIRECTOR OF PRODUCTION

1.15 3.4 REHABILITATION, MODERNIZATION, SERVICE LIFE EXTENSION EXECUTIVE DIRECTOR OF PRODUCTION

1.16 3.5 MANAGEMENT OF SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE EXECUTIVE DIRECTOR FOR NUCLEAR AND RADIATION SAFETY AND TECHNICAL SUPPORT

1.17 3.6 MANAGEMENT ENVIRONMENT, INTERNAL INFORMATION ABOUT THE ENVIRONMENTAL IMPACT OF EXECUTIVE DIRECTOR OF NUCLEAR SAFETY AND TECHNICAL SUPPORT

1.18 4. HUMAN RESOURCE MANAGEMENT PRESIDENT

1.19 4.1 MANAGEMENT PERSONNEL AND SOCIAL ISSUES DIRECTOR OF PERSONNEL AND SOCIAL AFFAIRS (CHANGE, CHANGE №3)

1.20 4.2 MANAGEMENT QUALIFIED PERSONNEL EXECUTIVE DIRECTOR OF NUCLEAR SAFETY AND TECHNICAL SUPPORT

1.21 5. PROCUREMENT MANAGEMENT VICE PRESIDENT

1.22 5.1 MANAGE THE PROCUREMENT OF EQUIPMENT AND MATERIALS DIRECTOR OF SE "ATOMKOMPLEKT" (CHANGE, CHANGE №1, 2)

1.23 5.2 PROCUREMENT MANAGEMENT OF NUCLEAR FUEL AND URANIUM CONCENTRATE EXECUTIVE DIRECTOR OF THE NUCLEAR FUEL PROCUREMENT AND INFORMATION MANAGEMENT (CHANGE, CHANGE №1))

1.24 6 DEPARTMENTAL SUPERVISION AND INSPECTION OF THE INSPECTOR GENERAL - DIRECTOR OF SECURITY

1.25 6.1 MANAGEMENT OF SAFETY, SUPERVISION OF NUCLEAR, RADIATION, TECHNICAL SAFETY, ENVIRONMENTAL PROTECTION DEPUTY INSPECTOR GENERAL - DIRECTOR OF SAFETY SUPERVISION

1.26 6.2 MANAGEMENT OF PHYSICAL PROTECTION OF NUCLEAR MATERIALS AND NF AND SPECIAL SECURITY DIRECTOR OF PHYSICAL PROTECTION OF NUCLEAR MATERIALS AND NF AND WB

1.27 6.3 MONITORING AND AUDIT OF FINANCIAL AND BUSINESS DIRECTOR OF SUPERVISION AND AUDITING WORK

1.28 THE RELATIONSHIP OF THESE PROCESSES IS SHOWN IN FIGURE 5, THE DETAILED RELATIONSHIP DEFINED IN MAPS PROCESSES AND RELEVANT DOCUMENTATION.

Fig. 5. Relationship Processes Management of the Company in the Company MIS

1.28.1 Execution processes outside organizations, or other departments

1.28.1.1 Some processes affecting conformity to product requirements are transmitted for execution to third parties (outsourcing processes). Within MIS outsourcing company, the following processes:

• design and development;

• capital construction;

• education and training in special institutions;

• medical practice services (periodic surveys).

The types and amounts of control over such processes are set in the contractual documentation and controlled units - customers and structural units directorate responsible for planning costs comply with the Company's requirements.

1.28.1.2 Some processes affecting conformity to product requirements involved as performers (or co) separate divisions of the Company: "Atomenergomash" "Atomremontservis", "Emergency and Technical Center", "Atomproektinzhynirynh", "Scientific and Technical Center" "Warehousing", "Atomkomplekt", "Office of."

1.28.1.3 Monitoring of processes in which they participate, as provided by the management of these units, and from the VP AES and / or the Board of Directors of the Company, regulated documents (regulations on the EP, the provisions on relations between the EP, standards and provisions on the organization of activities, etc.).

Documentation requirements

1.29.1 Given the large size of the Company as a whole, the complexity of processes and their interactions, high competence of staff, given the notes to § 1-3 4.2.1 standards [27, 28], the requirements for document management focused in the relevant regulatory and industrial documents that describe this activity and referred to in this section.

1.29.2 The Company used instruments developed independently and / or with the assistance of contractors (internal documents); Documents external organizations (government bodies, ministries, departments, etc.) that apply to the Company, and documents of other companies and organizations, which are used in the Company in accordance with established procedures.

1.29.3 The documents developed by the Board of Directors of SE "" Energoatom ", by VP Companies can be attributed to external documents in the case when they are consistent with the OP in accordance with established procedures.

1.29.4 Managing internal documents of the Company described in:

(Change, change №2)

JMA NAEC 002: 2014 Document management. Terms of development regulations.
JMA NAEC 003 2013 Office documents. The rules of construction, teaching, design and content requirements of regulations.
JMA NAEC 030: 2012 Management documentation. Remontnaya documentation. Requirements for development, oformlenyyu and treatment.
JMA NAEC 073: 2014 Document management. Typical content of technical specifications for safe operation of nuclear power units with VVER-1000. Terms.
JMA NAEC 001: 2014 Document management. The system documentation of SE ""

Energoatom ". Classification of documents and general provisions.
PL-D.0.06.001-04
Situation at working with documents proizvodstvennoe
PL-D.0.06.007-14
Situation manner of the consent and Adoption proizvodstvennoe and project documentation (modified, changing №3)

1.28.1 Managing internal documents of the Company provides:

1.28.2 • verification of documents for compliance before their approval and commissioning;

1.28.3 • Analysis of existing documents and, if necessary, adjusting their review and updating by the new approval;

1.28.4 • legibility and ease of identification documents, and changes the current status and revised versions of documents;

1.28.5

1.28.6 • availability of appropriate versions of existing documents in the field of application;

1.28.7 • prevent unintended use of obsolete documents and the use of proper identification documents in case of storage for any purpose.

1.28.8 1.28.2 Managing external documents described in the Company's documents

1.28.9 PL-D.0.06.019-15

1.28.10 (Change, change №3) Regulations on the procedure with the regulations of the State Enterprise "" Energoatom "

1.28.11 JMA NAEC 077: 2015 (modified, changing №1,4) Procurement Management products. "Specifications", "Technical Specifications" and "Terms of Reference" for products for nuclear power plants. Order of the development, review, approval and handling

1.28.12 and provides:

1.28.13 • legibility and ease of identification documents of external origin, amendments thereto, as well as control over their distribution;

1.28.14 • prevent unintended use of obsolete documents and the use of proper identification documents in case of storage for any purpose;

1.28.15 • Availability of relevant versions of applicable documents in their places of use.

1.28.16 1.28.3 In the documentation of the Company is applied in accordance with the requirements of the JMA NAEC 001: 2014, formed following main types of internal documents (change, change №2):

1.28.17 • regulations SE "" Energoatom ";

1.28.18 • Design, engineering and technology;

1.28.19 • organizational and administrative and official correspondence;

1.28.20 • production.

1.28.21 1.28.4 Procedures of work with the regulations set provisions

1.28.22 PL-D.0.06.019-15

1.28.23 (Change, change №3) Regulations on the procedure with the regulations of the State Enterprise "" Energoatom "

1.28.24 1.28.5 The list of regulations and standards of Ukraine on nuclear and radiation safety, which is guided by the EA in the exercise of their activities (requirement of paragraph 2.3 of emergency [37]) defined in the "List of existing regulations of the operating organization" PR D.0.06. 555-16, which is to provide access to all personnel of the Company is a local computer network; and to inform external organizations - on the website of "NAEC" Energoatom »(http://www.energoatom.kiev.ua/ua/law/docs_org.html). Additionally, use, adopts a "list of regulations in the field of nuclear and radiation safety", located on the website SCNS Ukraine (http://www.snrc.gov.ua/nuclear/uk/publish/article/101440). (Change, change №2,4)

1.28.25 1.28.6 The procedures for management of the design and design documents described in section 7.3.

1.28.26 1.28.7 The order of investigative work, the requirements for their design and determine the documents approved by management of the Company established provisions

1.28.27 PL-D.0.31.205-10 Regulations on work with organizational and administrative documentation and record keeping

1.28.28 1.28.8 The procedures for the organization of the production of documents, the order of development and design, as well as an indication of the documents approved by management of the Company established provisions

1.28.29 PL-D.0.06.007-14

1.28.30 (Change, change №2) Situation manner of the consent and Adoption proizvodstvennoe and project documentation

1.28.31 1.28.9 (deleted change №2)

1.28.32 1.28.10 Schematic representation of the hierarchical pyramid documentation submitted to the ISU Company Energoatom SOU 001: 2014 in Figure 8 (changed, change №2):

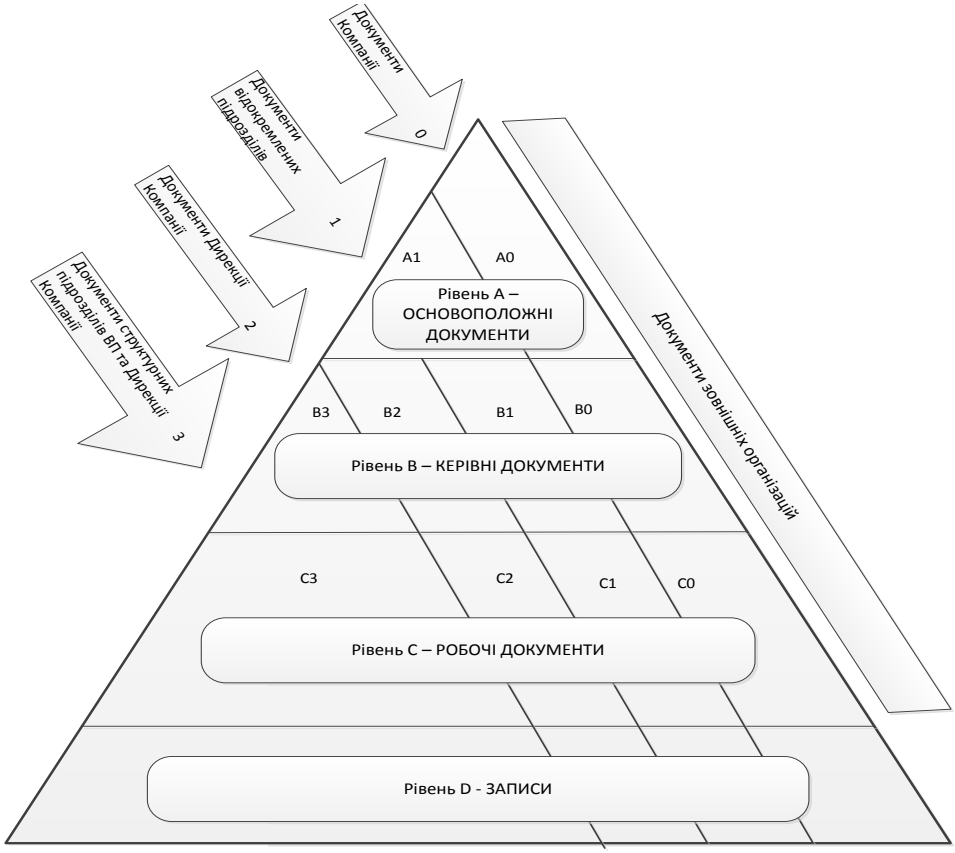


Fig. 8 hierarchical pyramid documentation MIS Company

1.28.33 to basic documents (level A) include:

• Constitution of the State Enterprise "National Nuclear Energy Generating Company" Energoatom ".

• The position of the operating organization (operator) of Nuclear Installations SE "" Energoatom ".

• The provisions of the separate units of the Company.

• General guidance on integrated management of SE "" Energoatom ".

• Guidelines for management IP.

• Applications management of SE "" Energoatom ".

1.28.34 with the regulations (level B) are documents that establish the organizational structure of organizational processes and management systems. These documents include:

• guidance on the quality (or quality program) in certain areas (types) of production activity;

• Standards, guidelines and provisions of certain of the Company (change, change №2);

• provision of segregation of duties, responsibilities and interaction between structural units of CAP, structural subdivisions of the Management Company or between the EP and the Board of Directors of the Company (change, change №2);

• provisions on structural subdivisions VP and Board of Directors of the Company (change, change №2);

• job (work) instructions personnel (change, change №2);

• provisions (instructions, regulations) Security (nuclear, radiation, fire, etc.) (change, change №2).

1.28.35 By working documents (level C) are documents that determine the order of work (operations) and used for production activities. These documents include:

• the operating instructions of equipment and facilities;

• specification of maintenance, processes, technological regulations (modified, changing №2);

• methodology, the test program;

• repair documents (change, change №2);

• scheme (technological, structural, functional, basic) (change, change №2);

• guidelines on health;

• organizational and administrative documents (orders, plans, schedules, events, etc.)

• Design and construction documents developed in the OP Company (change, change №2);

1.28.36 to record (level D) include documents containing information on progress achieved results found inconsistencies and eliminate them, as well as technical, economic and social information in standardized forms of documents. Records are evidence of conformity and effectiveness of MIS (including quality management system). Records relating to acts, records, reports, journal entries, and documents referred to in paragraph. 5.2.7.4 JMA NAEC 001: 2014 (modified, changing №2).

1.29 Management records (protocols)

1.30 1.29.1 In order to provide evidence of compliance and effective management system is developed and supervised a large number of records (protocols). Given the large size of the company (the Company in general and IP in particular), the complexity of processes and their interactions, high competence of staff, given the notes to § 1-3 4.2.1 standards [28-29] p.4.3.4 requirements [28-29] with records management (regarding the identification, storage, protection, retrieval, retention and removal) are concentrated in the relevant regulatory and operational documents that describe certain activities.

1.31 1.30 Electronic document

1.32 1.30.1 Requirements for electronic documents and electronic document defines the procedure for provision

1.33 PL-D.0.16.432-08 Regulation on electronic documents and electronic document "Energoatom"

1.34 1.30.2 The application of digital signatures in the Company's defined provisions

1.35 PL-D.0.09.431-08 provisions on the use of electronic digital signature "Energoatom"

1.36 The Company applies digital signature for taking legal action involving other businesses and individuals in the presence of their enhanced public key certificates. Electronic digital signature is used for:

1.37 • drafting of electronic documents that can not be original in the cases provided by law;

1.38 • taking legal action in an amount exceeding one million.

MANAGEMENT'S RESPONSIBILITIES

2.1 Management commitment

2.1.1 In accordance with the Law of Ukraine [1], detailed in Chapter V of the Law of Ukraine [3], and in accordance with the Cabinet of Ministers of Ukraine of 17.10.96 number 1268 SE "" Energoatom "is operated by nuclear installations located on the NPP sites .

2.1.2 The Company and VP AES, particularly within its powers EO, following the stated policy following the requirements of the legislation of Ukraine and regulations in the field of nuclear and radiation safety and the requirements and recommendations of IAEA agrees to maintain an integrated management system and continuously improve the effectiveness and efficiency of its processes.

2.1.3 Management commitment in key areas of the Company offered to the public to demonstrate commitment and responsible attitude of SE "" Energoatom "to security issues at all stages of the life cycle of nuclear installations, and set out in the following statements:

• security;

• the quality;

• In the field of ecology;

• in nuclear safety and radiation protection personnel;

• In the field of radioactive waste management;

• In the area of physical protection;

• In the field of health;

• In the area of personnel policy;

• In the field of information technology;

• On a single technical policy; (Uploaded, changing №2)

• to combat corruption; (Uploaded, changing №2)

• the relocation and restoration of living conditions necessary alienation of land and other immovable property objects during transport and energy infrastructure №NAEK SE "Energoatom". (Uploaded, changing №4)

The above statements issued only document

PR Z.0.06.130-14

(Change, change №2) statements of the state enterprise "" Energoatom "

which company personnel familiar in due course. Statements guide posted on the Company's website (http://www.energoatom.kiev.ua/ua/about_nngc/statements.htm).

2.1.4 Applications include main goal (problem) Companies ways to achieve them and expected results. The objectives for specific areas of activity is measurable and include criteria for evaluating their achievement; communicated to the staff and it is available for review; reviewed to ensure their compliance.

2.1.5 Evaluation on specific areas of activity carried out by responsible departments according to the list of forms of state statistic, departmental and internal reporting, which will come into effect by order of the Company. Evaluation of policy implementation in specific activities carried out by responsible units annually, taking into account the results of the analysis described in section 5.10.

By the Council on safety culture or document management company PR Z.0.06.130-14 "statements of the state enterprise" "Energoatom" may be supplemented by other corporate applications. If the evaluation is necessary to amend the statement unit responsible for the specific application, sends corrected statement to the executive management and quality management. Quality Department Department for Quality and Management provides VDYAU amendments / revision of the document in the prescribed manner (change, change №2).

1.39 orientation to the customer

1.39.1 company's main products are electricity sold nuclear power to the grid. In addition, consumers satellite cities of NPPs (utilities, businesses and institutions, population) released thermal energy (provided centralized heating, cold, hot water and wastewater according to [17]). The main products are other VP Company products or services for the operation of nuclear power plants.

1.39.2 Power quality ensured the stability of the process of production, NPP readiness for bearing load, security, reliability, and support equipment and modes of work according to the requirements of the project. The main controllable characteristics include:

• installed capacity and utilization of the installed capacity of power;

• the number of produced and supplied products (electricity and heat);

• duration of planned preventive maintenance units, planned and actual;

• the number of unscheduled stops and cuts power units;

• indicators describing the use of nuclear fuel and fuel of NF.

1.39.3 The company is guided by the fact that the end user products are society (population, enterprises and organizations). Due to the fact that the company can not directly influence the product characteristics such as frequency and voltage as compliance with customer requirements considered dispatching schedules bearing load power plants. With:

1.39.4 Customer electricity EP released in nuclear power network is GP "Energy", with which the Company signed a contract for the supply of electricity;

1.39.5 The tariff for electricity sold to the SE "" Energoatom ", establishes the National Commission, which performs state regulation in the energy and utilities Ukraine; (Change, change №2)

1.39.6 ECO performs supervisory control of SE "NEC" Ukrenergo ". Interaction with SE "NEC" Ukrenergo "the Company under the provisions of [51].

How concerned are considered public bodies of regulation and supervision, which express and protect the public interest through regulation, regulation and supervision.

1.39.7 To understand and meet the needs and expectations of stakeholders SE "" Energoatom ":

• identify and comply with legislative requirements, the requirements of regulations and other applicable requirements of the Company, proof requirements to the employee

• if necessary, puts the needs and expectations established in requirements

• identifies and assesses consumer satisfaction

• evaluates the safety of production

• Determine the impact on the environment

• improves processes to provide value to stakeholders.

1.39.8 Interaction with State Nuclear Regulatory Committee of Ukraine, as a representative of the state and society to ensure the safe operation of nuclear power plants,

set out in

JMA NAEC 016: 2012 The relationship with the state regulation and supervision. The organization and control of the conditions of licenses and permits

PL-D.0.03.171-10 Regulations on the procedure of transfer of operational information on the separate units of "Energoatom".

(Line removed, changing №1)

(Line removed, changing №1)

WP-D.0.03.454-14

(Change, change №1)

Typical rules of information exchange crisis centers NPP Emergency Information Center of the State Nuclear Regulatory Inspectorate of Ukraine.

1.38.1 SE "" Energoatom "monitors information relating to customer perception of satisfaction of its requirements regarding the production of electricity and heat and impact on the environment. Information about the level of customer satisfaction products collected, collected and analyzed during the contractual work with customers and the future performance of contractual obligations.

1.38.2 Operative tracking customer satisfaction is within the interaction of operational staff in the management processes of dispatching services.

1.38.3 Current information on customer satisfaction with the electricity supply is monitored to adjust TEP, production targets, the target of periodic meetings and the management of SE "" Energoatom ". The results of the meetings are made binding protocols.

1.38.4 When analyzing customer satisfaction using information on the receipt of complaints and claims. Organization claims and conduct related work has VDYuPtaSPZ (modified zmina№1). Information about lawsuits and claims from customers used during the management review.

1.38.5 Summary data on the level of customer satisfaction products are part of the reports are considered to balance commissions and used as input for management review

1.38.6 The procedure described in informing the outside

PL-D.0.03.171-10 Regulations on the procedure of transfer of operational information on the separate units of "Energoatom".

In-D.0.32.533-14

(Change, change №3) Instructions on access to public information and work with information requests SE "" Energoatom ".

1.39 Policy on Safety, Quality and Environment

1.39.1 The purpose of the Company, as operating company, established on the basis of the requirements of society to protect individuals, the public and the environment from potential radiological hazards associated with nuclear installations is to ensure the level of nuclear safety in accordance with the requirements of existing standards, rules and regulations.

1.39.2 Manual operating company DP "" Energoatom "aware of its responsibility, policymakers in the field of safety, quality and the environment and ensure its implementation, guided by certain fundamental regulatory, organizational and technical principles of security.

1.39.3 The implementation of environmental policy and to improve compliance with the achieved level of safety of existing nuclear power units, introduction of innovative environmental technologies is one of the priorities in the activities of the operating organization.

1.39.4 Quality management overhead is seen as a feature common to all structural units of the Company. Her performance requires making efforts of all staff. With:

• managers of all levels of government is responsible for ensuring the quality of the subordinate units and are personally involved in improving their activities;

• each employee provides quality proper performance of their duties in compliance with established requirements for the quality of his work.

• Management of the company believes the policy of quality his direct responsibility and considers it as an ongoing process that requires consistent effort and resources and is based on assessment of their progress and global results.

1.39.5 The Company is aware of its responsibility and ensure that the integrated management of SE "" Energoatom "requirements of the legislative, regulatory and legal acts of Ukraine, international standards ISO 9001: 2008, 14001: 2004 and the recommendations of IAEA safety standard GS-R -3. Based on the priority tasks planned and implemented a range of measures, implementation of which is associated with plant operation safety, environmental protection and the improvement of the Company as a whole.

1.39.6 The stated policy (see. P. 5.1.3) requires every employee of the Company:

• Know and follow it in its work;

• create the necessary conditions for effective and safe work;

• comply Laws of Ukraine, rules, norms and standards, current regulatory, technical, organizational and administrative documentation;

• comply with the requirements of industrial and technological discipline;

• eliminate the causes that prevent Implementation of high quality;

• Know that the prevention of errors has priority over the discovery of errors;

• responsible for the quality of their work. The existence of departments to ensure quality management and does not limit this responsibility.

1.40 Planning

1.40.1 The Company within its power ensure accurate planning of production and technical, financial and economic activity.

1.40.2 Planning of product is based on:

• proposals and requirements Minenergouglya and SE "NEC" Ukrenergo "to optimize schedules repairs and modes of power units as appropriate UES Ukraine (presence maneuverable and spare capacity, seasonal fluctuations in demand for electricity capacity transmission lines, the presence and quantity of reserves of fuel for thermal power plants, water resources, etc.);

• customer requirements according to the "Procedure for drawing up the forecast physical balance of power united energy system of Ukraine";

• AES for proposals VP of four graphics output power repair;

• The annual schedule of repairs, materials VP AES justifying regulatory excess length of repair;

• CAP proposals on nuclear altered schedule repair outage on the results of this year.

1.38.1 The output of the planning process are:

• forecast balance of electricity UES Ukraine per year, per month;

• Plan SE "" Energoatom "of electricity per year;

• VP AES targets for the production and delivery of electricity to the wholesale market of electricity per month.

1.38.2 On Planning costs associated with the production, set out in

PL-D.0.04.224-15 (change, change №1,3) Provisions on budgeting SE "" Energoatom "

PL-D.0.04.180-11 Regulation on compiling and approving the settlement cost estimates for electricity and heat

PL-D.0.04.332-09 typical situation of economic calculation of internal divisions in repair and factory complex "Energoatom".

PL-D.0.19.335-13 Regulations on the procedure of pricing for goods (works, services) produced separate units SE "" Energoatom "

1.39 Goals

1.39.1 The objectives of the Company, as a business entity producing electricity specified in the Statute of the SE "" Energoatom ".

1.39.2 The purpose of the Company, as operating company, established on the basis of the requirements of society to protect individuals, the public and the environment from potential radiological hazards associated with nuclear installations is to ensure the level of nuclear safety in accordance with the requirements of existing standards, rules and regulations in the nuclear industry.

1.39.3 To achieve the set target of SE "" Energoatom "decide the appropriate task. The main objectives of the EA are:

• Support project level nuclear safety;

• improve the security of nuclear power plants, based on the requirements of existing regulations and standards

1.39.4 Key features specified in EO

PL-S.0.06.002-13 (change, change №1) The provisions of the operating organization (operator) of Nuclear Installations SE "" Energoatom "

1.39.5 President GP "" Energoatom ", CEO (managing directors, directors) EP Company to implement certain their policies, approve objectives (policies, programs, plans, etc.) for the respective activities. Objectives are specific and include criteria for evaluating their achievement; communicated to the staff and it is available for review; reviewed to ensure their compliance.

1.39.6 fundamental documents that set goals in an integrated management system are:

• «management Statements SE" "Energoatom" PR Z.0.06.130-14 (change, change №2);

• Order №1 SE "" Energoatom "(the results of the previous year and planning activities for the current year);

• Complex (summary) program enhance the security of nuclear power plants;

• annual schedule (plan) repair the main, auxiliary and general station equipment NPP.

1.39 Responsibility and authority

1.40 1.39.1 The head of EA have said. For establishing an EA established by normative legal acts of Ukraine, the President forms the organizational structure of the operating organization and the leadership determines the operating organization.

1.41 1.39.2 The structure of EA Guidelines, in addition to the president, included First Vice-President - Technical Director, Chief Inspector - Director of Security, vice presidents and CEOs VP AES (deputy head of EA at the NPP).

1.42 1.39.2.1 First Vice-President - Technical Director manages the activities:

1.43 • Operating nuclear power plants and spent nuclear fuel;

1.44 • to assess the current level of NPP safety, safety assessment and reassessment of NPP;

1.45 • the analysis and use of operating experience;

1.46 • to prepare and support staff, inspection and monitoring of its compliance with the qualification requirements;

1.47 • in the treatment of spent fuel and radioactive waste management, control and accounting of nuclear materials and radioactive waste during operation;

1.48 • to ensure environmental safety in accordance with legislation, regulations and standards in environmental protection;

1.49 • to implement programs to improve safety and modernize the stage NPPs;

1.50 • the introduction of measures to improve the reliability, efficiency of nuclear power plants, increasing capacity factor of power;

1.51 • in emergency preparedness and emergency response EO;

1.52 • Management resource and extension of project deadlines NPPs, with preparation for decommissioning;

1.53 • (deleted change №2)

1.54 • the implementation of measures aimed at establishment and development of safety culture;

1.55 And • other - according to their job description.

1.56 First Vice-President - Technical Director operates and has the right to replace the President under license for officials operating organization for the implementation of organizational and administrative functions related to nuclear and radiation safety, issued by the State Nuclear Regulatory Inspectorate of Ukraine, which derived, and has canceled the order established [38] (hereinafter - the official license of the operator).

1.57 1.39.2.2 Vice President, which provides repair and management of the factory complex, manages activities:

1.58 • implementation of repairs and maintenance of NPP equipment on schedule and storage of spent nuclear fuel;

1.59 • the production equipment, spare parts, tools and accessories, hardware and repair aggregate principal nuclear facilities in terms of factory production according to the needs of disaster;

1.60 • development and implementation of the development strategy of maintenance and factory production, advanced programs and annual plans of the units included in the repair and factory complex;

1.61 And • other - according to their job description.

1.62 Vice President, which provides repair and management of the factory complex, provides organizational and administrative functions related to ensuring nuclear and radiation safety during the replacement of the President or the first Vice-President - Technical Director on the basis of license for operating officer of .

1.63 1.39.2.3 (deleted change №2);

Vice President, providing management of the economic and financial welfare and responsible for the organization of capital construction, manages activities:

• the current and long-term planning and monitoring the financial performance of the Company;

• providing the Company with the necessary financial resources for financing the approved limit production program and cost estimates;

• a financing schemes established state-wide and programs;

• implementation of mechanisms to accumulate financial reserves for decommissioning nuclear installations;

• FDI to finance projects of strategic development of the Company;

• calculation of the budget, to pay taxes and other mandatory payments to the state budget, with the repayment of receivables and payables;

• introduction of private pensions;

• to ensure security in SE "" Energoatom ";

• accounting and analysis of revenues from GP "Energy" for sold into the wholesale electricity market;

• implementation of cash and credit transactions;

• Organization of contractual work in the Board of Directors of the Company;

• Property Management, which is vested in and owned it at the right of business;

• the organization of labor and wages;

And • other - according to their job description.

(Modified, change №4)

1.63.1.2 Inspector General - director of security controls activities:

• with obligations under international conventions and treaties in the field of safety in nuclear energy Ukraine and to ensure the physical protection of nuclear facilities and transport of nuclear materials;

• Control (including departmental supervision) over compliance with rules, regulations and standards on nuclear and radiation safety in nuclear power and presenting the results of inspections to control nuclear safety regulatory body for nuclear and radiation safety.

• to monitor the implementation of measures to improve safety at nuclear power plants, fire safety measures in nuclear facilities. and with their commitment to safety;

• to monitor the activities of the investigation of violations of normal operation, emergencies and accidents at nuclear power plants, the development and implementation of measures to prevent the recurrence of violations;

• Control implementation of measures to create a culture of safety, with the introduction of indicators and criteria for assessment of safety culture in the company;

• NF physical protection, nuclear materials, facilities designed for handling radioactive waste and other sources of ionizing radiation;

• to ensure the functioning of the access to the specific work;

• the creation and operation of the monitoring system established pursuant staff qualification requirements, monitoring the organization of education, training and inspections knowledge of officials of the Company.

• Control and auditing activities;

• the collection and analysis of equipment failure and erroneous actions of personnel, accounting and analysis of accidents, occupational diseases, accidents and fires, and losses from these events.

Inspector General - Director of Security has the organizational and administrative functions related to ensuring nuclear and radiation safety, and performs binding company president and first vice president - technical director under license for official operating organization.

1.63.2 The Director General OP NPP commissioned deputy head of EA at the NPP site, provides organizational and administrative functions related to ensuring nuclear safety, on the basis of license for official operating organization. He manages the activities of nuclear power plants at all stages of the life cycle of NF accordance with the laws of Ukraine, rules, regulations, standards, conditions of licenses and permits for the use of nuclear energy.

1.63.3 In the absence of the President (on vacation, business trip, etc.) as head of the operating organization do: First Vice-President - Technical Director or Inspector General - Director for Security, or vice-president, which provides repair and management of plant complex, which tested knowledge and in the prescribed manner designed:

PL-K.6.07.481-11 Regulations on the procedure for the replacement officials in the Directorate "Energoatom"

? The company is operating organization under the laws of Ukraine bears full responsibility for the radiation and physical protection and security of nuclear installations, facilities for radioactive waste and sources of ionizing radiation, regardless of the activities and responsibilities of suppliers and of state regulation of nuclear and radiation safety.

? 1.63.2 Distribution of powers and responsibility for nuclear and radiation safety defined taking into account the rights of EA to make decisions that affect the nuclear and radiation safety, and manage the resources necessary to meet the requirements of safety. The division of responsibilities is documented in the Regulation of the EA, the provisions of GC NPP, regulations on the implementation of certain activities, job descriptions unit managers.

? 1.63.3 The functions of the operating organization that carried out structural units of the Board of Directors of the Company and other nuclear VP VP, determined by the relevant provisions of subsections.

? 1.63.4 The responsibilities of the functions of the EA, the rights and responsibilities of officers of the Company, the procedure for admitting them to work independently, knowledge test frequency set in the relevant job descriptions.

? 1.63.5 Company Organizational chart provided in the

? PL-S.0.06.003-10 Regulation on organizational structure "Energoatom"

? 1.63.6 In the organizational structure of the Board of Directors of the Company by heads of departments (process owner) and individual officials from a number of top management, whose competence includes development, implementation and analysis of the effectiveness of the Company's management, as well as taking steps to improve it (see. P .5.8). Their responsibilities for these matters are documented in job descriptions.

? 1.63.7 In the organizational structure of the Company VP-purpose unit managers (owners processes) and individual officers among the top leadership, the competence of which include development, implementation and analysis of the effectiveness of the management VP, VP guidance is performed.

? 1.63.8 Change management organizational structure, including informing the State Nuclear Regulatory Committee of Ukraine on structural changes carried out in accordance

? STP 0.06.087-2010 Management of organizational changes. Planning, preparation and implementation of changes in the organizational structure of "" Energoatom "

? 1.63.9 Regulation is based on the number of documents

? MT-D.0.07.449-08

? Guidelines for determining staffing levels at individual facilities and equipment that are introduced in operating nuclear power plants "(change, change №2)

? MT-D.0.07.450-08 Guidelines regarding the assignment of personnel VP AES "Energoatom" with participation in the provision of industrial and technological sector and by type of work performed.

? MT-D.0.07.455-08 Guidelines on the application of handling Directorate "Energoatom".

? MT-D.0.07.515-10 Guidelines on the application of the rules on handling nuclear VP, VP VRS and IP ATC "Energoatom".

? MT-D.0.07.516-10 Guidelines on the application of controllability in the OP "Atomenergomash" "Energoatom"

MT-D.0.07.517-10 Guidelines on the application of SEC handling VP, VP API, VP AC "Energoatom".

? representatives of the

? 1.63.2 President appointed executive director of quality management and representatives of the quality management system of laying on him responsibility and authority for the provision of:

? • ensuring that the necessary quality management system processes are designed, implemented and maintained;

? • Reporting to President of the Company for compliance with the quality management system and the need to improve

? • to provide information separate units and structural units of the Company Board of Directors of the Company acting on the requirements for a quality management system.

? 1.63.3 President appointed first vice president - technical director representative leadership on environmental management system of laying on him responsibility and authority for the provision of:

? • ensuring that the necessary environmental management system requirements, the Company established, implemented and their implementation is under control;

? • Reporting to the President of the Company on the functioning of the environmental management system and the need for its improvement;

? • to provide information separate units and structural units of the Company Board of Directors of the Company acting on the requirements for an environmental management system.

? 1.63.4 detail the duties, rights and responsibilities of the first vice president - technical director and executive director of quality management and defined job descriptions.

? 1.63.5 Status first vice president - technical director and executive director of quality and management can influence the actions of heads of departments of the Company Board of Directors, managers EP, plans to direct their activities, monitor the implementation of these plans, evaluate results and make the necessary motivation or self by the president.

? 1.64 Internal and external awareness

? 1.64.1 Given the large size of the organization, requirements for internal and external awareness focused on relevant regulatory and operational documents that describe this activity as well as those referred to in this section.

? 1.64.2 Informing staff and other stakeholders, including the public, about the state of nuclear and radiation safety, safety, environmental safety, public

health, civil defense, fire and technological safety of the Company to certain procedures

? 1.64.3 Internal communication about events in Ukraine NPP is under

? PL-D.0.03.010-11 Situation manner of investigation and accounting violations in the work and otklonenyy plant NNEGC "Energoatom"

? PL-D.0.03.169-09 Situation manner of Using "Ynformatsyonnoy system events in the work on nuclear power NNEGC" Energoatom "(IS CAESAR) Accumulation in the system, analysis and operation Using Experience"

? PL-D.0.03.171-10 Regulations on the procedure of transfer of operational information on the separate units of "Energoatom".

? PL-D.0.03.463-13 (change, change №1) Typical Situation manner of investigation and accounting of events in the OP maloznachymыh plant NNEGC "Energoatom"

? PL-S.0.03.135-10 Regulation on permanent commission "Energoatom" Review of NPP operational events and corrective actions.

? Information about events at other nuclear power plant is under

? PL-D.0.03.036-14

(Change, change №2) Typical Situation on the exchange of information about nuclear power plants in operation Experience GP "NNEGC" Energoatom "

? Internal communication regarding solving tasks and coordinate activities carried out at the meetings of collegiate bodies of the Company whose activities are regulated documents:

? PL-S.0.04.005-11 provisions of the Economic Council "Energoatom"

? PL-S.0.15.034-15 (change, change №1,2) Regulations on balance fees SE "" Energoatom "

? PL-S.0.06.010-11 provisions of the Working Council for Quality and Management

? "Energoatom"

? PL-S.0.06.038-15

? (Change, change №4) The provisions of the Working Council for Standardization SE "" Energoatom "

? PL-S.0.07.140-11 Council Regulation on information policy and public relations "Energoatom"

? PL-S.0.05.132-15

? (Change, change №3) of Council Regulation deputy chief engineer repair

? PL-S.0.03.042-13 Council Regulation on specialist chemists SE "" Energoatom "

? PL-S.0.03.061-08 Situation of Sauve hlavnыh engineers

? PL-S.0.03.115-13 (change, change №1) The provisions of Coordination - Expert Council of the NPP APCS while "Energoatom".

? (Deleted change №4)

?

? PL-S.0.03.095-13 Charter of the Council of experts of electrical equipment "Energoatom".
? PL-S.0.41.033-12 Situation of Scientific and Technical Sauve NNEGC "Energoatom"
? PL-S.0.03.112-14
? (Change, change №1,3) of Council Regulation experts from operational experience of NPP "SE" "Energoatom".
? PL-S.0.03.014-09 Commission Regulation on the SE "" Energoatom "Emergency Management
? PL-S.0.03.047-14
? (Change, change №2,3) The provisions of the Working Group on the organization and development of emergency preparedness and response SE "" Energoatom "
? PL-S.0.03.138-10 Council Regulation on specialists in emergency documentation.
? PL-S.0.18.143-12 Charter of the Council deputy chief engineer of nuclear safety SU NPP.
? PL-S.0.07.092-15
? (Change, change №3) of Council Regulation personnel, Labour and Social Affairs
? PL-S.0.10.063-14 (change, change №1,2) Provisions on the Committee on competitive bidding SE "" Energoatom "
? US-P.32.110-07
? (Uploaded, changing №3) editorial charter broadcasting organizations State Enterprise "National Nuclear Energy Generating Company" Energoatom "
? Since the protocol decision of the collegial staff oznayomlyuyetsya according to the mailing list of protocols.
? 1.63.2 Internal communication on other issues is also carried out at meetings at various levels of management. System meetings covered all levels of management and specialists; Each manager collects data and demonstrates superior management solutions for the group, whose leader he is.
? 1.63.3 Internal communication on organizational and administrative documents carried by familiarizing staff with the content of organizational and administrative documents "under the caption"
? PL-D.0.31.205-10 Regulations on work with organizational and administrative documentation and record keeping
? 1.63.4 The relationship between employees of the Company as a whole by the Code of Conduct
? PL-S.0.07.136-10 Code of Conduct "Energoatom"
? 1.63.5 appeals procedure Company employees and other citizens in the management of the company regulated
? PL-K.0.07.059-06 Regulations on the procedure of consideration of staff "Energoatom" and other citizens in the management of the Company.

? 1.63.6 Feedback management personnel by using:

? • meetings and meetings at different levels;

? • memos initiatives that are sent to court;

? • collect proposals of staff, organized in divisions;

? • Reception on personal matters.

? 1.63.7 Access to public information is provided under the Law of Ukraine [9]. For the purpose of the plan [10], the procedure for informing the public and staff of the Company identified in the documents

? PL-D.0.32.552-15

? (Change, change №3) Regulations on the procedure for maintenance of the official web-site of "" Energoatom ".

? In-D.0.32.533-14

? (Change, change №3) Instructions on access to public information and work with information requests SE "" Energoatom "

? PL-S.0.07.140-11 Council Regulation on information policy and public relations "Energoatom".

PL-D.0.03.171-10 Regulations on the procedure of transfer of operational information on the separate units of "Energoatom".

1.63.1.1 Information SCNS Ukraine is carried out continuously, in particular the PL-D.0.03.171-10, and according to documents

1.63.1.2 WP-D.0.03.454-14 (change, change №1) Model rules of information exchange crisis centers NPP Emergency Information Center of the State Nuclear Regulatory Inspectorate of Ukraine.

1.63.1.3 PL-K.0.18.061-15 (change, change №1,2,3) Regulations on the procedure for verification of knowledge of rules, regulations and standards on nuclear and radiation safety and technical operation of NPP personnel of the State Enterprise "National Nuclear Energy Generating Company" Energoatom "

1.63.1.4 1.64 Civil defense and emergency response

1.63.1.5 1.64.1 Development Program identified in emergency preparedness

1.63.1.6 PM-D.0.03.396-15 (change, change №3) Main activities and emergency response hotovnostii SE "NAEC" Energoatom "for accidents and emergencies at nuclear power plants for the period 2020

1.63.1.7 1.64.2 Emergency organizational structure of the CAP and the Board of Directors of the Company, division of functions, responsibilities and duties of the emergency response, the composition of the external organizations involved in emergency response, composition and procedure of emergency response measures in the OP and NPP sanitary protection zone defined in

1.63.1.8

1.63.1.9 PL-D.0.03.089-15

1.63.1.10 (Change, change №3) The main provisions of preparedness and response system SE "" Energoatom "for accidents and emergencies at nuclear power plants

1.63.1.11 PL-S.0.03.014-09 Regulations of "Energoatom" with emergencies

1.63.1.12 PL-S.0.03.047-14

1.63.1.13 (Change, change №1,2) The provisions of the Working Group on the organization and development of emergency preparedness and response SE "" Energoatom "

1.63.1.14 PL-S.0.03.049-09 typical situation of emergency groups and teams separate units "Energoatom".

1.63.1.15 and others.

1.63.1.16 1.64.3 Emergency training at SU NPP organized according to the rules [46], which are detailed in the SE "" Energoatom "provisions

1.63.1.17 PL-D.0.03.480-09 provisions on the preparation, conduct and evaluation of joint general station emergency training

1.63.1.18 1.64.4 Preparation, organization and conduct emergency training is carried out according to the procedures and regulations

1.63.1.19 MT-D.0.03.545-12 Methods of identification and analysis of similar violations and deviations in nuclear power plants (events that are repeated)

1.63.1.20 MT-K.0.03.419-10 Methods for the preparation, organization and conduct emergency training units separated "Energoatom"

1.63.1.21 WP-T.0.03.178-10

1.63.1.22 (Change, change №3) Model Regulations functioning crisis centers NPP

1.63.1.23 WP-T.0.03.180-13 (change, change №1) Model rules of information exchange crisis centers NPP

1.63.1.24 WP-D.0.03.454-14 (change, change №1) Model rules of information exchange crisis centers NPP Emergency Information Center of the State Nuclear Regulatory Inspectorate of Ukraine.

1.63.1.25 1.64.5 civil protection and civil defense plans regulated

1.63.1.26 (Line removed, changing №1)

1.63.1.27 PN-A.0.03.498-09 (DSC) Plan Civil Protection Directorate and separate units "Energoatom", located in the city. Kiev, in times of crisis

1.63.1.28 1.64.6 Classification of a nuclear accident emergency response system is subject to

1.63.1.29 STP 0.03.079-2009 Providing emergency response. Method of determining the classification criteria of radiation accidents at nuclear power plants

1.63.1.30 1.65 The management review

1.63.1.31 1.65.1 The Company, together with collective bodies referred to in

1.63.1.32

1.63.1.33 p.5.8.4 this guideline, at planned intervals analyzes management system to ensure its continuing effectiveness, adequacy and effectiveness and to make decisions on carrying out improvements. During the analysis evaluated opportunities to improve performance and determined the need for changes in the integrated management system, including policy and objectives in the field of safety, quality and environment.

? 1.63.2 Input in the management review covering general information on:

? • results of internal and external audits;

? • feedback from customers;

? • functioning compliance processes and products;

? • Status of preventive and corrective actions;

? • Action on the results of previous management review;

? • changes that may affect the Company's MIS;

? • recommendations for improvement.

? 1.63.3 The results analysis developed solutions related to:

? • improvement of efficiency of MIS and its processes;

? • improving the products according to customers' requirements;

? • resource requirements.

1.63.4 Analysis of MIS Company's senior management processes implemented within all groups of processes prescribed intervals. The monitoring process is carried out either continuously or at different intervals (in accordance with the provisions of the collective activities of the Company, standards and regulations on relations with regulators, provisions for activities, etc.). The final analysis is performed annually MIS; evidence analysis is the protocol book committee and order number 1.

? HUMAN RESOURCES

? 2.1 Provision of resources

? 2.1.1 Management staff

? 2.1.1.1 The procedures for hiring (appointment, transfer from office to office, dismissal, reduction, etc.) identifying current labor legislation of Ukraine and production company documents (change, change №1)

? PL-K.0.07.005-13 regulations on the organization of work with the staff of the State Enterprise "National Nuclear Energy Generating Company" Energoatom "

? PL-K.6.33.182-03 Internal Work Regulations Directorate "SE" "Energoatom"

? 2.1.1.2 Preparation of personnel reserve managers carried out according to the provisions of

? PL-K.0.07.353-15

? (Change, change №3) Regulations on formation and management personnel reserve managers SE "" Energoatom "

? 2.1.1.3 records management procedures in the management of human resources (index cards, personal business, etc.) by PORP, work rules and applicable labor laws of Ukraine.

? 2.1.1.4 Holding personnel received for work performed and documented in accordance with the procedure laid subsection 4.16 PORP and work rules.

? 2.1.1.5 Requirements for staff behavior by the Code of Conduct

? PL-S.0.07.136-10 and work rules.

? 2.1.2 Social and motivation of staff

? 2.1.2.1 The provisions that define procedures incentives and motivation and procedure to document their results, annexed to the Collective Agreement SE "" Energoatom ".

? 2.1.2.2 Collective Agreement SE "" Energoatom "- a regulation laying down employment and socio-economic guarantees for employees and governed the relationship between employees and management of state enterprise" "Energoatom" in accordance with the laws of Ukraine and the powers granted to the representative and the owner of the trade union committee of SE "" Energoatom ".

? 2.1.2.3 Procedure development (amendment, revision) incentive provisions documentary fixed by collective agreements.

? 2.1.3 Competence, awareness and training

? 2.1.3.1 General requirements for plant personnel training system Ukraine by GATS [31]. and emergency 306.1.187-2012. Basic principles of training SE "" Energoatom "Determination of PL-K.0.07.005-13 (PUWP)." (Change, change №1)

? 2.1.3.2 Depending on the complexity of the work, its impact on the quality and safety - training and staff development is carried out in foreign educational institutions at the SEC VP AES, OP ARS and the workplace

? LCD K.0.18.090-13 (change, change №1) Guide to Application podhoda system for the preparation of teaching staff in AES Ukraine

? PM-D.0.18.467-14

? (Change, change №2,3) Complex program of perspective development system personnel GP Preparation "NNEGC" Energoatom "in the 2014-2018 biennium

? 2.1.3.3 procedure test knowledge of rules, regulations and standards on nuclear and radiation safety documents set

? PL-K.0.18.061-15

? (Change, change №2,3) Regulations on the procedure for verification of knowledge of rules, regulations and standards on nuclear and radiation safety and technical operation of NPP personnel of the State Enterprise "National Nuclear Energy Generating Company" Energoatom "

? PR K.0.18.084-14

? (Change, change №2,3) list of positions directorate staff, admission to independent work which is carried out without knowledge test of the rules, regulations and standards on nuclear and radiation safety, technical plant operation and safety and fire safety

?

? 2.1.3.4 Test your knowledge of safety and fire safety specified in PR K.0.18.084-14 (change, change №2,3) and

? PL-K.0.18.002-15 (change, change №1,3) Regulations on teaching, instructing and testing of the labor protection and fire safety staff SE "" Energoatom "

?

? 2.1.3.5 The requirements for training and professional development of managers determines

? PL-K.0.07.203-07 Regulations on preparing and training managers of state enterprise "National Nuclear Energy Generating Company" Energoatom "

?

? 2.1.3.6 procedures and training in the workplace determines

? PL-K.0.18.176-15 (change, change №1,3) Regulations on workplace learning personnel of the State Enterprise "National Nuclear Energy Generating Company" Energoatom "

?

2.1.3.7 The order of referral to training of SE "" Energoatom "for the profession by the Company determines

? PL-K.0.07.074-09 provisions on training workers for the money "Energoatom"

? 1.63.1.34 Officials EA to duties which under Article 9 of the Law of Ukraine [3] belongs implementation of organizational and administrative functions related to ensuring nuclear and radiation safety, get a license in accordance with the procedures specified conditions [39] . Personnel directly manages the reactor according to [48] and 3.1 PORP unit is authorized in accordance with the procedures specified rules [40].

? 1.63.1.35 EO for the exercise of a training center SU NPP personnel training for operation of nuclear installations on the list of positions and professions, which is defined [48] SCNS is licensed under the procedures established by the rules [41].

? 1.64 Formation and support a culture of safety and security culture

? 1.64.1 Programme of events

? 1.64.1.1 According to Ukraine the main document that establishes the requirements for nuclear safety - regulations [34], taking into account the requirements for management activities in the field of nuclear energy set out in NP [37, 38] and IAEA recommendations, aware of the importance of culture safety security SE "" Energoatom "for many years, operates on the formation and improvement of safety culture.

? 1.64.1.2 measures are developed and implemented to achieve the objectives of cultural security and cultural security, comply with the following principles:

? • personal responsibility of each employee for compliance with safety requirements;

? • a responsible attitude to safety requirements - of each officer;

? • primary consideration compliance with safety requirements when making decisions;

? • atmosphere of trust and openness among staff in discussing safety issues;

? • nuclear and radiation technologies are recognized as requiring special attention for their use;

? • permanent storage, analysis and experience of its use to improve safety;

? • timely informing of public regulation of nuclear and radiation safety of violation of safety requirements.

? 1.64.1.3 program enhance the safety culture in the Company:

? PM-D.0.03.531-15

? (Change, change №2) "program of specific actions aimed at the establishment and development of safety culture in SE" "Energoatom" for 2015 ÷ 2016 "(change, change №2)

? The program determines organizational and technical measures to develop safety culture, structured accordance with the provisions of Section 5.1 [34] on three levels:

? • technical policy guidance in the field of security;

? • responsibilities and duties of leadership;

? • personal responsibility and duties of each manager.

? 1.64.1.4 Self-assessment of safety culture in the structural units of the Company Board of Directors implemented under the program

? PM-D.0.06.496-11 Program Conducting self-image urovnja safety culture in strukturnыh podrazdelenyyah Dyrektsyy NNEGC "Energoatom"

? verification of the safety culture in the nuclear VP - according to the program

? PM-D.0.26.217-15

? (Change, change №3) program verification of safety culture in separate divisions of SE "" Energoatom "

? 1.64.1.5 management policy SE "" Energoatom ", formed in the area of physical protection, aimed at ensuring the security of nuclear materials and nuclear facilities in accordance with the requirements of the law [7, 8] and the formation, implementation and development of security culture

? PR Z.0.06.130-14

? (Change, change №2) statements of the state enterprise "" Energoatom "

? 1.64.2 collegial body

? 1.64.2.1 To determine the goals, optimization works on the principles of safety culture in the operation of nuclear power plants of the Company, share experiences, assess the current level of safety culture and to review, approval and follow-up the implementation of programs of concrete actions in SE "" Energoatom "created Council on safety culture. The Council is governed by the provisions of

? PL-S.0.07.126-10 Situation of Sauve on safety culture NNEGC "Energoatom"

? organizational and administrative documents.

? 1.64.2.2 the initiative of one every two years to demonstrate and confirm the commitment of EA principles of nuclear safety and its priority over production and economic objectives and for effective internal and external exchange of experience and information to enhance safety culture held conferences on culture security. Meetings conducted in accordance with the provisions of

? PL-D.0.41.225-10 Situation at conference on safety culture

? 1.64.2.3 Top management plans and allocates the resources necessary for the implementation measures to create and maintain a culture of safety and security culture.

1.64.2.4 In order to organize and coordinate the work on implementation of nuclear fuel to Ukraine NPP subject to Appendix №13 to the Contract of 30.03.2008 №1 for the supply of fuel assemblies for VVER-1000 nuclear plant and Ukrainian "Plan works in 2015-2016 hh. on races shyrenyyu operation modernyzyrovannoho nuclear fuel production company "Vestynhauz" (FA-WR) The unit AES Ukraine "created operational headquarters on the implementation of the modernized nuclear fuel production company" Westinghouse "(attached, change №3). 1.64.3 Assessment 1.64.3.1 Procedure for assessment of safety culture in the departments of State Enterprise "" Energoatom "and the requirements for registration report documents the evaluation program specified in PM-D.0.26.217-15 (see. Item 6.2. 1.4) (change, change №3). 1.64.3.2 The list of indicators (set of indicators of safety culture) in the Company and criteria for assessment of safety culture by a method MT-D.0.03.486-09 Methods and Criteria otsenki STATUS Culture Center Security NNEGC "Energoatom" The proposed set of indicators enables: • give quantitative description of those qualitative changes taking place in the company to ensure the safety and describe existing safety culture; • determine the effectiveness of and trends in safety culture in SE "" Energoatom ". 1.64.3.3 If found that the evaluation results do not meet the requirements, these inconsistencies are recorded, captured, investigated and analyzed to develop the necessary corrective and preventive measures.

? **1.64 Infrastructure and Working Environment**

? 1.64.1 in the Company and in particular the EP established nuclear infrastructure needed to achieve conformity to product requirements. Infrastructure SU NPP includes:

? • construction, production facilities and related engineering structures;

? • linked to the process equipment (technological, mechanical, welding, testing, electrical, measuring tools, etc.);

? • support services (transportation, communication, communication).

? 1.64.2 Indicators harm and danger environment factors, severity and intensity of the work process in the nuclear VP determined according to the classification [23].

? 1.64.3 If you find that the state of the working environment does not meet the requirements, these inconsistencies captured, investigated and analyzed to develop the necessary corrective and preventive measures.

? 1.65 Occupational Safety, Health and medical monitoring

? 1.65.1 Safety at work is under

? PL-S.0.26.029-11 Regulation on public service work "Energoatom"

? Check the status of labor performed according to EP

? PM-D.0.26.034-06 program to check the status of labor in remote units SE "" Energoatom "

? 1.65.2 Accidents, including microtrauma that occurs with the staff, according to the order investigated [14] and order [15].

? 1.65.3 NPP operational events involving fire, collapse or damage to buildings, investigated using the procedure [16].

? 1.65.4 Health and medical monitoring carried out under the requirements of [22, 23], as well as:

? Resolution of the Cabinet of Ukraine from 02.11.1997r. №1238 "On mandatory preventive narcological review and its order of"

?

? Resolution of the Cabinet of Ukraine from 27.09.2000r. №1465 "On approval of the mandatory preliminary and periodic psychiatric examinations and mental list of medical contraindications for the implementation of certain activities ..."

?

? PL-K.0.07.005-13 (change, change №3) Regulations on the organization of the staff of the State Enterprise "National Nuclear Energy Generating Company" Energoatom "

?

1.65.5 for planning, preparation and annual approval of sanitary-epidemiological service acts determining contingents and lists of employees subject to periodic medical examinations, meets Department of Occupational Medicine DKSP Direction SE "" Energoatom "and the health department at SU NPP. These structural units are also involved in

the organization of work of medical support in the emergency preparedness and response (change, change №3).

? **output**

? 2.1 Planning of product

? 2.1.1 Planning of production activities carried out, based on the duration of each fuel campaign NPP power unit, the type and duration of power outage.

? 2.1.2 On the planning of production stated in p.5.4.2-5.4.3. When planning production activities Company defines:

? • objectives of quality, safety, environmental protection and other fields;

? • applicable statutory, regulatory and other requirements;

? • the need for developing the necessary processes and documents;

? • necessary resources for the production and support processes;

? • the necessary steps to verify (verification), approval (validation), monitoring, measurement, inspection and testing, which are inherent issue of electric and thermal energy;

? • the current level of safety and potential environmental impacts (environmental aspects);

? • records (protocols) containing objective evidence of their satisfaction, progress, product requirements.

? When planning production activities are also being developed:

? • Annual maintenance schedule equipment;

? • Annual inspection schedules efficiency of nuclear power plants;

? • data volumes repair of equipment and systems NPP;

? • graphic output of work systems that are operationally driving power controller and more.

? 2.1.3 SE "NEC" Ukrenergo "sets the schedule for load bearing power units according to the mode of power, authorizes the withdrawal of units in the repair and commissioning work. The procedure for planning electricity supply is set to [51].

? 2.1.4 Tariffs for electricity and heat generation are planned and defined by decrees issued NKREKP under the Law of Ukraine [2] on the basis of procedure [18] and order [19]. (Change, change №2)

? 2.2 Processes related to customers

? 2.2.1 Determination of requirements related to production

? 2.2.1.1 The requirements established by customers, relating to the schedule and commercial terms of delivery (delivery) of electricity and thermal energy. Trade conditions of electricity supply defined in the contract between the state enterprise "" Energoatom "and SE" Energy ".

? 2.2.1.2 Activities in the field of nuclear energy is governed by the laws of Ukraine.

? 2.2.1.3 Requirements related to the generation of electric energy, as defined in the regulations on safety in the field of nuclear energy. In addition to these requirements in the design of nuclear power limits and conditions of safe operation of nuclear facilities, failure of which may result in a violation.

? 2.2.1.4 Among the regulatory requirements relating to the supply of electricity are the following limitations:

? • impossibility of NPP at low or high frequency in the grid (outside the frequency range of the project);

? • The project provided the use of nuclear power units in maneuverable mode due to design limitations on speed dial and reduced capacity power units, and the number of cycles permissible load on the fuel assembly and manufacturing equipment;

? • the need to stop power (for refueling and scheduled preventive maintenance of equipment) with established project and normative documentation intervals.

? 2.2.1.5 Among the regulatory requirements relating to the supply of thermal energy are the following limitations:

? • uninterrupted supply of heat energy in accordance with the contract with the customer;

? • compliance with network water temperature, set temperature schedule.

? 2.2.1.6 According to the state hygienic standards [32, 33] rules [36, 42, 45] provisions [11, 43], order [12] and other regulatory documents EP NPP develop and implement a range of measures to reduce emissions (discharges) pollutants and radioactive substances into the environment, waste, the plan CAP NPP environmental measures and permits to operate.

? 2.2.1.7 SE NPP held a regular monitoring and measuring the characteristics of the environment and pollution. Activities EP NPP is under the control of supervisors.

? 2.2.1.8 Uncontrolled action on environmental pollutants resulting from the technological process in the OP NPP project excluded. The only source project actions are normalized emissions through the ventilation pipe ventilation units and special buildings, providing the necessary parameters on the air environment in the workplace personnel and technological areas.

2.2.1.9 The emissions of radioactive substances through the ventilation pipe units and special buildings make up one percent of the allowable, indicating the effectiveness of protective barriers and confirmed by data on radiation situation in the area of supervision VP AES. Personnel specialized laboratories external radiation monitoring conducted radiation monitoring of the environment, including background radiation, surface second layer of air, atmospheric precipitation, soil and vegetation in summer and winter - snow, in addition, controlled

important in the diet of the population of agricultural products. Monitoring is carried out on a regular basis according to the Rules of NPP radiation monitoring. In addition to laboratory control methods at the plant commissioned modern automated control system of radiation situation.

2

2.1.1 Analysis of the requirements relating to products

2.1.2 2.1.1.1 Analysis of product requirements is made in the planning of electric and thermal energy for the next calendar year on the basis of calculations the duration of power and fuel campaigns optimization of fuel loading, preventive maintenance units, taking into account their own energy consumption. Proposals sent to the NPP directorate.

2.1.3 2.1.1.2 After considering the proposals for the development, delivery and customer own electricity consumption set planned balance of electricity, which is included in the contract between the state enterprise "" Energoatom "and the subjects of energy. The company analyzes the ability to perform the obligations accepted on delivery of products.

2.1.4 2.1.1.3 VP AES measures the following parameters generated electricity:

2.1.5 • Power generated by turbogenerators units;

2.1.6 • consumption for own needs NPP;

2.1.7 • overflows nuclear - overhead lines emanating from the open switchgears;

2.1.8 2.1.1.4 The main indicator of effective VP AES is the utilization of installed capacity. The main indicator of reliability of supply is a factor of readiness for load bearing.

2.1.9 2.1.1.5 Increasing values of readiness and load bearing capacity factor achieved by reducing planned and unplanned loss of power generation. To generate electricity losses include the planned outage, overdelivery prolong outage, unplanned stops power to eliminate defects in equipment, testing equipment, reducing stress through engineering and technological constraints, and so on.

2.1.10 2.1.1.6 The most important condition for the safe operation of nuclear power plants is unconditional compliance rules, regulations and standards on nuclear and radiation safety, technical and environmental safety, conditions of licenses and permits, and compliance with fire safety regulations and safety.

2.1.11 2.1.2 Communication with customers

2.1.12 2.1.2.1 The company identifies and implements measures to support communication with customers relating to:

2.1.13 • reconciliation schedules (O repair) NPPs;

2.1.14 • monitoring obligations for delivery of electricity and heat;

2.1.15 • issues with deviations caused by production at the plant causes or dispatching restrictions;

2.1.16 • ongoing operational interaction with dispatchers power during operational use;

2.1.17 • feedback from customers.

2.1.18 2.1.2.2 Interaction operational staff SU NPP in the management processes of dispatching services regulated by the provisions [51].

2.2 Design and development

2.3 This section discusses the design does not own production (electricity and heat), and participated in the design, carried out the modernization, renovation, construction of new facilities and more.

2.4 Design services provide specialized organization with the established procedure and the necessary documents (in the case of the design work on equipment SRB) have been evaluated in accordance with the established requirements

2.5 JMA NAEC 012: 2012 Procurement Management products. Evaluation of suppliers

2.6 Planning and design 2.2.1 rozroblyannya

2.7 2.2.1.1 General requirements for design management in SE "" Energoatom "generally set the standard

2.8 JMA NAEC 053: 2015

2.9 (Change, change №4) Quality Management. Office design

2.10 2.2.1.2 A prerequisite for planning the design work on the new facilities is agreed and duly approved terms of reference for the design object.

2.11 2.2.1.3 A prerequisite for planning design work associated with the reconstruction, modernization of existing facilities are prepared, agreed and approved in due course a technical solution.

2.12 2.2.1.4 Planning project work to be done on the basis of terms and resources needed to ensure the quality of the work.

2.13 2.2.1.5 In planning for the design of set milestones that include verification project involving personnel related to project themes and related tasks.

2.14 2.2.1.6 The plans are determined by activities performed by structural units of the Company (the distribution and structure of interactions), and the amount of work performed by outside organizations.

2.15 2.2.1.7 When contracting project organization formed task, defining stages and deadlines of design work, which may be subject to adjustment in coordination with the contractor.

2.16 2.2.1.8 Management covers the design activities and management personnel of the Company related to execution of works on designing functions within customer products. Activity Management covers the design work regarding new projects, and activities on the reconstruction and modernization of existing systems, equipment, buildings, and includes the definition of input and output control design data.

2.17 2.2.1.9 Quality Design provided design technology that takes into account the implementation of the rules, regulations and standards. Quality design is confirmed by external quality checks on the basis of the contract (contract) and in accordance with the Guidelines as an organization that provides this service.

2.18 2.2.1.10 Requirements interaction (between units SE "" Energoatom "and relevant organizations) to manage the project set in the standard JMA NAEC 053: 2015 (modified, changing №4).

2.19 2.2.1.11 For each project from the units SE "" Energoatom "determined leader responsible project management.

2.20 2.2.2 Input for design and development

2.21 2.2.2.1 Input formed on the basis of the investment program SE "" Energoatom "year approved funding limits the production program SE" "Energoatom", title object object vnutrishnobudivelnyh titles.

2.22 2.2.2.2 Further development is done, approval and adoption president of terms of reference for design work. By the terms of reference annexed all initial data needed for the development of project documentation, including functional, operational and environmental requirements, and can be installed Requirements:

2.23 • of the project documentation;

2.24 • to the presentation of project documentation;

2.25 • the content of project documentation;

2.26 • the software tool and software used for the collection, processing and analysis of objective data;

2.27 • the supplier (executor of the project documentation);

2.28 • to evaluate the results of project work;

2.29 • the reconciliation and examination of project documentation.

2.30 2.2.2.3 The scope and content of the information contained in the composition of the initial data for design, refinement may be subject to a contract and during the project work.

2.31 2.2.2.4 Terms of Reference for the design of new facilities (nuclear facilities) and technical specifications for the design change systems important to safety, according to the requirements of NP [35] sent to the State Nuclear Regulatory Committee of Ukraine for approval.

2.32 2.2.3 Background design and development

2.33 2.2.3.1 Output projection presented in the form of reports, charts, drawings that meet the input requirements; provide necessary information processes of procurement, manufacturing and services; establish product characteristics that are significant for their reliable and safe use.

2.34 2.2.4 Critical reviews of design and development

2.34.1.1 at some stage is carried critical reviews of design and development. VP AES and / or appropriate structural division directorate for consistent project documentation:

• conducts input control its completeness, quality of performance and visual readability;

• documentation records by assigning to it archive rooms;

• makes documentation a computer network database;

• sends the documentation on the analysis of other production units (the owners of the equipment, buildings or structures, technology, etc.);

• provides feedback to the project organization to make changes to the documentation on the analysis;

• Keep the documentation before issuing it into production.

2.34.1.2 Critical reviews of design and development aimed at the following conditions:

• input data for design, set and approved in accordance with the procedure;

• project documentation meets the requirements of technical specifications;

• Project documentation was necessary approvals and expertise.

2.34.1.3 activities planned design control and covers all aspects of design that are important for the safety and reliability of designed objects, components, systems, namely:

• Does the architectural and town-planning requirements and high architectural and artistic quality;

• compliance with applicable regulations;

• environmental protection and rational use of natural resources;

• operational reliability and safety;

• nuclear and radiation safety;

• technical security and fire protection;

• calculations and analysis of physical condition, stress, earthquake resistance, emergency situations, etc.

• defining acceptance criteria and testing;

• requirements for inspections and tests;

• checks carried out by qualified and technically competent personnel.

2.34.2 Verification of design and development

2.34.2.1 In order to guarantee the conformity of products with established requirements SU NPP project organization conducted coordination and approval of the project or its parts according to the plan of the project. Analysis subjected to any changes in the input design data to determine whether they affect the previously approved project test results.

2.34.2.2 For conformity assessment results specified requirements of design work, all project documents (including parts of the project, and the results of operations for individual stages) is checked.

2.34.2.3 Requirements volume of checks set depending on the specific impact of the safety equipment in the specifications for the design. In contract to the supplier (project organization) are required, relating to:

• the required volume of checks;

• documenting the results of the audits revealed discrepancies taken corrective measures;

• reporting or acts of earlier testing performed by the State Enterprise "" Energoatom ".

2.34.2.4 During the inspection project works are considered:

• adequacy, relevance and reliability of the initial design data, compliance with the prescribed format, the signature of the responsible official, and the adequacy and accuracy of data not included in the initial project data, but reduced and used in the design contractor;

• compliance with the specification for the design;

• Does the design technology established requirements;

• correct selection and application of regulations and standards when performing project work;

• compliance staff, performing works specified requirements;

• eligibility initial design data (their conformity with specified requirements);

• availability of documentation work results.

2.34.2.5 inspections to the project include:

• Internal check of the design process responsible officials of the project;

• alternative calculations (calculations), to confirm the results obtained by the applied design technology;

• conducting proficiency testing design models or prototypes (for certified test equipment according to approved testing methods);

• regulatory control of project documentation (required type of inspection performed in any case and is an integral part of the design process).

2.34.2.6 design examination performed and documented by qualified professionals or groups of professionals who participated in the design stages. They should be given the necessary powers to perform inspections and have access to all relevant information.

2.34.2.7 When considering a contractor submitted design and estimate documentation departments responsible staff assesses the compliance of the results of the established technical requirements.

2.34.2.8 documented positive test results are the basis for the decision to end the project work.

2.34.2.9 Project documentation is public examination to the extent prescribed by legislation and regulations we requirements. Positive results of the examination are the basis for approval of project documentation established [21] order. 2.34.2.10 Changes in the project, affecting one element products evaluated in terms of their impact on the project as a whole and given the fact that improving one characteristic can lead to a deterioration of its other characteristics. 2.34.2.11 design changes identified relevant applications and other necessary data. Any change or deviation from the design requirements are made and checked.

Purchases

2.35.1 procurement procedure in accordance with the Law of Ukraine [4] established in the Company's provisions

PL-S.0.10.063-14 (change, change №1, 2) The provisions of the Tender Committee of State Enterprise "" Energoatom "

Competitive Bidding, which do not fall under this provision made in the EP committees (where created).

2.35.2 The procedure for purchasing inventory products found to meet the requirements of the Act [5] production company documents:

(Deleted change №2)

JMA NAEC 042: 2014

(Change, change №1,2) Procurement Management products. Company purchases products

2.35.3 Procedure for procurement of material assets and services to domestic suppliers Company - separate units specified documents

PL-D.0.43.499-12 provisions on the formation of lists of goods (works, services), which is planned to produce (perform, provide) OP "Atomenergomash" and the EP "Atomremontservis" for the needs VP nuclear power plants within the medium-term (four-year) period

PL-D.0.43.511-14

(Change, change №2) Regulations on the procedure of interaction OP "Atomenergomash" structural units of the Management Company and VP NPP during the formation of the order and in the manufacture of products

2.35.4 For the development, design, construction, repair, installation, commissioning organizations, technical support, equipment manufacturers and organizations that provide services to "" Energoatom "(emergency requirements of section 7 [37] and section 7.5 NP [38]) is their score. Requirements to order the evaluation of potential suppliers of products in SE "" Energoatom "set standards

JMA NAEC 012: 2012 Procurement Management products. Evaluation of suppliers

JMA NAEC 049: 2015

(Change, change №3) Procurement Management products. Audits of suppliers

(Deleted change №4)

2.35.5 Priority purchase of products (services) determined by the impact of products (services) purchased, the safety of nuclear power plants approved annual plan funding, the actual cash flow. The issue of creating and managing stocks identified in

PL-D.0.45.613-14

(Change, change №2) Regulations on the procedure of forming and using reserve neznychuvalnoho SU NPP State Enterprise "" Energoatom "

PL-D.0.45.027-15

(Change, change №3) Regulations on centralized energy supply basic equipment and spare parts for nuclear power plants SE "" Energoatom "

PR D.0.29.426-09 the list of stocks tsentralyzovannoho main power machinery equipment and spare parts for nuclear power NNEGC "Energoatom"

(Deleted change №4)

PL-D.0.45.550-14

(Change, change №2) Regulations on management of stocks of inventory in SE "" Energoatom "

2.35.6 Procedure contracts in SE "" Energoatom "generally applicable provisions

PL-D.0.04.066-14

(Change, change №2) Regulations on the procedure for concluding and maintaining agreements (contracts)

2.35.7 Information on procurement describes the products to be purchased in the first place, the requirements for

• approval of product, procedures, processes and equipment;

• training of staff;

• Quality Management System.

The procedure for publishing information determined by the provisions of

PL-S.0.10.063-14 (change, change №1, 2) The provisions of the Tender Committee of State Enterprise "" Energoatom "

(Deleted change №2)

2.35.8 Procedure of the technical requirements for products and equipment delivery terms of safety of nuclear installations is regulated basic standard

JMA NAEC 005: 2014

(Change, change №2) Procurement of products. Tehnycheskye Requirements and terms for the supply of nuclear power plant. Terms of development, oformlenyya and treatment. Requirements for Content

Procurement of information technology identified as:

JMA NAEC 042: 2014

(Change, change №2) Procurement Management products. Company purchases products

2.35.9 Procedure of the technical requirements to some important operating nuclear materials and reagents defined in

JMA NAEC 006 2013

(Change, change №2) Procurement Management products. Turbine oils for nuclear power equipment. Technical requirements for quality, reception and storage conditions

JMA NAEC 007: 2011 Materials yonoobmennые filtering systems environments vodnыh treatment plant. Requirements for Quality, vent and control эkspluatatsyonnomu

JMA NAEC 029: 2012 Procurement Management products. Compatibility of means electromagnetic. Technical equipment for nuclear power plants. Requirements and test methods

2.34.1 Verification of purchased product

2.34.1.1 The system of conformity assessment of products purchased operated by Set (change, change №1)

JMA NAEC 024: 2012

JMA NAEC 039 2013 Procurement Management products. The system of conformity assessment of products purchased by the operating organization. Terms

Procurement Management products. The system of conformity assessment of products. Evaluation of products during production.

JMA NAEC 045 2013 Procurement Management products. The system of conformity assessment of products. Criteria for selection of the conformity assessment procedures

JMA NAEC 046 2013

Procurement Management products. The system of conformity assessment of products. Conformity assessment of electrical products during manufacturing. Primary measuring converters of temperature, pressure, flow and level

JMA NAEC 047 2013

Procurement Management products. The system of conformity assessment of products. Conformity assessment of electrical products during manufacturing. circuit breakers, contactors, starters, cables

2.34.1.2 Requirements for the order of entrance control products in SE "" Energoatom "set the standard

JMA NAEC 038 2013 Procurement Management products. The organization of entrance control products for nuclear power plants

2.34.1.3 Procedures acceptance of products in quality and quantity by instructions [49] and [50].

2.34.1.4 procedure of individual permits for work on CSR described

PL-D.0.26.485-15

(Change, change №3) «Situation on vыdachy manner chastnыh razreshenyy to perform activities on systems and vazhnыh element for safety in GP" NNEGC "Energoatom"

2.34.2 Report on contractors

2.34.2.1 To comply with the requirements of paragraph 7.4.3 of emergency [38] and the license terms for the stage of the life cycle "operation of a nuclear facility" VDYAU licensing department provides annually to the State Nuclear Regulatory Committee report on the work of contractors that were involved in the execution of works (services) repair modernization and reconstruction of systems important to safety.

2.35 Production and service provision

2.35.1 Validation of processes for production and service provision

2.35.1.1 For all processes and activities that affect the safety management developed and approved for implementation (regulations, regulations, instructions, procedures, programs, process maps, measurement techniques, etc.), which defines:

• functions, responsibilities, authority and accountability of the personnel performing the work or process, as well as their interaction;

• procedures for cooperation and sharing of responsibility to suppliers and consumers process;

• sequence of process or work;

• point control processes; parameters are checked against the planned value;

• procedures for monitoring and evaluation of security activities;

• a list of important features and tools, materials, equipment, and special test equipment, remedies necessary to perform the job.

2.35.1.2 nomenclature only indicators of operational safety, design procedure and analysis technique to identify trends change status indicators operational safety, and also for developing and reporting described in the standard

STP 0.41.066-2006 system otsenki urovnja ekspluatatsyonnoy and safety of technical electric STATUS nuclear power stations with VVER. General specifications Requirements

2.35.1.3 The results of analyzes performed work on the basis of a comparison of planned and actual work performed.

2.35.2 Identification and traceability

2.35.2.1 Identifying products due to the nature of energy production does not apply. Effective management facilities should be properly identified. Identification is performed with respect to these control objects:

• material objects (buildings, structures, facilities, equipment and systems);

• documentation;

• elements of organizational structure (numbers and abbreviations, units and positions);

• hazard (category designation and area fire, radiation and explosive hazard).

2.35.2.2 Means of identification are:

• marking equipment belonging to the system;

• Marking production facilities, buildings and structures;

• numbering of documents;

• certain colors painting production equipment;

• classification of zones and areas for VP AES categories and modes of access;

• Installation of signs that prohibit certain elements of the work equipment.

2.35.2.3 Measures to identify all applicable processes include

but facilities management (documentation, equipment, material resources) and are designed to ensure their traceability throughout their existence and use as facilities management. 2.35.3 Property of the customer company does not use in the

manufacturing process of any property (property) of the customer and, accordingly, does not control it. 2.35.4 Production 2.35.4.1 Save Save compliance electricity production from its transmission grid to the customer at the expense of respect for issuing electrical circuit design capacity. 2.35.4.2 Saving accordance thermal energy during transport to the customer at the expense of respect for the rules of operation of heat networks. 2.35.4.3 conservation measures are applied regarding products purchased material resources. All materials (spare parts, purchased equipment, supplies, etc.) are transported, stored and maintained in accordance with the requirements established in the standard STP 0.45.029-2011 storage of industrial products. General requirements for organization and control requirements 2.35.4.4 saving products developed based on regulatory requirements and in accordance with the classification approach. If necessary, developed and implemented special measures to ensure the necessary conditions for preserving products (related to ensuring nuclear and radiation safety, environmental protection). 2.36 Control of monitoring and measuring devices

Production processes, testing provided measuring and testing equipment. Tools, standards and devices for testing, measuring and test selected and used in accordance with established metrology requirements on procedures / order:

• calibration of measuring instruments;

• calibration of measuring instruments;

• metrological certification of measuring instruments;

• transfer of measuring instruments indicators;

• carrying out metrological certification of measuring instruments and audits;

• destination responsible for the state of measuring devices in offices.

Examples:

STP 0.03.030-2001 metrology. Measuring Systems Automated Clearing and control system tehnolohycheskymy processes. Procedure for Choice and Adoption main sample

PL-D.0.03.037-09 Regulation on certification of measuring laboratories separate units "Energoatom". General requirements, organization and procedure

PL-D.0.03.122-10 Regulation on certification of metrological services SE "Energoatom" on the right calibration of measuring instruments for their own needs. General requirements, organization and procedure

PL-D.0.03.135-10 Regulations on the order of manufacture, use, storage and disposal gauge Taurus in "Energoatom"

PL-D.0.03.140-10 regulations on the organization and conduct inspections metrology services, calibration, measurement and testing laboratories SE "Energoatom"

(Change, change №4) Regulations on metrological service parent organization of the Ministry of Energy and Coal Industry of Ukraine - State Enterprise "National Nuclear Energy Generating Company" Energoatom "in nuclear - industrial complex

2.34.2 The execution of management control and measuring equipment involved for commercial metering of electricity carried out under instructions [24] and the operating instructions of electrical information systems applied in the OP NPP.

Measurement, analysis and improvement

3.1 General

3.1.1 The Company as a whole and in particular nuclear VP made the monitoring, measurement, if applicable, as well as analysis and improvement activities to:

• demonstrate conformity of products and services established requirements;

• maintenance and continuous improvement of management system.

3.1.2 General provisions and basic principles of planning, organization, implementation and monitoring of results measurement, analysis and improvement of the Company are set out in

JMA NAEC 054: 2015

(Change, change №4) Quality Management. Monitoring and testing

JMA NAEC 056: 2015 (modified, changing №3) Quality Management. Independent evaluation management system

JMA NAEC 056: 2015 provides for the following types of assessment:

• internal audits;

• independent external audit;

• Independent evaluation;

• departmental supervision (change, change №4).

3.1.3 General provisions and basic principles of planning, organization, implementation and monitoring of the results of internal quality audits in the Company are set out in the standard

STP 0.06.006-2007

(Change, change №2) integrated management system. An independent assessment. The procedure of internal audit

3.1.4 audits environmental management system in EP held during comprehensive inspections in the OP, and according to schedule inspections VP consolidated company we inspecting authorities annually formed Directorate of safety supervision.

3.1.5 General provisions and basic principles of independent review of SE "" Energoatom "NNEGC out in SOU 056: 2015 (modified, changing №2,3).

3.1.6 According to paragraph 8.8 [38] requirements for internal oversight processes identified in

PL-D.0.26.136-15

(Change, change №3) Regulations on departmental oversight system in the operating organization SE "" Energoatom "

In-D.0.26.512-12 Instructions organization and procedure for internal investigations in SE "" Energoatom "

3.1.7 Concerning the Management of the Company structural subdivision responsible for the internal oversight on security issues and implementing measures to improve security, is the management of safety supervision. General provisions and basic principles of planning, organization, implementation and monitoring of results in departmental supervision SE "" Energoatom "set out in section 11 of the JMA NAEC 056: 2015 (modified, changing №2,3).

Monitoring and measurement of processes

2.35.1 The Company shall apply suitable methods for monitoring processes MIS. These methods demonstrate the ability of processes to achieve planned results. Owners processes evaluate the efficacy of processes, the results of which are responsible and accountable according to the law.

2.35.2 Inspection and test technology systems, equipment, buildings, constructed and put into operation, carried out in accordance with established regulations of the works on commissioning. The results of this type of inspections are documented statements of operation.

2.35.3 Method of nuclear power generation technology and existing production accompanied by the formation of environmental aspects that can have a negative impact on the environment, including:

• radioactive waste;

• spent nuclear fuel;

• emissions / discharges to the environment;

• industrial waste;

• electromagnetic radiation;

• ionizing radiation;

• Water or steam circulating cooling systems, and others.

2.35.4 Environmental monitoring generally carried out in the Company as required by state hygienic standards [32, 33] rules [36, 42, 45] provisions [11, 43] and monitoring in the field of air accordance with the order [12]. Industry requirements listed in the regulations Minenergouglya Ukraine

JMA NAEC 076: 2015

(Change, change №4) Environment. Organization and implementation of environmental activities in separate divisions

Company standards Requirements

STP 0.03.088-2010 system standardization SE "" Energoatom ". Procedure development Regulation hydrobiological monitoring the cooling pond, cooling systems and industrial water supply NPP with VVER. guidance

JMA NAEC 004: 2011

(Change, change №2) system standardization. Environmental assessment units of nuclear power plants. General requirements for structure and content material evaluation

STP 0.26.085-2009

(Change, change №2) Ensuring environmental safety. Requirements for the form and content of reports SU NPP "Energoatom" to assess the impact of non-radiation factors NPP on the environment

JMA NAEC 076: 2015

(Uploaded, changing №3) Environment. Organization and implementation of environmental activities in separate divisions

2.35.5 Examples of identification requirements for an environmental management system is a separate list

PR D.0.18.583-13 separate list of legislative and regulatory acts in the field of environmental protection requirements which relate to the activities of SE "" Energoatom "

2.35.6 Identification and evaluation of environmental aspects, namely: identification of environmental aspects related to production activities; assessment of the materiality of the identified environmental aspects; Environmental formation programs carried out and documented in accordance with typical methods

MT-D.0.18.571-12 typical method to identify and evaluate environmental aspects in

"Energoatom"

and developed similar regulations / procedures in EP NPP.

2.35.7 The evaluation of environmental aspects generated lists (example on the list of the Board of Directors of the Company)

PR D.6.18.586-13 list of environmental aspects in the Management of SE "" Energoatom "

which consist environmental program VP, environmental program of the Company

PM-D.0.18.195-14

(Change, change №2,3) program of environmental activities SE "" Energoatom "in 2014-2016 years

comprehensive program of radioactive waste management

PM-D.0.18.174-12 comprehensive program for radioactive waste management in "Energoatom" for the period 2012-2016.

2.35.8 for nuclear and hazardous work composed and Ukraine agree SCNS typical work programs and their implementation, such

PM-T.0.41.215-10 Typovaya program conducting nuclear hazardous work on podъemu transportyrovke block and protective tubes IZ reactor VVER-1000 the mine revyzyy

PM-T.0.03.217-10 Typovaya program conducting nuclear hazardous work on protaskyvanyyu OR CPS

PM-T.0.03.226-10 Typovaya program for emptying the tank avaryynoho Stock rastvora bornoy acid (GA-201). Nuclear opasnaya Business

Monitoring, measuring and control nonconforming product

2.35.1 Standards of quality of electricity must meet the requirements of GOST [25]. Commercial metering of electricity carried out according to the instructions. [24]

2.35.2 In order to verify the requirements for products, AES VP is controlled such basic electricity parameters:

• active power generated by turbogenerators units;

• reactive power generated by turbogenerators units;

• active power on overhead lines;

• reactive power on overhead lines;

• amperage for airlines;

• frequency current;

• voltage air lines

• and quantitative indicators produced, consumed and supplied electricity:

• amount of electricity;

• amount consumed for own needs of electricity;

• overflows - air lines emanating from the open switchgears;

• the number of supplied electricity.

Current and overall monitoring of production plans with the delivery of electricity and thermal energy is within the process of "electricity production planning and maintenance operating nuclear processing facility." Relevant work is carried out with the executive management of production.

2.35.3 For the purpose of analyzing and reliability of electricity each reactor nuclear power plant performed calculation of underproduction of electricity.

2.35.4 Accounting supplied heat is carried out according to performance units for consumers. In the absence of metering at the consumers account carried VP AES calculation method.

2.35.5 Accounting and control of the released heat carried VP AES. Information on the number of customers and heat supplied meets monthly. As a result, VP AES prepare reports on supply of thermal energy per year in the form №1-heat (annual), approved by the State Statistics Committee №371 from 01.09.2010.

2.35.6 With respect to the process equipment conformity with specified requirements is verified monitoring and conducting tests oprobuvan, checking equipment and systems. Monitoring and testing are carried out:

• during commissioning - in accordance with the requirements of regulations defining the scope and procedure of testing;

• the operation - according to the approved operational documentation and software testing;

• third parties (expert assessment, independent expert, etc.) in cases determined by the requirements of the regulations.

2.35.7 Planning of testing and monitoring on the basis of the Law of Ukraine [6] rules [44, 46] for nuclear materials, norms and standards and other regulatory documents ([50, 51]). Plans of controls and tests take into account the requirements of security and surveillance and control part of people, depending on the importance of security and complexity of the process. Organization of control and testing and completeness of performance is controlled depending on the relevant departments for activities and the importance of security.

2.35.8 Controls and tests include:

• organization of control;

• Metrological expertise of documentation (design, engineering, technology);

• incoming inspection and testing of components;

• control and testing during the activity;

• control of finished products and their testing;

• A protocol for monitoring and testing, other established records;

• inspection results for conformity with specified requirements;

• identifying discrepancies and corrective action monitoring and testing.

2.35.9 Documentation of inspections and tests include initial conditions, design requirements, eligibility criteria, scope, sequence, methods, means security requirements for staff qualifications and the necessary environmental parameters.

2.35.10 inspection and test technology systems, equipment, buildings, built and put into operation, carried out in accordance with established regulations of the works on commissioning. The results of this type of inspections are documented statements of operation.

2.35.11 inspection and test technology systems and equipment Units pursuant to the requirements of Regulation maintenance, repair and testing of CSR and operating instructions. Heads of departments organize inspection and test execution process equipment and systems, assigned to the structural unit, according to the requirements. Inspections and tests not covered by existing operating instructions are carried out in accordance with developed and approved programs.

During maintenance and repair of the equipment provided technical quality control of repair and reconstruction works, control of metal and welded joints, control (diagnosis) vibration condition of the equipment.

2.34.2 During the handling of nuclear fuel carried out specialized monitoring, including accounting and control of nuclear materials, control of the containment shell TVEL.

2.34.3 control measures periodically analyzed and reviewed by the responsible personnel, to ensure their adequacy, efficiency, use of operating experience and consideration of changes in existing regulations.

2.34.4 assessment of the current security level for each unit held the previous year. The requirements for evaluation and registration statements set out in document

STP 0.41.066-2006 system otsenki urovnja эkspluatatsyonnoy of technical and safety STATUS nuclear power stations with electric water power reactors vodyanыmy. General requirements.

Reports are provided to the SCNS. Organization, coordination and maintenance of operational safety assessment carried out structural units of the safety analysis.

2.34.5 Monitoring and measuring discharges water from promploschadok NPP emissions and placement of industrial wastes is under the relevant Regulations.

2.34.6 Monitoring of environmental aspects of radiation character performs management of nuclear and radiation safety, non-radiation nature - Department of Environment VDYaRBiNTP.

2.34.7 conducting nuclear radiation and dosimetry control the environment in the vicinity of nuclear power plants (thirty kilometer surveillance zone) assessment of nuclear radiation effects on the environment and population controls and review of emissions and discharges of radionuclides into the environment and the establishment of interdependence ' connection between their size and, as the clearing and process equipment units, modes of power.

2.34.8 Radiation Control Regulations set types, facilities, frequency, methods, means of radiation monitoring parameters that are monitored, and it referred to the established norms of radiation parameters.

2.34.9 Inconsistency electricity (as product) specified requirements exclude the implementation of project requirements and work tools and supervisory control of power systems.

2.34.10 In respect of any identified irregularities carried out:

identifying discrepancies are methods and means;

documentation revealed inconsistencies in the prescribed form (record of operational documentation of act, etc.);

measures to eliminate the detected nonconformity;

implementation of measures to prevent the use of nonconforming product (process), which depending on the discrepancy may include designation or marking removal, fences etc.

implementation of measures to preserve security features (use of appropriate compensatory actions to restore the use of nonconforming product and / or process);

information about the discrepancy in the prescribed manner and volume (including informing the State Nuclear Regulatory Committee of findings that affect the safety of a nuclear installation).

2.34.11 Requirements management irregularities established in STP

JMA NAEC 022: 2014

(Change, change №2) integrated management system. Management of discrepancies

analysis of data

2.34.2 Company determines collects and analyzes relevant data for assessing management capabilities in terms of continuous improvement of its effectiveness. These data include results:

• monitoring and measurement;

• audits of departmental oversight and inspections;

• Work with suppliers of products and services;

• management of significant environmental aspects.

2.34.3 Analysis of data carried VP and specialized structural units of the Board of Directors of the Company and provide the results of the management of CAP and SE "" Energoatom "for decisions on necessary measures.

2.35 improvement

The company as a whole and particularly VP seek to continuously improve performance management, adjusting policies and objectives in accordance with the challenges of time, using the results of audits and other internal and external audits, self-assessments, analysis of data from management. On the basis of the said guide defines the objectives to improve the activity and supervises their implementation.

2.35.1 Corrective actions

2.35.1.1 Company as a whole and in particular the EP takes action to eliminate the cause of nonconformities in order to prevent their recurrence. Corrective action is governed by the effects of the inconsistencies.

2.35.1.2 Corrective actions include:

• review of discrepancies in importance based classification approach in accordance with the established procedure for their consideration;

• analyzing the causes of discrepancies and determine corrective and preventive actions;

• corrective actions and analyze their effectiveness.

2.35.1.3 Production (processes) after elimination of non-compliance to their use are checked and tested according to the requirements.

2.35.2 Preventive action

2.35.2.1 Company as a whole and in particular the CAP to eliminate the causes of potential irregularities and prevent their occurrence conducts preventive actions requiring:

• identifying potential nonconformities and their causes;

• assess the need for action to prevent inconsistencies;

• the necessary action;

• check the results of the action;

• analyzing the impact of preventive action performed.

REGISTRATION SHEET CHANGES

NON SHEETS MESSAGE

A CHANGE-THEY BEEN REPLACED, THESE NEW ANULO-EMYH GUESTROOMS

SIGNATURE DATE SHEET

SHEET REVIEW

Name	Position	Date	Signature

Appendix C18

EnergoAtom. 2014a. Regulations on the Procedure for Concluding and Maintaining Agreements. Document 485R. June 4.

Ministry of Energy and Mines UKRAINE

NATIONAL NUCLEAR GENERATING COMPANY ENEGOATOM

Order

Number 485 r from 06.04.2014.

On the implementation of the Regulations

In order to establish a uniform procedure for concluding and maintaining agreements (contracts) concluded in separate divisions of Management and State Enterprise "of" Energoatom "

oblige:

1.To inforce from the date of registration of this order "Regulations on the procedure for concluding and maintaining agreements (contracts)" PL-D.0.04.066-14 (hereinafter - Regulations), thus eliminating the effect "Regulations on the procedure for concluding and maintaining agreements (contracts) "PL-D.0.04.066-09.

2.To appoint Directorate of Finance and Budgeting unit responsible for maintaining Regulation.

3.To establish mailing list of discounted copies of the Regulations in accordance with Annex to this order.

4. Executive director of quality management S. Popov to make provisions to the current "List of production documentation of SE" "Energoatom" in due course.

5.General directors (directors, managing director) SS unit managers and the Management Company to ensure implementation of the Regulation in due course.

6.Control of the execution of this order to put to Vice President Aysin AA

President Yu Nedashkovsky

Havryliuk AM 78-10

Regulations on the procedure for concluding and maintaining agreements (contracts)

NAEC

PL-D.0.04.066-14

CONTENT

Terms and definitions ....

GENERAL ..... 1 ....

2 ORDER AND TERMS approval AGREEMENTS (contracts)

Concluded in directorate ....

3 ORDER EXECUTION instrument of acceptance of

Works (services) goods supplied under the agreements

Fit into the directorate ....

4 REGISTRATION CLOSING PROCEDURES agreements that were concluded in

MANAGEMENT COMPANY ....

5 allocation of duties and responsibilities in

Concluding and maintaining agreements concluded in the administration

COMPANY ....

6 PROCEDURE contracting SE SE "" Energoatom "....

7 CONSEQUENTIAL AND CONDITIONS REQUIRED CONTRACT DETAILS ..... .

8 REQUIREMENTS annexed to the Treaty ....

9 ADDITIONAL CONTENT REQUIREMENTS contract to perform work

(Services), goods of safety NPP ....

APPENDIX A special stamp ....

Appendix B. itinerary ....

ANNEX VI LIST OF DATA THAT MUST BE STATED IN curator

Memo ADDRESSED TO THE PROJECT MANAGEMENT COMPANY

CONTRACT (Supplementary Agreement), concluded in the directorate ....

ANNEX D. AGREEMENT TO CARD ACCOUNT (Supplementary Agreement) .....

Appendix D. STATEMENT OF PRIVATE CONTRACTS FOR 20 MONTH _____ _ P .....

REGISTRATION SHEET CHANGES ....

SHEET REVIEW ....

Regulations on the procedure for concluding and maintaining agreements (contracts) NAEC

PL-D.0.04.066-14

Terms and definitions

Number Term Definition

1. REFERENCE complex technical, organizational, economic,

CONTRACT legal action curator and separate units

(Contract) directorate and structural divisions

Companies focused on performance of the contract

(Contract) in accordance with the Parties

obligations and applicable law

(Used herein).

2.SU recipient separate unit, which is the recipient

(User) works (services), goods under agreements (contracts) concluded directorate (used herein).

3. The contract agreement between two or more parties, aimed at (contract) the establishment, modification or termination of civil rights and obligations (Art. 626 of the Civil Code (CC) of Ukraine 16.01.2003r. №435-IV as amended).

Terms of the contract referred to in section II of the fifth book of the Central Committee of Ukraine.

4. The contractual documents (including in writing) that have documents related to the coordination of procedures for signing, execution and termination of each agreement (contract) concluded with a specific counterparty

(Used herein).

5.KONTRAGENT party (legal or natural person), which

The Company enters into contractual relations

(Used herein).

6. Curator unit (worker) Management of the Company,

responsible for organizing the planning,

agreement, contract (contract) in

Management of the Company, as well as monitoring of its implementation

to achieve the desired result for BF

"" Energoatom "(used in the

document).

7. OFFER proposal to conclude an agreement (contract), which is addressed

one or more persons who refers to the essential

contract terms and expresses the intention of the person who made

proposal to consider itself bound by the contract if

acceptance (used herein).

8. 8AREKR 8uz1etz Apayiuziz ADF Rho§hash sieueiortepi Epiehrhize

Kezoyhse R1appip§ - software firm

8AR systems analysis and design applications

enterprise resource planning.

9. ONE single information-analytical system (CIAS).

Regulations on the procedure for concluding and maintaining agreements (contracts)

NAEC

PL-D.0.04.066-14

INFORMATION subsystem "Accounting for contracts" on the basis of software BAZAzabezpechennya 8AR ERC.

R**egulations on the procedure for concluding and maintaining agreements (contracts)**

NAEC

PL-D.0.04.066-14

1. GENERAL PROVISIONS

1.1Tse "Regulations on the procedure for concluding and maintaining agreements (contracts)"

(Hereinafter - Regulation) establishes a uniform procedure for concluding and maintaining agreements (contracts) concluded in separate divisions of Management and State Enterprise "" Energoatom "(hereinafter - Company).

1.2 During concluding agreements (contracts) All officers of the Company shall be guided by the current legislation of Ukraine, this Statute and other industrial, regulatory, organizational and administrative documents of the Company.

1.3 All agreements (contracts) concluded only with the subject of the agreement (contract) in the approved annual procurement plans of the Company and if secured sources of funding for the duration of the agreement (contract).

1.4 Ahreement (contract) (hereinafter - the contract), together with other contractual documents issued in the manner and sequence provided by this Regulation. Any person may refuse sighting contract without providing reasoned written comments or suggestions to the terms established by this Regulation.

1.5 All agreements in the Directorate and separate units (the EP) the Company concluded in compliance with the current legislation of Ukraine regulating the exercise of public enterprises procurement of goods, works and services, particularly for public funds.

1.6 Changes made to the agreement concluded by the conclusion of additional agreements (contracts). If you change the payment details of a party is allowed to use a written message, which is an integral part of the contract, if required by the contract and SU

1.7 All companies carrie out contractual activities and are responsible for the conclusion and implementation of agreements (contracts) Under the provisions of the relevant EP, this Regulation and its

own Regulations on the procedure for concluding and maintaining agreements developed in accordance with this Regulation. Leaders of the EP at the conclusion of contracts are within the powers granted power of attorney.

1.8 Purchase of goods and services accounts without contracts performed, provided that the sum of one account does not exceed 30 000.00. Moreover, all invoices shall be registered in a single information base, except payment for services of state bodies (institutions) for the issuance of permits, certificates, conclusions, licenses, statements, excerpts and certificates from the registers, payment of duty, legal costs, notary services etc. . All bills are issued and registered only with the subject of procurement in the approved annual procurement plans of the Company and if secured funding sources. (Modified, change №3).

1.8.a When concluding agreements (contracts) the use of such forms of payment like credit coated prohibited. If acceptance of Committee tender offer uchashiyka procurement procedure, which involves another Letter of credit, a draft agreement (contract) agrees accordance with regulatory, manufacturing and organizational and rozporyadchyhdokumentiv Company (Attachment, change MI).

1.9 All agreements and additional agreements to them concluded as a Board of Directors and in EP Businesses must register with the department of control and accounting department work with suppliers of financial planning and monitoring of financial management and budgeting (hereinafter - VKORP) in the manner prescribed this Regulation.

Features 1.9a conclusion, approval and execution of contracts financed by the EBRD and Euratom established the "Regulations on the use of the loans of the European Atomic Energy Community and EBRD loan for the project" Complex (summary) program enhance the security of nuclear power plants "PL - D.0.04.622-16 (attachment change №4).

1.10 The provisions must be in capital production documentation Management of the Company (the original), in the archives of the EP, the structural units of the Board of Directors of the Company.

1.11 VKORP is a unit responsible for the conduct of this Regulation.

2. **Terms of approval and signing of agreements (contracts) concluded in directorate**

2.1 Company President and Senior Vice President - Technical Director have the right to review and sign the Charter under all contracts concluded in the Management Company.

2.2Vice presidents and other heads of departments of Management for activities examine and sign treaties within their competence, under the Charter, manufacturing and organizational and administrative documents of the Company.

2.3 All projects (contracts), or offer additional agreements (hereinafter - the draft agreement), coming to the company, together with a covering letter registered with the general department of executive management of nuclear fuel procurement and information management as incoming mail, and on the day of revenue goes to the proper supervisor for deciding on the need for further processing. In no later than the next business day from the date of imposition of the resolution draft agreement transmitted to the unit-curator defined by the supervisor. If the decision to return the draft contract without issuing a return made subdivision defined by the supervisor.

2.4 Contract be concluded provided that the subject of the contract approved annual procurement plans of the Company and the procurement of nuclear fuel and services for the export of spent nuclear fuel - annual proposals under this program, drawn up in accordance with the Regulations on the procedure for export of fresh and spent nuclear fuel PL- D.0.20.200-11. Without the purchase of annual plan or in excess of its value over the planned contract may be concluded only after making appropriate amendments to these plans.

2.5Projects agreements concluded in the Management Company for works (services), supply of goods recipients (users) by GC Company, prior to the approval procedure in the prescribed manner to be agreed

by the EP - recipient works (services) products. Term of approval of the draft agreement in each EP - recipients do not exceed 5 working days. Approval is possible by sending a letter to the Board of Directors or sighting last leaf of the contract manager in the appropriate direction OP. After the signing of the contract and assigning him the registration number of the copy sent to the appropriate supervisor of EP Company.

2.6 Conditions of the purchase agreement with the winning bidder shall be set out in full compliance with the terms of the tender documentation and proposals from winning trades, in the case of presentation in the tender documentation material terms of the agreement in the form of draft contract, the procurement contract shall be set out in full compliance with the draft contract. Procurement contract must be concluded within the time provided by law on public procurement.

2.7 Conditions of the contracts for works (services) non-capital nature may provide for the phased implementation of works (services) only on condition that the results of these individual stages of works (services) can be used independently in economic activity.

2.8 Curator considering a draft agreement for compliance with the requirements set out in points 2.4 - 2.7, sections 7, 8, 9 of the Regulations, and prepares supporting documents to it which are sent to the head in the direction, which granted the right to sign the relevant agreements. Supporting documents shall include:

• official note on the model set out in Annex B to this Regulation (except for contracts to provide interest-free loans to employees of the target company and the Board of Directors of mortgage agreements);

• filled card account (Appendix D to this Regulation) (except contracts do not provide financial liabilities);

• The results of price monitoring or rationale for choice of supplier agreements made without the use of competitive procurement procedures;

• for contracts concluded by the results of a competitive procurement procedures, further - an extract from the minutes of the Committee of competitive bidding SE "" Energoatom "on the recognition of the counterparty winning bidder, a copy of the tender documentation, the message of acceptance and demand (price) by winning trades .

2.9 President of SE "" Energoatom ", head in the direction that has the right to sign contracts, or the person who replaces them, make administrative endorsement to the draft agreement on its design or inscription on the return of the project without clearance, and return it to the General Department . The general department within one business day passes the draft agreement (contract) with the Director of Finance and budgeting, which sends the draft agreement with the administrative label to VKORP.

2.10 VKORP makes the preliminary registration and registration of the project contract, organize and control its consideration and viewing the relevant departments and officials of the Board of Directors of the Company as follows:

2.10.1 VKORP records the draft agreement in Journal of contractual documentation, affix the last sheet of his specimen special stamp (Annex A) Company.

2.10.2 VKORP draws trip sheet (Annex B) and passes the entire package of contractual documentation curator at the signature of the responsible person in the Journal

2.10.3Head of the unit - curator, received a draft contract, a one-day period shall appoint the officer directly responsible for the maintenance contract (curator agreement).

2.10.4 Curator contract within two days considering the contractual documents according to assigned duties and responsibilities, affix a visa in the itinerary and submit division head curator for viewing route sheet and a stamp, and then returns to VKORP project.

2.10.5 VKORP after sight-curator unit transmits the draft agreement to branches of the Company's Board of Directors indicating movement in logbooks contract documents receipt date and return the draft agreement in the following order:

• Executive Directorate for Quality and Management (if the contract is not expected to purchase products that affect safety in nuclear power plants, is an entry in the itinerary, with a special stamp to the draft contract signature executive director of quality and management is not put);

• Inspector General - Director for Security;

• Directorate of Information Technology executive management of nuclear fuel procurement and information security (for contracts involving the execution of any works (services) on the creation and implementation of automated systems management and acquisition of information technology, software);

• management of procurement of nuclear fuel and regulation of foreign economic activity of executive management of nuclear fuel procurement and information security (for foreign economic contracts);

• Management of other units of the Company for the decision of leadership, reflected in the accompanying memo;

• Directorate of Economic Affairs;

• Accounting;

• executive management on legal issues and support procurement procedures;

• VKORP;

• Director of Finance and budgeting.

2.10.6 Project agreement signed by the head of the relevant structural unit of the Board of Directors of the Company (or the person who replaces him and / or deputy) or provided comments and suggestions in writing to the completion of the relevant section of route sheet.

2.10.7 Curator provides the necessary explanations heads of structural divisions of Management Companies that endorse the draft agreement.

2.10.8 Revewing contract is to route sheets and sheets the last copy of the contract, which remains in the Company, within their respective fields of special stamp (Annex A). Not allowed to exercise sighting contract documents pencil.

2.10.9 Projct agreement concluded with the Board of Directors of the Company should be considered and, in the absence of comments endorsed subdivisions (officials) Management of the Company in the following terms:

• Executive management and quality control - 1 day;

• Inspector General - Director of Safety - 1 day;

• Directorate of Information Technology Procurement Executive Directorate

fuel and informational support - 1 day;

• management of procurement of nuclear fuel and regulation of foreign economic activity of executive management of nuclear fuel procurement and information support - 1 day;

• Directorate of Economic Affairs - 1 day;

• Accounting - 2 business days;

• executive management on legal issues and support procurement - 2 business days;

• Directorate of Finance and Budgeting:

■ VKORP - 2 business days;

■ Director of Finance and budgeting - 1 working day.

2.10.10 For agreements to be concluded by the results of procurement procedures, the general term for review and signing of sight should not exceed the term of the contract for specified requirements of legislation of Ukraine on public procurement.

2.10.11 For agreements of one-time seminars, individual training, provision of interest-free loans to employees of the target and the associated mortgage agreements, restructuring of tax debt settlement agreements, agreements on settlement and cash services, loan agreements, deposit agreements, contracts bank account overdraft agreements, contracts for bank guarantees and letters of credit, collateral agreements, valuation of assets associated with the conclusion of credit agreements and contracts for bank guarantees, contracts relating to the issue and circulation of securities, agreements on confidentiality apply shortcut consideration. These contracts are considered such units, curator, accounting, executive management on legal issues and support procurement procedures VKORP and director of finance and budgeting, and management of international cooperation, if the contract is in a foreign language.

2.10.12 In case of urgency the draft agreement on the accompanying document and the itinerary to the agreement is labeled "Urgent" and terms established by this Regulation for viewing, reduced to one working day for each unit.

2.10.13 Curator summarizes all comments and suggestions to the draft contract, if possible - eliminate shortcomings into account comments and suggestions, take measures to coordinate corrections and settlement of disagreements with the contractor, then revised draft agreement provides relevant business unit mark for the withdrawal of remarks and agreement.

2.10.14 In case of absence of comments on the draft agreement VKORP head or the person who replaces him, parafuyetsya each sheet contract.

2.10.15 Conract signed by the head of the company or person to whom the established order have the right to sign the contract after viewing curator and heads of departments of the Company in accordance with the procedure laid down in this Regulation. This agreement with all applications must be signed by the one officer of the Company indicated in its preamble. In the absence of an official contract signed by another official who has the appropriate credentials, marked her signature at the office, names, initials and document confirming authority.

2.10.16 In caseof presence of unresolved disagreements on certain terms of the contract workers VKORP a protocol discrepancies in duplicate with all outstanding and provided comments and suggestions. At each copy of the contract in place for the signature of the head (other authorized official) of the Company, stamp or label

- "The protocol differences."

2.10.17 Protokol differences seen and agrees urgent procedure of project agreements without registration route sheet. In case of registration of the discrepancy contract transferred to

signature of the head only after approval of the discrepancy in due course.

2.10.18 Both copies of the differences along with the signed contract sent with a covering letter or transmitted in painting contractor and must be reviewed and signed in 20 days. If the discrepancy report signed by the contractor, one copy it back to the Company.

2.10.19 If the protocol settlement of differences, which is clause in the protocol differences, it is considered within 20 days following the procedure provided for consideration of the discrepancy, and in the absence

of official comments signed by the company that signed the contract, certified by the stamp, one copy is returned contractor, the second - is attached to the contract.

2.10.20 In caseof presence of observations that can not be eliminated protocol differences or settle differences Protocol, the draft agreement back curator for improvement. The dispute between the parties to the agreement on the differences that remain unresolved may be referred to the court.

2.10.21 If the parties fail to agree on all essential terms of the contract such contract under the law is not concluded.

2.10.22 After signing by the parties VKORP making information about its essential conditions to a single information base, the agreement assigns a registration number that is stamped on the first page at all copies and all annexes to the agreement. If the number agreement is already given by the counterparty, the Company's registration number is put through a slash after the existing number, the date specified below. If the contract is the date affixed contractor, the date the contract is considered later of these dates on it. Date on foreign trade agreements (contracts) affixed slovesno- digitally.

2.10.23 Signing of the contract is transferred to the General Department of executive management of nuclear fuel procurement and information support for the seal.

2.10.24 Order of registration of contracts defined by this section shall also apply to order execution of additional agreements (agreements) to existing contracts for amicable agreements, innovations, agreements on the order of settlements and other agreements governing the calculation of counterparty after a judicial decision with legal disputes arising from the Company's main contract of works, services or supply of goods.

This unit-curator of contracts (agreements of lawsuit) is the curator of the main contract, and in the absence of the main contract supervisor in the structure of the Company acting curator structural unit, the direction of which the indebtedness.

2.10.25 If agreements (supplementary agreements) signed by authorized persons not established in this Regulation and approval procedure sighting or without the removal of all the comments that were provided by relevant departments, full responsibility for the conformity of contracts (additional agreements) with current legislation of Ukraine and the Company relies on the interests of the officials who signed them.

2.10.26 If agreement signed on behalf of the Company by an authorized person who is not a worker (in accordance with agency contracts, orders, etc.), such an agreement in one-day period from the date of directed structural unit-curator accompanying official note with the addition of cards accounting for management of finances and budgeting. Accompanying official note should contain information under Annex V to this Regulation.

2.10.27 One original copy of the agreement and its annexes remain in storage VKORP. The second copy, no later than one working day from the date of signature transmitted curator for further direction counterparty. To organize and control the performance of the contract curator makes it a working copy. If the recipient works (services), goods are OP, curator of a copy of the contract of applications transmit to the appropriate VP within 3 days after its signing.

3.1 Curator (and VP-receiver) during the life of the operational control for full, timely and quality performance of contractual obligations.

3.2 During performance of the contract at the end of each stage (if any) curator (and VP recipient) performs acceptance of works (services) or goods for an act performed works (services), delivered goods (hereinafter - the Act), which consists counterparty in the manner and terms defined by the contract, checking compliance with the results of the works (services) with the contract.

3.3Akts up in the number of copies specified in the contract, but not less than 3 hprymirnykiv. In Acts must indicate positions, names and initials of people who signed them. In the absence of comments Acts are

signed by head curator agreement for a single copy of the front side of the first sheet. If the recipient works (services) is VP Companies Acts agree appropriate first EP - the recipient no longer than 5 working days of their receipt. Approval procedure defined by the relevant agreement. While agreeing on the back of the first sheet of the Act (2 copies) is curator inscription confirmation volume and quality and promotion of works (services).

3.4 In presence of remarks to the amount and / or quality of works (services) curated by the specified contract term returns Act counterparty with a cover letter to address the deficiencies and notify the Directorate of Finance and Budgeting (hereinafter - DFB) official note. This is an act of identified deficiencies specifying the manner and period of their removal (faulty act), if provided by the contract.

3.5 After acts signed by the counterparty, an official note sent to the DFB to verify compliance to deadlines, prices specified in the Act, the terms of the signed contract, and to conduct a cumulative accounting. If comments DFB directs these acts curator corrective, and if the concerns regarding violation of terms of contractual obligations counterparty to initiate curator of litigation.

3.6 After deficiencies and observations curator acts to transmit DFB for further.

3.7 After inspection and registration Act in the Journal internal accounting transfers VKORP Act signed by the head direction. Statement signed by company president or first vice-president - technical director or other person who signed the contract, indicating the date of its signing. The signing of the Act may only official mentioned

Act in text. In the absence of an official act signed by another official who has the appropriate powers of compulsory

3.8 Akts relating to the procurement of nuclear fuel, nuclear materials, removal of spent nuclear fuel and services related and capital construction, repair buildings, completion of units (Akts f.KB-2c and Information f.KB -3 (sample forms enacted by the Order of the Minregionstroya 05.07.2013 №293), cost of which is calculated on the basis of state building codes (DBN) regulating the pricing in construction, considered vizuyutsya and sent an official note to the DFB. VKORP DFB provides design Acts checks the terms of the contract obligations and transmit the signature of the CEO.

3.9 after signing Acts VKORP transmits them to the General Department of executive management of nuclear fuel procurement and information support for the seal. One copy shall remain in VKORP, the second copy to the accounting VKORP transmits weekly on the roster, and the other copies of the Acts passed under the signature of the representative supervisor for directions counterparty established in the contract terms. This curator makes for a copy of the signed Act.

3.10 Counterparty breach of contractual obligations, including the timing, scope or quality of the works (services), unit-curator immediately prepares official note to the head of the Company, which initiates litigation in accordance with the provisions of conduct litigation related work in SE "" Energoatom "(PL-D.0.10.017-14).

3.11 After curator of VKORP signed Acceptance Certificate curator gives a SE "" Energoatom "within five working days of electronic tax invoice, drawn up in accordance with the Tax Code of Ukraine, in the manner determined by the terms of the agreement, the Company determined in order (Modified, change №3).

4 ORDER OF REGISTRATION of CLOSING of agreements that were concluded in directorate

4.1 In case of termination pursuant to applicable law, all contractual obligations of the parties, including their proper implementation, the contract shall be closed.

4.2 Servise note on the need to design treatments closure agreement curator forward to the DFB.

4.3VKORP draws close contract by means of official notes to branches in the following order:

•curator;

• Accounting;

• executive management on legal issues and support procurement procedures;

• DFB.

4.4 Accounting dpartment in obtaining official note VKORP to close it adds decoding operations under the contract.

4.5 In absence of comments on the official closing of the contract note received from VKORP, signed by the heads of these structural units and returned to VKORP.

4.6VKORP makes data close to the information base contract agreements concluded with the Management Company, the original official note attached to the contract.

4.7 In case of presence remarks on the closing of the contract VKORP notify these observations curator to remove them.

4.8 In case of the circumstances under which they further or complete performance of the contract is unnecessary and, in the absence of grounds for litigation pozovnoyiroboty curator prepares official note to the head that signed the treaty, and in his absence upon them ' I was head of the company, which initiates the transaction to terminate contractual obligations (breach of contract) (hereinafter - agreement), indicating these circumstances and grounds.

4.9In case of absence of objections to the registration of the Agreement makes relevant administrative head of her label design director of finance and budgeting, and sends official note to the regulatory label VKORP.

4.10 VKORP draft agreement is being considered and signed by the procedure provided for consideration of the draft agreement.

4.11 After sign the Agreement corresponding head VKORP transmits it to the General Department of executive management of nuclear fuel procurement and information support for the seal.

4.12 Both Agreement copies are sent by curator with a covering letter or transmitted in painting contractor. One copy of the agreement signed by both parties returned to the Company and attached to the contract

5.DEVIDING OF functional responsibilities when concluding and maintaining agreements concluded in directorate

5.1 Head of the unit curator agreement provides and is responsible for:

• Availability of annual procurement plans of works (services) goods for which it is planned to sign a contract, procurement and supply limits approved financing;

• Selecting potential counterparty to the contract provided that the legislation of Ukraine, manufacturing and organizational and administrative documents provided the related procurement, subject to the following criteria for counterparty:

-data state registration must be not later than 6 months before the date of the contract;

-Number of employees in the company more than 10 people, confirmed by documentary form, which is set by the current legislation of Ukraine;

- head and chief accountant - different individuals;

- counterpart fund equal to or more than 200.0 thousand. USD .;

IP addresses, which is specified as the domicile of the counterparty is not at mass registration and of the counterparty to the address;

-existence assets and production capacity, in addition to contractors, which acquired principally services;

• prevent separation of the object of purchase in order to avoid competitive bidding;

• timely preparation and submission of documents to the Committee on competitive bidding SE "" Energoatom "for procurement in cases where it is necessary under the current legislation of Ukraine and production documents of the Company;

• accuracy, specificity and completeness of technical specifications, technical requirements or specifications for works (services), supply of goods and their compliance with the goals and objectives that need to be implemented as a result of works (services), goods under the contract;

• Does the contract requirements of paragraphs 2.4 - 2.7 and Sec. 7, 8 of these Regulations;

• compliance with the contract terms of technical specifications (specifications) or technical requirements, as in the case of a competitive procurement process - tender documentation and the competitive (price) proposals from winning trades in terms of compliance with terms of reference, specifications and technical requirements;

• Does the contract estimates the current state building codes and standards (for contracts for construction, repair of building constructions, reconstruction, modernization, etc.);

- Availability of documents that substantiate the value (price) of works (services), goods under the agreement (contract); inclusion in the contract demands the presence of the contractor license permits for certain activities, works in the cases provided by law, and control over their availability for the duration of the contract (copies of licenses are added to the package of contractual documents); timely transfer agreements concluded counterparty;
- Timely transfer copies of contracts with applications to VP recipient and timely coordination with OP-recipient of the original documents on the contract; avoid making changes to the agreement which may lead toarbitrary dismissal contractor from liability for breach of terms; if necessary, early (before graduation) extension of the contract;
- Monitor the proper implementation of the contract within the competence of the curator: compliance schedule (deadlines) and quality of performance of the contract works (services) supplied goods; organization and reception of works (services), goods of the relevant registration acts and other primary documents; conformity with the contract of the actual volume and quality of work performed and services rendered, goods delivered, the amount recorded in Acts, if the recipient is not a VP; timely processing within the authority (in the terms providedcontract, and if not provided - in 5 days) Acts of executed works (services) supplied goods and other primary documents evidencing the contract; timely and complete order financing needs for
- Payment of work performed (services), delivered goods, subject to payment of VAT on receipt by the buyer from the seller (executor) tax bill, executed and registered in the Unified Register of tax invoices (hereinafter - YERPN) in the legally established procedure and in due time; timely processing of documents for payment under the contract, as well as the additional costs that may result from failure or improper performance of the contract, including judgments for the recovery of fines, inflationary costs, penalties, damages etc. organizing and conducting assessments (audits) and its contractor subcontractors during the contract in cases provided by industrial and organizational and administrative documents DP "" Energoatom "; participate in the testing of products supplied to by the manufacturer in cases stipulated by the contract;

• timely provision of necessary acceptance documentation for executive VKORP;

® timely provision of necessary information on the implementation and execution of payments for contracts, etc., at the request of other departments and / or management of the Company;

• timely receipt accounting SE "" Energoatom "from counterparty (for five days) of electronic tax invoices in the manner determined by the contract, in a certain order in the Company (as amended, the change number> 3);

• timely transfer within three working days, all incoming and outgoing correspondence for changes and refinements to the essential terms of the contract VKORP;

• providing timely, if the contractor breaches the contract, the executive management on legal issues and support procurement of all necessary contractual, cover, and other primary documents, letters confirming improper performance contracting contractual obligations for related work under pretenziyno- the Regulations on the conduct of litigation in SE "" Energoatom "(PL- D.0.10.017-14);

® timely preparation of all necessary documents for closing the agreement;

• fill in all sections of card counting to contracts concluded by the Board of Directors of the Company.

5.2 Executive Directorate for Quality and Management provides and is responsible for:

• Does the contract for works, services, purchasing goods that are important for plant safety requirements of Sec. 9 of the Regulation;

• providing information for the assessment of the supplier and the decisions regarding the approval of the contractor (services) purchase of goods under a contract concluded;

• determine the need for the presence of licenses and permits for activities contractor works (services), goods under the contract and contractor compliance with existing licenses, permits set requirements;

• Does the contract documents set out requirements for conformity assessment (certification) of goods (works, services).

5.3 Directorate of Information Technology Executive Directorate of purchasing fuel and providing information during the audit of contracts that provide for the implementation of works (services) on the creation and implementation of automated systems management and acquisition of assets and / or

Rights to use information technology provides and is responsible for:

• determining the appropriateness of procurement of works, services and products in the field of information technology;

• providing analysis and proposals on the value of purchases.

• the project's contract law on the functioning of information, telecommunication and information and telecommunication systems (attachment change MI).

5.4 Directotrate of purchasing nuclear fuel and regulation of foreign economic activity of executive management of nuclear fuel procurement and information support checks draft foreign economic agreements for compliance with their terms of customs and currency legislation of Ukraine provides and is responsible for:

"Obtaining permits and guarantee documents State Service of Export Control of Ukraine if necessary;

• Preparing and obtaining documents required for customs clearance of goods coming under foreign economic contracts;

• obtaining necessary documents for the excess of statutory deadlines of payments for foreign trade contracts of industrial cooperation, consignment, complex construction, delivery of complex technical products and products for special purposes, to control and create a database of compliance with currency legislation of Ukraine.

5.5Directorate of Economic Affairs provides and is responsible for:

• Does the scope of work and services under the contract concluded, the amount provided for in the approved cost estimates and work plans of the Company, except VBTS.

5.6 Accounting department provides and is responsible for:

• recording the Management Company business operations on basis of the original documents on the implementation of agreements (the provisions of the accounting GIL-P.6.15.001-12);

• correctly reflect the agreement details the Company, including payment and settlement, the status of taxpayers and other tax issues;

• timely provision of information on VKORP made payments under executed;

• timely provision curator at its request information on the receivable or payable under the contract;

"Verification received tax bills for compliance HIKU (Modified, change №3).

5.7 Executive management on legal issues and support procurement ensures and is responsible for:

• monitoring the compliance of agreements concluded by the results of the tender (competition), the requirements of the tender documentation and the competitive (price) offers uchasnyka- winner of the procurement procedure, in addition to compliance with the technical project requirements and specifications;

• legal analysis of contracts for their compliance with the current legislation of Ukraine.

• organization and implementation of litigation.

5.8 Directorate of finance and budgeting VKORP provides and is responsible for:

• Development and maintenance of industrial and organizational and administrative documents concerning the exercise of contractual work in the company;

• methodological support agreements concluded SE "NAEZH" Energoatom ";

• maintaining common information base (contracts) entered into by the Company;

• verification of compliance of contracts concluded in the Board of Directors, the requirements of this Regulation;

• for compliance with the agreement in certain circumstances, regulated vidpovidnymyorhanizatsiyno and administrative documents of the Company, provided advances, tax bills, etc.

• organization and control proceedings, viewing and signing of contracts;

• initialling the agreement, in addition to contracts, which provides signature of each page;

• timely transfer curator signed agreements for their transfer to the counterparty;

® storage of original signed treaties and other contractual documents signed in the Management of the Company that all applications that are specified in the text of the agreement;

• monitoring compliance with the contract related to the timing of works (services), supply of goods and payments, and when considering the design of appropriate legislation;

• timely preparation and transmission to the accounting register of accompanying acts performed works (services), delivered goods

(Modified, change №3);

• confirmation documents for payment of work performed (services), delivered goods coming to VKORP, terms of payment under the contract;

®providing copies of documents and information relating to the drafting, execution and maintenance contracts at the request of other departments or at the direction of management of the Company;

• timely closing contracts on the basis of submitted documents curator;

• monthly inform supervisor to analyze performance contracting directorate of contract terms to comply with the obligations;

• timely execution of reallocation in funding within the existing limits of financing production program SE "" Energoatom "for the planning period for ensuring payment for additional costs that may result from failure or improper performance of the contract, including judgments for the recovery of fines , inflation costs, penalties, damages, etc.

5.9 VP recipient on contracts for which it is the recipient works (services) catalog, provides and is responsible for:

• Does the contract estimates the current state building codes and standards (for contracts for construction, repair, renovation, modernization, etc.);

• organization and reception of works (services), products with appropriate design of the Acts and other primary documents under the terms of the contract;

• Does the actual volume and quality of work performed and services rendered, goods delivered volumes are reflected in the Acts of acceptance of works (services), products and terms of the contract.

5.10 General department of the Executive Directorate of purchasing fuel and providing information support and is responsible for:

• Keep all incoming registration of contracts, other correspondence, letters concerning the contract of the Company;

• timely transfer of contracts to VKORP;

• seal in the presence of a VKORP, contracts, annexes, acts of performed works (services), goods delivered and other contract documents after signing management or authorized persons of the Company;

• timely registration for the initial cover letters contractual documents and other correspondence relating to contracting activities and their counterparties sending by mail.

6.1 For all agreements and additional agreements are being concluded in separate divisions of SE "" Energoatom ", including contracts commission, agency, innovations, amicable agreements, which have no financial obligations established this procedure for their consideration and registration of the Management Company:

6.1.1 During receiving a draft agreement to the counterparty separate division general VP department treats incoming number and date in the lower field first page of the contract.

6.1.2 Projekt contract reviewed and signed by all the relevant services of the EP, then parafuyetsya on each page of the contract and its annexes head contractual department VP and signed by the authorized person or another EP, the seal is not sealed.

6.1.3 Terms of consideration sighting services, signing the head of the EP and the registration of contracts concluded on the results of the procurement procedure shall not exceed the period specified by the legislation of Ukraine regulating the procedure for procurement of goods, works and services by public enterprises (with public funds).

6.1.4 No later then the next business day after signing the head of VP employee responsible for contracting work in the Company's VP loaded scanned copy of the agreement (signed by the contractor) in a single database for prior checking employee VKORP DFB.

6.1.5 OffiserofVKORP DFB, no later than the next day sent

contract tested for:

• signature of the parties;

• All applications provided in the text of the agreement;

• initialling the agreement;

• Items in the agreement on issuing tax invoices in accordance with the procedure established organizational - administrative documents DP "" Energoatom ".

6.1.6 If any employee comments VKORP DFB removed scanned copy of the contract and internal email sent 8AR ERC informed comments.

6.1.7 After revision and removal of comments SS officers in a single information base carried out re-sending copies of the relevant contract.

6.1.8 In the case of absence of comments, the employee VKORP DFB confirms scanned documents, as compliance officer SS gets message 8AR ERC internal mail.

6.1.9 After obtain approval scanned copy of the contract workers VP filled cardboard registration of contracts and specifications or schedule a single information base and incorporate the scanned copies of the following contractual documents (edited, changing №3):

-fillud up trip sheet;

-protokol differences and disagreements coordination protocol signed by the parties to the contract (if any);

-filled up card account (Appendix D to this Regulation) (except contracts that have financial obligations and contracts for works, services subdivisions of enterprises, institutions, organizations);

-at the conclusion of the EP contract for an amount exceeding a specified power of attorney to conduct economic activities provided

president of the head of the EP, the contract included a copy of the corresponding single warrant;

-Search price monitoring or rationale for the choice of the supplier - for contracts concluded without the use of procurement procedures;

-in the case of advance payment under the contract - the documents specified in the relevant organizational and administrative documents of the Company;

-for agreements concluded by the results of the procurement process - relevant extract from the minutes of the Committee on competitive bidding SE "Energoatom" Ensrhoatom "(EP), notice of acceptance of the bid's winner of the tender, the tender (price) offer by the tender winner.

6.1.10 Afer full completion of the registration card of the agreement, not later than the next business day, checked employee VKORP DFB for correctness and availability of the required supporting documents.

6.1.11 If there remarks for completing the registration card of the agreement or not the document binding defined organizational - administrative and production company documents are sent to the employee VKORP DFB internal mail 8AR ERC.

6.1.12 absence of comments, the employee VKORP DFB approve a card registration agreement, and the agreement is automatically assigned a registration number and date of the unified information base.

6.1.13 Officer of VKORP DFB prints the first page of the contract, which affix the registration number of a single information base contract and the date the aforementioned sheet scans and downloads skankopiyu to register a card.

6.1.14 Officers responsible for contractual work in the EP, also note the registration number of the unified information base and the date on the first page of the contract and all its annexes. If the number is already affixed contract counterparty, the Company's registration number is put together by slash date specified below. Then head VP signatures on the contract sealed.

6.1.15 Officers of VP responsible for contracting work, make a scanned copy of the contract with all the signatures, seals and bear the registration number on the contract and all its annexes sent by e-mail compliance officer VKORP DFB to add up to the card agreement.

6.2 For contracts financed at the expense of the state budget, the same procedure applies, but after registration VKORP VP sends the contract to the General Department of executive management of nuclear fuel procurement and information provision for binding signature of the head (authorized person) SS seal SE " "Energoatom".

6.3 For foreign agreements concluded in separate divisions, apply all of the procedures in this section, but the verification scanned copy of the contract VKORP sends a copy of the draft agreement with the official note signed by the Director of Finance and Budgeting for review for compliance with the customs and currency law to the management of procurement of nuclear fuel and regulation of foreign economic activity of executive management of nuclear fuel procurement and information management, which for two days considering the agreement, prepares an opinion and sends an official note to the DFB. Registration card contract approved after receipt of such a conclusion without remarks or after their removal.

6.4 For agreements concluded in separate divisions and the enforcement of any works (services) on the creation and implementation of automated systems management and acquisition of assets and / or rights to use information technology, applied all of the procedures in this section, but under verifying scanned copy of the contract VKORP sends a copy of the draft agreement with the official note signed by the Director of Finance and Budgeting for consideration to the Directorate of information technology executive Directorate purchasing nuclear fuel and information management, which within two working days to examine the contract draws its conclusions official note and sends to the DFB. This registration card is considered and approved the agreement after obtaining the opinion without reservations.

6.5 For agreements concluded in separate units and include the provision of banking and insurance services, apply all of the procedures in this section, but the verification scanned copy of the contract VKORP sends a copy of the draft agreement with the official note for the consideration of compliance with legislation on financial credit and insurance activities to the department of payment and credit operations directorate of finance and budgeting, which for two days considering the agreement draws its conclusions official note and send to VKORP. This registration card is considered and approved the agreement after obtaining the opinion without reservations (Modified, change MI).

6.6 Agreements that require verification in accordance with p.6.3, p.6.4 and 6.5 concluded the results of the procurement procedure for registration sent VKORP no later than five working days before the deadline for the conclusion of such agreements, as defined by applicable law Ukraine.

6.7 Agreements on goods, concluded EP "Atomkomplekt" for other emitters must agree on the appropriate VP subject of timing, volume and characteristics of the supply of goods and the availability of financing.

6.8 Fullresponsible for the conclusion and implementation of OP in compliance with the current legislation of Ukraine, manufacturing and organizational and rozporyadchyhdokumentiv the Company, including the procedure for selecting the contractor under the contract, the existence of the subject of procurement in the approved annual plans of the Company, the validity of the contract price, contract security sources (limits) financing rests with the heads of separate units.

6.9 At all documents relating to the conduct of the contract (supplementary agreements, minutes of discrepancies and reconciliation differences pryymannya- acts of the executed works (services), customs declaration, receiving documents from the purchase of goods, invoices, memos, drafts, reports of contractual activity, etc.) separate units necessarily indicate a registration number, which is assigned by contract.

6.10 For additional agreements (contracts) apply all of the procedures in this section.

Company 6.11VP to 20 of this month to provide analysis of the DFB counterparties on terms of contract obligations indicating: the planned amount of liabilities, in fact, deviation from the emergence of such justification - in terms of each contract.

Company 6.12VP 15 month DFB to provide a report on closed contracts from the previous month to the model in Annex D.

6.13Agreements (contracts) for the support of the Delegation of the State Enterprise "" Energoatom "in Brussels (Belgium) (hereinafter - representation) Director Delegation concluded on behalf of SE" "Energoatom" within the powers granted by the Company in compliance with the Regulations on the procedure contracts (contracts) to the extent not inconsistent with the legislation of the Kingdom of Belgium. Scanned copies of contracts (contracts) with a scanned copy accompanying notes are transferred to the DFB VKORP for registration of a single information base of the Company (Attachment,

change №2)

7.1 Content of contract terms are determined at the discretion of the parties and approved by them and the conditions that are mandatory under the current legislation of Ukraine.

7.2 Essential are conditions recognized as such by law or necessary for certain type of contracts and the conditions for which at the request of one of the parties must be reached agreement.

7.3 All contracts concluded with residents of Ukraine shall be the Ukrainian language in accordance with the laws of Ukraine. If the contract with Ukraine residents obligatory presentation of the text

contract, along with another language, Ukrainian language or a certified translation into Ukrainian language (except for non-residents registered in the Russian Federation).

7.4 Necessarydetails of the agreement is the name (contract, agreement, contract), place (city, country) and date of the contract, the full name, address and bank details of the parties, the data on persons who signed the agreement on behalf of the parties (name, initials, title , power) status as a party payers of income tax HIDV. Applications for the contract, information on the number of copies of the contract, the signatures of authorized persons of the contracting parties indicating their positions, names and initials, seal sides.

7.5 In case of purchase of goods under foreign trade contracts that require storage in warehouses EP "Warehousing" in foreign trade agreements (contracts) indicate consignee - SE "" Energoatom "OP" Warehousing "and for which products come VP AES. If you purchase goods for foreign economic contracts that come directly at the site of NPP VP of unloading is performed according to processes VP NPP in such agreements (contracts) indicate consignee - SE "" Energoatom "SU NPP.

7.6 Essential conditions that are common to all types of contracts:

7.6.1Subject of contract: name, type and scope of works (services) of goods, referring to the need for applications that more fully define their requirements (specification, output specifications, design estimate documentation, specifications, specification, etc.); Quality Guidelines.

7.6.2 Terms of works (services), supply of goods; if they are performed (provided) in stages, mandatory appendix to the contract is the schedule.

7.6.3 Cost of contract (cost of works, services and goods), indicating - solid or approximate (dynamic) referring to the need for applications such as protocol of the contract price, estimate, calculation, calculation and others.

7.6.4 Order of payments and settlements with the indication, where appropriate, sharing the cost of banking, tax and customs duties. Thus the agreements (contracts) on goods necessary to provide that the calculation (payment) for goods (excluding advance payments) made after completion of the procedures input control of goods in quantity and quality in accordance with the regulations of the Company.

7.6.5 Rights and responsibilities.

7.6.6 Order of performance (organization) works (services), supply of goods; order logistics and project support.

7.6.7 Order and terms of acceptance of the results of the works (services), delivered goods with the stipulation of drafting regulations fault detection works (services), goods and deficiencies.

7.6.8 Grantees obligations.

7.6.9 Responcibilities of parties, penalties for failure or improper performance of the parties under the contract.

7.6.10Fors majeure.

7.6.11 Terms of privacy.

7.6.12 Order of settlement of disputes, the presence of pre-trial procedure regulation, applicable law, judicial (arbitration) clause; for international contracts - penalties for violations of currency legislation if payment terms are provided down payments.

7.6.13 If contract is a resident in a foreign language - language clause.

7.6.14 terms of the contract, reason, order changes and termination of the contract.

7.6.15 Duties of seller (artist) (VAT) to provide the buyer (customer) e-tax bill, issued and registered in YERPN in the legally established procedure and within the time specified for registration in the tax bill YERPN establishment of responsibility for the failure of the required ' communication through unilateral right to reduce the contract price in the amount of VAT which was not given tax bill

(Modified, change №3)

7.6.16 Other conditions (defined for a particular contract).

7.7 During concluding contracts (procurement of works (services) on capital construction, reconstruction, repair of buildings, technical re-equipment) must comply with the requirements of the "General conditions of conclusion and execution of contracts for capital construction", approved by the Cabinet of Ministers of 01.08.2005, the . №668 (as amended)

7.8 Contract must include the following anti-corruption clause

andobligations contractor regarding compliance with anti-corruption

legislation (attachment change №3):

7.8.1 Contragent ensures that its leader and other officials (officers) persons exercising authority to manage its activities (deputy director, chief accountant and his deputies, members of collegial bodies of management) (hereinafter - the governing entity), not be subject to liability for commission of corruption offenses and / or were sentenced for a crime committed with mercenary motives, and will in the event of these circumstances immediately notify the Company in writing

(Attachment change MR).

7.8.2Contragent warrants and undertakes not to (either directly or through third parties) any tangible / intangible incentives, interest, encouragement, suggestions, that is not offered, do not promise not to provide monetary compensation, property, property rights advantages, benefits, services, discounts, intangible assets and any other preference to employees of the Company and persons related by any relationship with the Company, which is responsible for the conditions of delivery, sale, payment of goods and other obligations provided hereunder, including their relatives and other similar or authorized persons for committing their acts or omissions using their powers in the interests of the counterparty and / or of a third party and against the interests of the Company (Attachment, change MR).

7.8.3 In case of a counterparty to the part of the Company's employees, requirements or suggestions about getting tangible / intangible incentives, interests, stymulyuvan in the form of monetary compensation, property, property rights, preferences, privileges, services, discounts, intangible assets and any other

preferences for they commit certain acts or omissions using their powers in favor of the contractor, the latter shall immediately inform the Company about such facts (attachment change MR).

7.9 The provisions of the contract that defines the responsibilities of the parties, be sure to include the following provisions on liability in the event of non-compliance with anti-corruption legislation (attachment change MR):

1.9L Failure counterparty obligation prescribed Monday. 7.8.1 or for detection of this Agreement by the Company bringing facts leading contractor persons liable for corruption offenses and / or conviction for a crime committed with mercenary motives, the counterparty pays a fine of not less e __% of the cost of goods (works, services) (Attachment, change MR).

7.9.2 Company case of committing contractor actions listed in the North. 7.8.2, the counterparty for each such case confirmed indisputable evidence, the Company shall pay a fine of no less e __% of the cost of goods (works, services) (Attachment, change M C).

7.9.3 Payment fine not exempt from compensation for damages caused to the Company

(Attachment change MR).

7.9.4 Failure to follow counterparty obligations under paragraph. 7.8, the Purchaser may waive this Agreement unilaterally, through its dissolution. A contract is terminated after receiving the contractor written notice of the Company (Attachment, change MR).

8.1 Terms of Reference (TOR), the original specifications (PTD), technical requirements and terms of delivery (TV and UP) or sheet binding agreements for applications that require the presence of these applications.

8.1.1 TOR signed by the Contractor and agreed (approved) by the Customer. Requirements set out in ISO TC 1.2: 2003 "National standardization. Terms developing national regulations "ISO 3973-2000" System development and putting to production. Terms of research work. General "ISO 3974-2000" System development and putting to production. Rules of Implementation of development work. General Provisions ", GOST 34.602-89" Information technology. Complex standards for automated systems. Terms of Reference for the automated system, "MLA 95.0.01.03.006-97" Terms of reference for scientific research, experimental design and research and technological work. The procedure for the development, construction, coordination, approval and registration. "

8.1.2 TOR is the basic document for acceptance of the results of works (services). Where necessary, the vehicle may be amended in the manner set for the development of the vehicle, with the vehicle on the front page is the inscription: "Effective with the addition № _____» and made appropriate changes to the contract.

8.1.3 Specifications agreed (approved) by the Customer and shall include:

• The name of works (services);

• Details Customer;

• Details of the Contractor;

• A tentative deadline of works (services);

• The purpose of works (services);

• The basic technical requirements;

• Feasibility study work (services).

8.2 Calender plan:

8.2.1 Calender plan skladayetsyau if robotavykonuyetsya stages, each stage is made act as implementationobligations and funded in stages. When making the schedule observe the requirements of paragraphs 2.7.

8.2.2 Calender plan contains the serial number of the application details of the contract to which it belongs, their names, numbers of stages; name list each phase of works, services and stating their volume (quantity); start and completion of works (services); value stage; the total contractual price of works (services) including VAT; the type, form and procedure for reporting on the results of works (services).

8.2.3 Calender plan signed by the parties who signed the contract, and sealed parties.

8.3Protokol price agreement.

8.3.1Cost of contract may be determined in the record price agreement, which added to the estimate or calculation, or zip estimated calculation or other document containing information on the formation and components of the contract price. The protocol may include links to installation of discounts, allowances, benefits (Modified, change MI).

8.3.2 Cost sheet (calculation, calculation) must contain a complete transcript of the components of the contract price, the cost of production, materials, equipment, salaries, travel, overhead costs of own production, collaborating institutions, deductions, income and other factors indicating that applicable, in accordance with state building codes or other guidance documents.

8.3.3Protokol price agreement signed by the parties who signed the contract, and sealed parties.

8.3.4 Cost sheet (calculation, calculation) signed and sealed by the parties was the document.

8.4Specifications is a major addition to contracts for the supply of goods. Specification signed by the parties who signed the contract, and sealed parties. The specification contains the serial number of the application; details of the contract to which it relates; your name; list and description of goods with an indication of their number; cost per unit; total contractual cost of goods; Additional information about the products (if necessary).

8.5Tehnichal requirements and delivery conditions annexed to the contract for the supply of goods. Requirements for the development, design, maintenance and treatment of TV and UP set out in the NAEC SOU 005: 2014.

9 Additional content requirements contracts for works (services), goods are important for plant safety

9.13 to ensure compliance with the requirements of the operating organization's rules and regulations on nuclear and radiation safety in the design of contracts for works (services) and the procurement of goods, important for nuclear safety, which are subject to the requirements of the JMA NAEC 012: 2012 "Procurement Management products. Evaluation of suppliers "to their conditions should include the following additional requirements depending on the type of goods, works (services):

• providing opportunities for Contractor Company (Customer) assessments of manufacturers of products (goods and services) important to plant safety by Artist supplies in terms agreed by the parties;

• Contractor obligations regarding the inclusion of subcontracts (supply) the possibility of customer evaluations producers for CSR;

• the need to provide the Contractor during the contract information on the suspension or cancellation of existing him or his subcontractors (suppliers) licenses, certificates of conformity for products sold;

• the possibility of customer product conformity assessment on the stages of its creation (design and manufacturing), taking part in atenterprise products manufacturer, including participation in the acceptance, transceiver acceptance tests;

• in cases provided by law, the provision for products supplied under the agreement (contract), one of the following documents - Declaration of conformity certificate of conformity, certificates of recognition of conformity;

• the need to provide the Contractor with every batch of products, unless otherwise agreed technical specifications for products, a set of documents which is defined by the customer, based on the type of product, the requirements of the rules, regulations and safety standards, YESKD (maintenance, repair, design documentation, including including specifications). When the supply of products from abroad should be discussed language documents (Ukrainian, Russian and English), transferred under the contract;

• specific conditions and limits of liability of the Contractor (supplier) and its sub-contractors, who are manufacturers of products important for nuclear safety, the quality of products supplied.

APPENDIX A

(obligatory)

SPECIAL STAMP

Signature Head of Unit

Head curator

Executive Director for Quality and Management Inspector General - Director of Security Chief Accountant

Executive Director of Legal Affairs and support procurement Director of Finance and Budgeting

Appendix B

(obligatory)

itinerary

the draft agreement number from

(Additional agreement to the contract number on the number of

The business unit Output Sent

Signature Date Name

Head curator Name

Curator name

Executive management and quality management

Inspector General - Director of the Security Directorate of Economic Affairs

Accounting

Executive management on legal issues and support procurement

VKORP Department for Financial Planning and Monitoring Directorate 3 Finance and Budgeting

number

draft agreement " " '20

Director of Finance and Budgeting

ANNEX C

(obligatory)

The list of data to be specified in the curator memo addressed to the management of the company in the project agreement (supplementary agreements) concluded in directorate

1.Purpose, the rationale for works (services) purchase of goods.

2.Full name counterpart.

3.Number and date of the project contract (additional agreements) the counterparty.

4.Procedure of selecting the contractor (services) supplier of goods with reference to the report of the Committee of competitive bidding or tender committee.

5.Subject of contract (additional agreement).

6.Cost of contract (additional agreement). If the terms of the additional agreement changing the contract price shall be specified further price agreements and the contract price of the additional agreement, as well as the grounds for changes in the contract price.

7. Text code and existing organizational and technical program activities; unique requisition number (constant) material assets and / or works / services (Modified, change

№3).

8.Source of funding.

9.Kod fare.

10. Article of funding limits the production program.

11.Abendums to the contract (additional agreement).

12. During direction of the design project supplemental agreement (the contract) to the set of documents necessary to add a copy of the main contract and any additional agreements entered into by him with the available protocols and resolution of differences and divergences indicate the status of the agreement and justification of the change.

13.During direction of the execution of the Agreement on termination of the contract necessarily provided justification for termination, the condition of the contract, no violations of contract by the contractor, the possibility of further use of the results partially completed work and unreasonableness execution stages remaining unfulfilled.

The card account to the agreement with _____

name of the contractor, the code EDC

Code value stage (in the shaft. The amount of payments (in the shaft.

Name of Procurement

contract) contract)

document, according to the Total Cost Code

Date Currency Facility

Content number / name to which document stage settlement date spets- Source Code limit Code Code Code fare

end

phase phase is determined that kontrak¬ (currency payments (currency funding pro- * finance * * For TSFV TSFV OTPZ * * * OTPZ financing /

stage determines the subject of the contract) total contract excluded) VAT excluded all programs * debiting *

purchase item VAT **

purchase

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Total:

Notes:

* Fields are filled in accordance with Annexes to the Regulation on the preparation and approval of funding limits the production program of "Energoatom" (PL-D.0.04.224-13)

** Field is as follows:

-When purchasing goods and services - according to the State classification of goods and services DK 016-2010;

-When purchasing services from routine maintenance of buildings - according to GOST BD 1.1-1: 2013

-When purchasing works - according to GOST B D. 1.1-1: 2013

To form a reserve of financial liabilities at additional costs agreement concluded with non-residents of Ukraine (customs duties, import VAT) So] And neither I

Apply inflation when calculating the obligations under the contract concluded [Yes] [No I

Head of the center of financial responsibility (TSFV) # Director responsible for planning center costs (VTSPV) ***

On VP - Head of financial and economic services

(Full name). _____ (Name).

(Signature) (signature)

curator agreement

(Full name). ....

tel ._____

_____ _____ _____ __
_____
_____ *** Agreements for the Company's Board of Directors
_____

Annex D (Modified, change №3)

Report on closed contracts for the month 20__r.

№№ Reyestration¬ Kontragent¬ Subject¬ Currency¬ Cost¬ Perfomance¬ Payment¬ date- Notes

1 2 3 4 5 6 7 8 9 10

* Broken down by year, the financial position and financial area

SHEET REVIEW

Name Position Date Signature

Appendix C19

EnergoAtom. 2016b. Risk Management: Centralized Storage of Spent Nuclear Fuel (Facility).

APPROVED
CEO
EP "Atmproektinzhynirynh"
_____ AM Rybchuk
«___» _____ 2016

risk Management

Centralized storage of spent nuclear fuel (Facility)

	Name	Date	Signature
Developed	M. V. Yatsenko		
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CONTENT

Contents 2
GLOSSARY 3 1
2 Preamble 4
INITIALIZE 3 5
3.1 Definition of risk 5
3.1.1 Introduction to risk category 5
3.1.2 Options 6
3.1.3 Definition of risks / Internal risks 7
3.1.4 Definition of risks / External risks 12
3.2 Outlook mitigation / action 13
3.2.1 Introduction 13
13 3.2.2 Coordinators
3.2.3 mitigation plans / activities: internal risks 14
3.2.4 mitigation plans / activities: external risks 23
3.2.5 Identification of risk management strategies (mitigation plans / actions) 25
3.3 Organization 26
3.3.1 Organization and participation of the parties 26
3.3.2 Risk Consideration cards: definition and rules 27
4. MONITORING SOLUTIONS EFFICIENCY 28
5. Results 28

1 GLOSSARY

term	Definition
Risk:	The risk or inconvenience to a greater or lesser degree affect project
Risk Factors:	An event (cause) that contributes to the emergence of one or more risks
Importance:	1 (-) 3 (+) Score risk factor Criticality assessment takes into account the likelihood of risk factors and the severity of the consequences caused by this factor for the project
Frequency:	Probability 1 (-) 3 (+), which is a risk factor
Mitigation plan / action:	Plan to reduce the likelihood or severity of risk
Cards risk:	A special list of risks mitigated and plans / actions pursuant tracked and managed key persons of Risk Management (technical director (TC), Raman, an expert on schedules and planning (EGP), Business Manager (BM) and etc ... ..)

1 Preamble
Risk analysis is defined in four phases: initialization, implementation and monitoring Mitigation / action plans, adjustments and results

1 INITIALIZE
1.1 Definition of risks
1.1.1 Introduction to Risk Categories

For the project manager substantial risk is the likelihood that the project will be executed according to schedule and within budget, with the resulting impact on the value (emphasis on budget and schedule risks (delay)).

For financial analyst significant risk is the possibility that the project cost will exceed the existing budget (focus on financial risk).

The station is a substantial risk that the quality of the event may be poor, or, as a result, the radiation level exceeds the norm, which does not meet the requirements and standards agencies; or the installation and operation of the new system may cause operational difficulties (emphasis on operational risk and risk quality).

These cases cover risk aspects that are important for the process of the organization. To get a complete picture of risk must take into account all aspects. All aspects should be considered in an integrated structure of risk management.

Many risks affecting the organization. The risks can be divided into five main major categories:
Figure 1. (delay)
2. Financial
3. Performance and quality
4. Organizational
5. Manipulation

Organization of the CAP API covered in this report as being composed of five key sectors (financial sector, Chart, Operation and Quality Organization, Manipulation), the strategic influencing events (see. Figure). These sectors intersect with each other so that decisions in one area affect or influence decisions on the subject in another sector. Besides, there are participants outside VP API that influence these five sectors, and strategic terms.

Controlled risks - those for which: * Importance Frequency> 3. Every 6 months, these criteria are revised to take into account new list of risks

1.1.1 Options
Stages of implementation / implementation steps

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
Schedule	IRS1	Stage concept and bidding on development (Phase 1 implementation) longer than expected	IRS1.1	Missing	Missing	missing	
	IRS2	Step purchasing goods (Phase 2 implementation) longer than expected	IRS2.1	Poor planning trades	2	2	There is no planning methods, absolutely new measures
			IRS2.2	Poor Performance Requirements (TV)	3	2	See IRQ2.1
			IRS2.3	Inappropriate tender documentation	2	1	Bidding for goods could cancel and re-declare their conduct, to move, to change (too high qualification criteria, the discrepancy in prices, etc.). Cycle auction lasts longer.
			IRS2.4	Not executed graphics of tender	2	2	There is a need forecasting tasks and schedule control
	IRS3	The stage production and installation of equipment (Phase implementation) longer than expected	IRS3.1	Disclaimer provider of the contract	2	1	Supplier refuses to do the job
			IRS3.2	Period manufacturing process than expected period	2	2	
			IRS3.3	Equipment made, but is not available for installation	2	2	Test box manufacturer unsatisfactory. Delay imported equipment at customs ...
			IRS3.4	The period of outage is shorter than the period required to	2	2	

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
				implement on the ground			
			IRS3.5	Changes in the project after the supply of equipment	2	1	
			IRS3.6	Delays in regulatory approval (technical) documents	2	2	
			IRS3.7	Change the scheduled outage	2	2	
			IRS3.8	EA's lack of experience power in measures	2	1	Implementation of new measures may take longer than expected
	IRS4	Step adoption installation (Stage 4 implementation) longer than expected	IRS4.1	Testing poor	2	3	This topic does not apply to licensing. Licensing - a separate category of risk management
	IRS5	Schedule the project goes beyond the forecast schedule	IRS5.1	Late start	3	3	
			IRS5.2	An additional amount	2	2	
			IRS5.3	Changes in regulations	1	1	
			IRS5.4	Inaccurate implementation schedule, which prevents proper execution and control	3	2	
			IRS5.5	Trades not prioriterized	3	2	
			IRS5.6	Change the scheduled outage	3	2	

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
Finacial	IRF1	Insufficient credit facilities	IRF1.1	Invalid projected budget	3	3	
			IRF1.2	Complaints to suppliers	2	2	
	IRF2	Unavailability of credit	IRF2.1	Conditions of entry into force are not met	2	2	
			IRF2.2	Unmatched payment	3	2	
	IRF3	Insufficient funds EA	IRF3.1	Invalid projected budget	3	3	
			IRF3.2	Outage longer than expected (lack of income)	2	2	Lower electricity sales -> fewer funds
			IRF3.3	The non-extension of the operation of some units (insufficient income)	3	1	Lower electricity sales -> fewer funds
			IRF3.4	Rates do not cover investment / expense (income insufficient)	3	2	
			IRF3.5	The cost of the project exceeds budget (Overruns)	2	2	Expenses increased. Prices of contracts increased due to increased prices of services, goods (market fluctuations). Insufficient or association in optimized packages. Lack of money funds for the project (as well as the implementation phases of the project). Increased raw material costs. Project scope changes .....
	IRF4	Controlling costs is unable to show cost overruns on the project	IRF4.1	Department of cost control does not work properly (process data warning)	3	1	

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
Operations and Quality	IRQ1	Quality problems during the purchase of goods (Phase 2 implementation)	IRQ1.1	Tender specifications do not meet a) Standard tender documentation Bank and b) procurement rules and processes Bank	3	1	
			IRQ1.2	Purchases financed by creditors, there are not in accordance with the Rules and the EBRD Procurement Processes	3	1	
			IRQ1.3	Contracts funded by creditors, did not meet the conditions of contracts under which these bidders were invited	2	1	
			IRQ1.4	Procurement is not competitive and non-transparent	2	1	There are complaints from suppliers / subcontractors Objections of Creditors
	IRQ2	Problems of quality at the production and installation of equipment (Phase 3 implementation)	IRQ2.1	Poor Performance Requirements (TV)	3	2	
			IRQ2.2	Inconsistency contracts (TV, services ...). Inconsistency goods (ie. Including security issues)	2	1	Inconsistency technical requirements. No regulatory compliance and legal standards / certification. Low level of detail for important functions
			IRQ2.3	Implementation does not meet quality assurance procedures (QA) EA	2	1	
	IRQ3	The information system is not working	IRQ3.1	The database is corrupted	3	1	
			IRQ3.2	Employees of the IT department is not able to provide maintenance	2	1	

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
Organization	IRO1	Staff bad doing its job	IRO1.1	Employees do not adhere to processes, procedures, organization Plan	3	1	Not implementing organization's ability to perform efficiently, on time and within budget. Look for each role Mitigation Center. office, KR, stations .....
			IRO1.2	Lack of or inadequate workforce skills needed for the project	3	2	
			IRO1.3	KR effectively coordinate implementation	2	2	Curators work
			IRO1.4	Not enough support communication between PMU and stations	2	2	
practices	IRX1	Manipulation that exist in the project	IRX1.1	To be determined (BV)	БВ	БВ	
			IRX1.2	To be determined (BV)	БВ	БВ	
Credits	IRL1	Violated conditions of Loan Agreement	IRL1.1	No credit management	2	1	
			IRL1.2	The conditions are not met	3	1	The conditions are not met under the loan agreements

1.1.1 1.1.1 Definition of risks / External risks

Category	N°	Risk	N°	Factor Risk	Importance	Frequency	Details
Licensing	IER1	Technical Requirements (TA)	IER1.1	In CSSNF not apply internationally accepted safety levels	3	1	
			IER1.2	Changes in safety regulations	3	1	Changes to the technical conditions of the regulator, the regulatory framework, ...
Financial	IEE1	Insufficient funds	IEE1.1	Inflation	3	3	Planned spending increases due to inflation
			IEE1.2	Interest rates	2	1	The interest rate on loans to banks increases
			IEE1.3	Currency exchange rates	1	2	Unanticipated exchange rates
Operations and Quality	IEO1	delay schedule	IEO1.1	Emergency stations	3	1	The cause of emergency should be considered for the modernization program
Strategic (Political)	IEP1	Global risk the project	IEP1.1	Changes in legislation	2	2	The adoption of regulations in the direct / indirect connection with the project
			IEP1.2	Changes nuclear strategy Ukraine	2	1	
			IEP1.3	Changes Policy of the European Commission (in relation to Ukraine or in the nuclear sector) the impact on project	3	1	
			IEP1.4	The events in the environment that influence the project	3	1	The accident at Fukushima., ...
			IEP1.5	The economic crisis in Ukraine	2	1	
			IEP1.6	Political situation in Ukraine	3	3	War ...

1.2 mitigation plans / actions

1.2.1 Introduction

For each risk Mitigation / action defined by experts on risk.

Risk reduction includes at least two dimensions. The first - to reduce the likelihood (or frequency) of occurrence of the event, and the second - to reduce the consequences of the event.

The distribution of duties and responsibilities.

Coordinator of providing fixed their comments (expected results, etc.)

N° Ризику	*Фактор Ризику*	*N° Пом'якшення ризику/ дії:*	*Опис Пом'якшення ризику/дії*	*Відповідальна особа*	*Прогноз кінц. строку*	**Переглянута дата виконання**	**Очікувані результати**	**Статус**	**Досягнення**
IRS1	Незадов. Технічні Вимоги (ТВ)	IRS1.1-A1							
		IRS1.2-A2							
		IRS1.3-A3							
IRS2	Незадов. планування торгів	IRS2.1-A1							
		IRS2.2A2							
		IRS2.3-A3							
…	…	…							

БУДЕ ВИЗНАЧАТИСЯ

1.1.2 Coordinators

Definition: risk mitigation coordinator is the person responsible for the use of risk mitigation. It does the work itself or provide performance

1.1.2 mitigation plans / activities: internal risks

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achieves
schedule	IRS1	Stage concept and bidding on development (Phase 1 implementation) longer than expected	IRS1.1		Not specified	Not specified	1. Not specified	. Not specified					
	IRS2	Step purchasing goods (Phase 2 implementation) longer than expected	IRS2.1		Poor planning trades	IRS2.1-M1 IRS2.1-M2 IRS2.1-M3 IRS2.1-M4	1. Plan your trades based on the hypothesis originator schedule and / or experience / hypothesis experts 2. Expert schedule and planning group 3. Consultations of experts appointed technical expert planning 4. Detailed schedule	ΕΓΠ ΚΓΚ ΕΓΠ ΕΓΠ	Done Done				
			IRS2.2		Poor Quality specifications	**See IRQ2.1**	**See IRQ2.1**	**See IRQ2.1**					
			IRS2.3		Inappropriate tender documentation	IRS2.3-M1 IRS2.3-M2 IRS2.3-M3	1. Qualifications should not rule out all potential suppliers 2. . If necessary, split tenders for several lots 3. . If there is no choice but to change the type of bidding for the procurement (open -> or selective tender with one bidder)	ΜΚ ΜΚ ΜΚ					
			IRS2.4		Graphics are not fulfilled tendering	IRS2.4-M1 IRS2.4-M2 IRS2.4-M3 IRS2.4-M4	1. The members of the tender committee should reread the tender documentation for the auction 2. The graphics department controlled purchases of goods contracts 3. . Holding no more than 3 guest at a time. 4. Ensuring a competitive application in order to reduce the risk of the supplier to withdraw their tenders after his victory	ΜΚ ΜΚ ΜΚ ΜΚ					

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achieves
	IRS3	The stage production and installation of equipment (implementation phase 3) longer than expected	IRS3.1		Disclaimer provider of the contract	IRS3.1-M1 IRS3.1-M2 IRS3.1-M3 IRS3.1-M4 IRS3.1-M5	1. Provision of advance payment (standard document in the tender documentation. In the case of non fulfillment provider returns the money) 2. Provision of the contract (standard) 3. Keep the information on open TV to attract more bidders 4. Supplier Audit (if not included in the list of suppliers Energoatom) 5. Make a request guarantees from producers if the contract is concluded with small intermediary companies (sales / contracts) 1. Period of the production process is based on the hypothesis of potential suppliers, or the experience / hypothesis experts 2. Control charts manufacturing suppliers (and subcontractors), the systematic visiting their shops (frequency of visits should be determined) 3. Monitor to docs and procedures aimed supplier (and subcontractors) comply with the contract and customer needs 4. Monitor to docs filed supplier (and subcontractors) were discussed and agreed time-org this project in order to avoid any delay production equipment 5. Use appropriate methods and organization, which are used on a pilot plant 6. Observe and monitor quality assurance plan provider to implement (hol.chynom point of control and coordination) 7. Detailed schedule specified in the contract 8. If possible, schedule time with a reserve to production (our deadline - 2 months	МК МК ТК Спец. ПЗЯ МК					

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achieves
			IRS3.2		Period manufacturing process longer than expected	IRS3.2-M1 IRS3.2-M2 IRS3.2-M3 IRS3.2-M4 IRS3.2-M5 IRS3.2-M6 IRS3.2-M7 IRS3.2-M8		ΜΚ ΚΡ ΚΡ ΚΡ ΚΡ ΚΡ ΚΡ ΕΓΠ					
			IRS3.3		Equipment made, but is not available for installation	IRS3.3-M1 IRS3.3-M2 IRS3.3-M3	1. 1. To provide shipping and customs issues 2. 2. Provide all goods and action required for the installation of equipment 3. 3. Schedule extra time for the first delivery equipment	ΜΚ ΜΚ ΕΓΠ					
			IRS3.4		The period of outage is shorter than the period required to implement on the ground	IRS3.4-M1 IRS3.4-M2	1. 1. Expert planning group (+ consultations appointed technical experts) to optimize Some actions can be performed during operation, if possible. 2. 2. Implementation schedule	ΕΓΠ ΕΓΠ					
			IRS3.5		Changes in the project after the supply of equipment Delays in	IRS3.5-M1 IRS3.5-M2	1. 1. Approval of all design documentation (EA experts, regulators) 2. 2. Evaluate adopted the first set of equipment as it is, despite rejection	ΚΡ ΜΚ (*)					

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achieves
					regulatory approval (technical) documents								
			IRS3.6			IRS3.6-M1 IRS3.6-M2 IRS3.6-M3	1. 1. Make a schedule for the various stages where there is need for coordination (tasks and stages). On average, 3 months before the planned start of the box. 2. 2. Maintain a close relationship with the regulatory body 3. 3. Provide support for vendors in this process (to be provided in the TV)	ЕГП КР КР					
			IRS3.7		Changes zaplanov. PPR terms	IRS3.7-M1	1. Identify the contract the possibility of changing the terms of installation and commissioning	МК ЕА					
	IRS4	Step adoption installation (Stage 4 implementation) longer than expected	IRS4.1		Experime. unsatisfactory	IRS4.1-M1 IRS4.1-M2 IRS4.1-M3 IRS4.1-M4	1. 1. Presence capabilities maintenance and associated parts 2. 2. Trained staff 3. 3. Preliminary testing and test production fully meet the technical requirements 4. 4. Quality of design (approval of the regulator and the customer, QAP, the choice of the pilot plant, the problem of interaction envisaged in the project)	МК МК КР КР					
	IRS5	Schedule the project exceeds the planned IRS5.1 IRS5.2			Late start	IRS5.1-M1	1.X	Кер.ГУП					
					An additional amount	IRS5.2-M1	1. 1. Planning unforeseen expenses	БМ					
			IRS5.3		Changes in regulations	IRS5.3-M1 IRS5.3-M1	1. 1. Planning unforeseen expenses 2. 2. Distribution	БМ ТК					

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achieves
			IRS5.4		Inaccurate graphs real-tion, not allowing them correctly observe and monitor	IRS5.4-M1 IRS5.4-M2 IRS5.4-M3 IRS5.4-M4 IRS5.4-M5 IRS5.4-M6 IRS5.4-M7 IRS5.4-M8	1. 1. Expert planning group 2. 2. Advice EGP designated technical experts 3. 3. Identify new priorities and make changes to the schedule 4. 4. It is necessary to develop the change in graphics 5. 5. Update periods beginning / end of implementation steps. Update timing start / performance, milestones and critical path milestones (request for a building permit to the regulator (SNRIU) .... Improve coordination between service personnel and staff of implementation, which is responsible for installation 6. 6. Develop a schedule for creating a single Facility	ΚΓΚ ΕΓΠ ΚΡ ΕΓΠ ΕΓΠ ΚΡ ΕΓΠ ΚΡ	DONE DONE DONE DONE				
			IRS5.5		Trades are not prioritized	IRS5.5-M1	1. 1. prioritize bids	ΕΓΠ					
			IRS5.6		Terms changed	IRS5.6-M1	1. 1. Establish communication with the relevant central department for it as soon as possible to inform in order to anticipate these changes	ΕΓΠ					

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemer
			IRF1.2	Complaints to suppliers	IRF1.2-M1 IRF1.2-M2	1. 1. In the final wording of the contract should not be discrepancies between initial customer requirements and price accepted the proposal of the bidder to avoid different understanding between EA and the selected supplier. Head of the contracts should review all documents before signing the contract. 2. 2. Comply with payment terms in the contract. Payments should be laid out and provided. X	МК БМ						
	IRF2	Unavailability of credit	IRF2.1	Conditions of entry into force are not met	IRF2.1-M1	1. 1. EA in a position to finance the measures at their own expense	Кер.ГУП						
			IRF2.2	Unmatched payment	IRF2.2-M1 IRF2.2-M2	1. .1. Need to develop specific processes, procedures and tools for monitoring respective payments (timely availability of the necessary funds) 2. 2. Terms of payment are not violated (applying for payments made under the rules of creditors, the costs supported by invoices) (in the case of Euratom - paid by the creditor) under contracts, money lenders were not used to pay taxes on purchased goods without there is evidence of present / future cost overruns of more than 30% of the original budget, the deadline for completion of the project does not exceed 6 months from the planned schedule)	БМ БМ						
	IRF3	Insufficient funds Energoatom	IRF3.1	Invalid projected budget	IRF3.1-M1 IRF3.1-M2	1. 1. The budget is based on the proposals of potential suppliers, or the experience / hypothesis experts 2. 2. Budget verified by qualified experts	МК КГК	DONE DONEo					
			IRF3.2	Outage longer than expected (lack of income)	IRF3.2-M1 IRF3.2-M2	1. 1. Planning unforeseen expenses 2. 2. Raising fares	Кер.ГУП Кер.ГУП						

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemer
			IRF3.3	The non-renewal of certain operating units (insufficient income)	IRF3.3-M1 IRF3.3-M2	1. 1. Planning unforeseen expenses 2. 2. Raising fares	Кер.ГУП Кер.ГУП						
			IRF3.4	Rates do not cover investment / expense (income insufficient	IRF3.4-M1 IRF3.4-M2	1. 1. Planning unforeseen expenses 2. 2. Raising fares	Кер.ГУП Кер.ГУП						
			IRF3.5	The cost of the project exceeds budget (Overruns	IRF3.5-M1 IRF3.5-M2	1. 1. Open tender 2. 2. Check all implementations costs	МК МК						
	IRF4	Controlling costs is unable to show cost overruns on the project	IRF4.1	Department of cost control does not work properly (process data warning)	IRF4.1-M1 IRF4.1-M2	1. 1. It is necessary to develop specific processes, procedures and tools in order to properly control costs 2. 2. Accurate data (operational data)	БМ БМ						

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	**Coordinator**	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemen
Operation and quality	IRQ 1	Quality problems during the purchase of goods (Phase 2 implementation)	IRQ1.1	Tender specifications do not meet a) Standard tender documentation Bank and b) procurement rules and processes Bank	IRQ1.1-M1	1. 1. Consideration of the head of PMU	МК						
			IRQ1.2	Procurement financed lenders do not comply with procurement rules and principles EBRD	IRQ1.2-M1	1. 1. Consideration of the head of PMU	МК						
			IRQ1.3	Contracts funded by creditors, did not meet the conditions of contracts under which these bidders were invited	IRQ1.3-M1	1. 1. Consideration of the head of PMU	МК						
			IRQ1.4	Procurement is not competitive and non-transparent	IRQ1.4-M1 IRQ1.4-M2	1. 1. Consideration of qualified procurement ekspertamyiz 2. 2. Do not monopolistic scenario in the procurement process	КГК МК						
	IRQ 2	Problems of quality at the production and installation of equipment (Phase 3 implementation)	IRQ2.1	Poor Performance Requirements (TV)	IRQ2.1-M1 IRQ2.1-M2 IRQ2.1-M3 IRQ2.1-M4	1. 1. Develop TV based on previous similar equipment for TV 2. 2. Standardization TV. It has to meet the standards of management NAEC SOU 005: 2011 3. 3. To conduct an independent analysis of the TV (technical, international trade compliance, etc.) 4. 4. Enhance TV on the stage providing quotations based on questions and requests from bidders for clarification	КР КР КР КР						

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemer
			IRQ2.2	Inconsistency contracts (and services ...). Inconsistency goods (including security issues)	IRQ2.2-M1 IRQ2.2-M2 IRQ2.2-M3	1. 1. The award of the contract to the supplier, to analyze the training if it has not passed the preliminary qualification, according to the quality assurance EA in order to really know his abilities. It will also be distributed at major subcontractors. 2. 2. Check all the important requirements when assessments 3. 3. inconsistency done by following the procedure	МК МК КР						
			IRQ2.3	Implementation does not meet quality assurance procedures (QA) EA	IRQ2.3-M1 IRQ2.3-M2 IRQ2.3-M3	1. 1. The final issue and follow the new edition of "overall management of the combined EA syst.upravlinnya" 2. 2. appoint a Manager for QA, which reports directly to the project, thereby strengthening compliance management quality 3. 3. inconsistency done by following the procedure	Кер.ПЗЯ Кер.ГУП КР						
	IRQ 3	The information system is not5r nmmmmmmm mmmmmmmtrf 4y workinguj	IRQ3.1	The database is corrupted	IRQ3.1-M1 IRQ3.1-M2 IRQ3.1-M3 IRQ3.1-M4 IRQ3.1-M5 IRQ3.1-M6 IRQ3.1-M7	1. 1. Develop procedures for backup strategies and test them 2. 2. Train users 3. 3. Daily enter data in the database 4. 4. Ensure antivirus software 5. 5. Take PC use policy 6. 6. Conduct testing in the field (the rules will be determined) 7. 7. Conduct crosschecked field (rules will be determined)	ТК ТК ТК ТК ТК ТК ТК						
			IRQ3.2	Employees of the IT department is not able to provide maintenance	IRQ3.2-M1 IRQ3.2-M2	1. 1. Create a procedure backup strategies and test them 2. 2. Select the IT department and employees to conduct their training (fiz.osoboyu or company) who is able	ТК КГК						

Category	**N° of risk**	**risk**	**N°**		Risk factor	number Mitigation/ action	Description Mitigation / Actions	**Coordinator**	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemen
						to provide technical support database (internal / external)							

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemer
Організація	IRO 1	Персонал погано виконує свою роботу				1.							
			IRO1.2	Недостатня кількість трудових ресурсів або незадовільні необхідні навички для реалізації проекту	IRO1.2-M1 IRO1.2-M3	1. Контроль відповідність труд. ресурсів для дотримання графіку з ін. існуюч. проектом, який виконується 2. Організація, процес, процедури	КР						
Махінації	IRX 1	Махінації, які існують у проекті	IRX1.1	Буде визначатись (БВ)	IRX1.1-M1	1. Буде визначатись (БВ)	БВ						
			IRX1.2	Буде визначатись (БВ)	IRX2.1-M1	1. Буде визначатись (БВ)	БВ						
Кредитні кошти	IRL1	Порушуються умови Кредитної Угоди	IRL1.1	Відсутнє управління кредитами	IRL1.1-M1	1. Призначені співробітники ГУП для управління кредитами	КГК						
			IRL1.2	Угоди не досягаються	IRL1.2-M1	1. Призначені співробітники ГУП для керівництва/контролю за угодами за безпосередньої відповідальності керівника програми	КГК						
Екологічний та соціальний	IRE1	Порушуються умови Кредитної Угоди	IRE1.1	Природоохоронний та соціальний план дій (ESAP) та План взаємодії з зацікавленими сторонами не відповідають Правилам та Принципам ЄБРР	IRE1.1-M1	1. Призначені співробітники ГУП для керівництва/контролю за дотриманням умов захисту навколишнього середовища та соціального захисту	КГК						

(*): За допомогою окремої служби з нормативними процесами і процедурами (DOIC: Дирекція організації вхідного контролю)

3.2.4. Mitigation plans / activities: external risks

Category	N° of risk	risk	N°		Risk factor	number Mitigation/ action	Description Mitigation / Actions	Coordinator	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemer
Licensing	IER1	Technical Requirements (TA))	IER1.1	In the SUP does not apply internationally accepted safety levels	IER1.1-M1 IER1.1-M2 IER1.1-M3	1. 1. A sufficient number of trained personnel with internationally accepted safety levels 2. 2. Involving employees Pilot Station to share the experience 3. 3. Support for communication with regulators	Кер.ГУП КР КР						
			IER1.2	Changes in safety regulations	IER1.2-M1	1. 1. 1. Anticipate changes in regulation, with designated persons within the PMU, which constantly communicate with regulator	Кер.ГУП						
Financial	IEE1	Insufficient funds	IEE1.1	Inflation	IEE1.1-M1	1. . Planning unforeseen expenses	БМ						
			IEE1.2	Interest rates	IER1.2-M1	1. . Planning unforeseen expenses	БМ						
			IEE1.3	Currency exchange rates	IEE1.3-M1	1. . Planning unforeseen expenses	БМ						
Operations and Quality	IEO 1	delay schedule	IEO1.1	Emergency stations	IEO1.1-M1	1.X	ЕГП						
Strategy. (Political).	IEP1	Global risk the project	IEP1.1	Changes in legislation	IEP1.1-M1	1. 1. Anticipate changes in regulation, with designated persons within the PMU, which constantly communicate with regulator	Кер.ГУП						
			IEP1.2	Changes nuclear strategy Ukraine	IEP1.2-M1	1. 1. Anticipate changes in the nuclear strategy of Ukraine with designated persons within the PMU, which constantly communicate with Ministerstvomvom Energy and Coal Industry of Ukraine	Кер.ГУП						

Category	**N° of risk**	**risk**	**N°**		Risk factor	number Mitigation/ action	Description Mitigation / Actions	**Coordinator**	Expected deadline	Reviewed Expected deadline	Expected results	Status	Achievemen
			IEP1.3	Changes Policy of the European Commission (in relation to Ukraine or in the nuclear sector) the impact on project									
			IEP1.4	The events in the environment that influence the project									
			IEP1.5	The economic crisis in Ukraine									
			IEP1.6	Political situation in Ukraine									

1.1.3 Identification of risk management strategies (mitigation plans / actions)

Risk mitigation plans / actions or measures to change the nature of risk situations include:

• Reduction of uncertainty and / or reduce reliability
• Replacement of events with high probability to the event of medium or low probability
• Improving the quality of systems or components to reduce the probability of failure
• Improve training of personnel responsible for the development / implementation of measures
• Reducing the time during which the system, component or personnel exposed to hazardous environment (avoiding unnecessary delays ...)
• Use clear and documented procedures
• Support the examination processes / procedures
• Transfer of risks (insurance contract terms with suppliers, ...)

Control mitigation plan / action to answer the following questions:

• Does the selected strategy or solutions found to eliminate the risks?
• Does the solution agrees with the decisions regarding other risks?
• Were removed the major risks?
• Can we apply an exit strategy?
• Do survived possibility of adaptation?

1.2 Organization

1.1.3 1.1.3 Organization and participation of the parties

Member	Added value through participant	expected role / contribution	
Initiator ***(CEO OF THE project)***	Visibility to achieve the project objectives. Expectation. Faster decision making.	The final decision is made. Extend the highest level of the company.	
Manager Risk Management (Specialist strategies)	The overall vision. Project management. The emergence of the "right" decisions is clear. Promotion Strategy Manager.	Perform risk analysis approach. Provide support for risk analysis and management for arbitration. Inform initiators. Transfer expert knowledge of risk (Energoatom)	Identify and assess risk factors. Identify and assess risk factors.
Expert risk (Specialist operation - Energoatom)	Negotiations on substantive issues to specialist strategies. Manage your area. Priority solutions that are relevant to the issues. The collective vision that is based on transparency.	Implement approach. Listen, not subject to punishment. Offer arbitration specialist strategies. Perform tasks on their own after the transfer of knowledge	Dissemination of experience How to decision taken
Expert risk		Makes suggestions for expanding the list of risks Offers alternative mitigation actions	
Coordinators Managers and project team	The general view of things Weather actions on problematic aspects of the	The statement of all opinions without self censorship. Evaluate your problem from a	

Member	Added value through participant	expected role / contribution	
	project. Understanding the decisions and exchange. Acceleration arbitration.	different angle in the context of issues project.	

1.1.4.Consideration Cards risks: Definitions and Rules

Cards risks: A special list of risks and relaxed Plans / actions pursuant tracked and managed key figures Risk Management (technical director, KR, expert graphics and Planning, Business Manager, etc ... ..)

Cards risks are file liaison between the Head of Risk Management and key stakeholders of risk management.

Cards 2 types of risks:

• Global Facility for the project
• Separate for each category

Major participants who perform their special cards to track risks risks:

• Project Manager (VP API)
• License Manager (VP API)
• Contracts Manager (VP API)
• Technical manager (VP API)
• Expert schedules and Planning (CAP API)
• Curators work (VP API)

Coordination Cards risks at the level of Head of Risk Management

4 MONITORING OF EFFICIENCY SOLUTIONS

• Measuring Success: It should define

• Stages and milestones, should be established

• Responsible for monitoring: should be defined

• Monitoring of risks arising, must be defined

• Experience exchange for the corresponding stage / point to adjust strategy, should be established

5 results

Determined separately for each category of risk.

Appendix C20

State Nuclear Regulatory Inspectorate of Ukraine. No Date(a). Report on Nuclear and Radiation Safety in Ukraine for 2014.

REPORT ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2014

The Report on Nuclear and Radiation Safety in Ukraine in 2015 has been agreed by the editorial board composed of: **Serhii Bozhko**, Chairman of the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), **Vladimir Berkovsky**, Executive Director of the Radiation Protection Institute, Academy of Technological Sciences of Ukraine, **Ganna Gorashchenkova**, Head of SNRIU Division for International Cooperation and European Integration, **Oleksandr Grygorash**, Deputy Director, SNRIU Directorate on Nuclear Installations Safety, **Anvar Derkach**, Press Secretary of SNRIU Chairman, **Taras Kozulko**, Head of SNRIU Division on Chairman Office, Public Relations and Information Policy, **Olga Kosharna**, member of SNRIU Public Council, **Viktor Kushka**, Head of SNRIU Department on Nuclear Security, **Olga Makarovska**, Advisor to SNRIU Chairman, **Natalia Rybalko**, Deputy Head of SNRIU Department on Radioactive Waste Management Safety, **Ruslana Tripailo**, Deputy Head of SNRIU Department on Radiation Safety, **Nadia Chorna**, Deputy Head of SNRIU Division on Safeguards, **Ihor Shevchenko**, Director of the State Scientific and Technical Center for Nuclear and Radiation Safety.

Dear Readers!

We propose to your attention the Report on Nuclear and Radiation Safety in Ukraine for 2014.

In the past, Ukraine experienced unprecedented times in its history. The events that currently occur in Ukraine have posed new challenges to regional and global safety and security and have questioned the existing norms of international law. Threats to the political independence and territorial integrity of Ukraine have become obvious to the international community, expressing its support as reflected in the UN General Assembly Resolution adopted on 27 March 2014.

The annexation of the Autonomous Republic of Crimea and military actions in eastern Ukraine have led to loss of the SNRIU's regulatory control on certain territories of Ukraine, which was perceived with understanding by the IAEA and other international partners.

The counterterrorist operation in 2014 prompted the public authorities to strengthen the physical protection of fuel & energy enterprises of Ukraine, particularly national nuclear power plants, in order to prevent acts of nuclear terrorism.

The external aggression increased the relevance and need for diversification of nuclear fuel supplies for Ukrainian NPPs and spent fuel management.

Chornobyl NPP decommissioning and Shelter transformation into an environmentally safe system traditionally remain an important area of focus for the SNRIU. A series of international projects are underway on the Chornobyl site, with the common objective to construct the new safe confinement, solve issues related to spent fuel management, and ensure treatment, safe storage and disposal of radioactive waste.

The expansion and strengthening of international relations have become especially significant for Ukraine, including the area of nuclear and radiation safety. In 2014, the SNRIU applied to the Western European Nuclear Regulators Association (WENRA) to give Ukraine full membership instead of an observer status in this organization.

More detailed information on these and other areas of the SNRIU's activities in 2014 can be found in the Report.

Sincerely Yours,

Chairman
State Nuclear Regulatory
Inspectorate of Ukraine **Serhii Bozhko**

Table of Contents

1. Year 2014 in Details 5

2. Introduction 8

3. Optimization of Regulatory Activity 11

4. Safety of Nuclear Installations
4.1. NPP Safety Improvement 13
4.2. Safety Review and Long-Term Operation of Nuclear Installations 18
4.3. Implementation of New Nuclear Installation Designs 21
4.4. NPP Operational Events 23
4.5. Releases, Discharges and Exposure Doses 26

5. Nuclear Fuel Management
5.1. Nuclear Fuel Transport 32
5.2. Westinghouse Nuclear Fuel 32
5.3. Spent Nuclear Fuel Management Facilities 34

6. Safety in Management of Radiation Sources 41
6.1. Management of Radioactive Waste Resulting from Use of Radiation Sources 45

7. Activities in Exclusion Zone
7.1. Chornobyl NPP Decommissioning 57
7.2. Construction of Shelter New Safe Confinement 59
7.3. Radioactive Waste Management Facilities in Exclusion Zone 53

8. International Activity 59

Annexes:

1. Violation of Budapest Memorandum 64

2. Situation in Donetsk and Luhansk Regions 67

3. Nuclear Installations in Autonomous Republic of Crimea 72

4. International Nuclear and Radiological Event Scale 76

1. YEAR 2014 IN DETAILS

January	
29	Review of the working design "Reconstruction of the Main Building of ChNPP Stage II (Units 3, 4) with Strengthening and Sealing of Civil Structures Enclosing the NSC" was completed, compliance with nuclear and radiation safety requirements was verified
31	Transfer to enhanced physical protection of nuclear installations
February	
19.02.14 – 06.03.14	Prohibition of nuclear material transport
March	
23.03.14 - 04.04.14	Ukrainian delegation successfully presented the Report on Compliance with Obligations under the Nuclear Safety Convention at the Sixth Review Meeting of Contracting Parties (Vienna, Austria)
31.03.14 – 02.04.14	NSC eastern part was successfully moved to the holding area. The structure with a total weight of about 12.6 thousand tons was moved during 72 h by 112 m towards the Shelter
April	
9	Serhii Bozhko appointed Chairman of the State Nuclear Regulatory Inspectorate of Ukraine
18	SNRIU Order No. 48 approved the Action Plan on harmonization of NPP safety requirements with WENRA reference levels for reactor safety in the framework of general harmonization of national safety requirements with EU legislation
26	First batch of four packages of conditioned radwaste from the Chornobyl NPP liquid radwaste treatment plant was disposed of in ENSDF
May	
12	First lifting of the NSC western part with a weight above 8300 t
12-13	Ukraine participated in the Second Extraordinary Review Meeting of Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Vienna, Austria)
19-23	Workshop on experience exchange in implementation of safeguards with support of the U. S. Department of Energy (Lviv, Ukraine)
June	
2-3	Second lifting of the NSC western part with a total weight above 10,500 t
16	License was issued to the Sevastopol National University of Nuclear Energy and Industry for nuclear installation operation was terminated for violation of Ukrainian regulations
16-18	Ukrainian delegation participated in the annual WWER Regulators Forum (Helsinki, Finland)
26	Annual meeting of the Ukraine–IAEA Safeguards Implementation Review Group (SIRG) was held in Ukraine
July	
1	First Swedish-Norwegian-Ukrainian consultations on the trilateral initiative

	aimed at improving nuclear and radiation safety in Ukraine and declared at the Nuclear Security Summit held in The Hague in March 2014
4	Interdepartmental working group was established to develop the Action Plan on implementation of Council Directive 2013/59/Euratom of 5 December 2.05.2013, laying down basic safety standards for protection against the dangers arising from exposure
18	Ukrainian delegation took part in the meeting of the Assembly of Donors of the European Bank for Reconstruction and Development (London, UK)
21-25	Visit of the SNRIU delegation to the U. S. Nuclear Regulatory Commission, Department of Energy, Department of State
August	
12-13	Participation in the meeting on planning IAEA national technical assistance projects for Ukraine (Vienna, Austria)
13	Cabinet Resolution No. 336 identified national competent bodies for emergency preparedness and response
20	Cabinet Resolution No. 363 approved the Statute of the State Nuclear Regulatory Inspectorate of Ukraine
20	Regulatory document on safety conditions and requirements (licensing terms) for treatment, storage and disposal of radioactive waste was revised
22	With support of the German Government, 250 spent high-level radiation sources were transferred for storage to a specialized enterprise in the Odessa region
September	
4	SNRIU issued an individual permit for strengthening and sealing of existing ChNPP civil structures that serve as NSC enclosure
11	SNRIU Board agreed the Fifth National Report of Ukraine on Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
8-12	Training workshop on the physical protection of radioactive waste for SNRIU inspectors with support of the Swedish Radiation Safety Authority SSM (Kyiv, Ukraine)
22-26	Participation of Ukrainian delegation in the 58th Session of the IAEA General Conference (Vienna, Austria)
October	
2	Procedure for training and examination on radiation safety for personnel and officials dealing with activities in the area of nuclear energy was approved
10	Fifth National Report of Ukraine on Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was officially transferred to the IAEA
16-17	First bilateral meeting with the Norwegian Radiation Protection Authority to discuss prospects of cooperation (Oslo, Norway)
23-24	Serhii Bozhko applied with official request for Ukraine to become a full member to WENRA within the plenary meeting
November	
	Third (last) lifting of the western part of the arc with a total weight above 12,560 t to a height of 109 m. Eastern part of the arc moved by 25 m toward the western part.

3-7	Training workshop on the physical protection of radiation sources for SNRIU inspectors with support of the Swedish Radiation Safety Authority SSM (Kyiv, Ukraine)
17	Trilateral Swedish-Norwegian-Ukrainian consultations on implementation of the first projects under the Initiative declared at the Hague Summit in March 2014 (Kyiv, Ukraine)
18	Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and Norwegian Radiation Protection Authority on cooperation in the area of nuclear and radiation safety and statement on cooperation in the field of nuclear safety and security were signed between Ukraine, Norway and Sweden during the official visit of Prime Minister of Norway, E.Solberh, to Ukraine
December	
8	Bilateral consultations with experts of the U.S. Nuclear Regulatory Commission to discuss current status of joint projects and prospective areas of cooperation (Kyiv, Ukraine)
8-12	Training workshop on safety analysis and licensing of spent fuel dry storage facilities with support of the U.S. Nuclear Regulatory Commission (Kyiv, Ukraine)
12	Ukrainian delegation took part in the meeting of the Assembly of Donors of the European Bank for Reconstruction and Development (London, UK)
25	List of radiation sources exempt from licensing was revised and optimized to reduce regulatory pressure on source users
29	SNRIU made a positive decision on further operation of the VVR-M nuclear research reactor of the Nuclear Research Institute until 31 December 2023

2. INTRODUCTION

State regulation of nuclear safety is aimed at ensuring the safety of people, the environment, nuclear facilities and radiation sources as well as physical protection of nuclear installations.

The highest priority for the SNRIU as a central executive body is to protect people and the environment against harmful effects of radiation in the implementation of any activities related to exposure to radiation additional to natural background, including activities at all life stages of a nuclear installation or radioactive waste storage facility, radioactive waste management, radioactive material transport, fabrication and use of radiation sources as well as security and reliable protection of nuclear installations, nuclear material and other radiation sources against unauthorized access and impact.

In order to improve state regulation of nuclear and radiation safety in connection with Ukraine's commitments under the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, the State Nuclear Regulatory Committee of Ukraine was established on 5 December 2000 as a central executive body with special status. Under the optimization of central authorities in 2010, the State Nuclear Regulatory Committee of Ukraine was renamed the State Nuclear Regulatory Inspectorate of Ukraine.

Basis functions of the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) relating to safety regulation of nuclear energy are to:

- identify safety criteria, requirements and conditions for the use of nuclear energy (*rule-making*);
- issue authorizations and licenses for activities in this area after review of the applicant’s (licensee’s) submittals to confirm compliance with safety requirements (*licensing*);
- conduct state supervision over compliance with legislation, regulations and standards on nuclear and radiation safety and apply sanctions established by law in case of violation (*supervision*).

For proper implementation of these functions, there are the following priority areas in regulation of nuclear and radiation safety in Ukraine:

- fulfill the Action Plan on implementation of the Association Agreement between Ukraine, on the one hand, and the European Union, European Atomic Energy Community and their Member States and plans for harmonization of national safety rules and regulations with the WENRA reference levels, including implementation of some legislative acts of the EU:
  - Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure and cancelling Council Directives 89/618/Euratom, 90/641/Euratom 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom;
  - Council Directive 2006/117/Euratom of 20 November 2006, on the supervision and control over shipments of radioactive waste and spent nuclear fuel;
  - Council Directive 2014/87/Euratom of 8 July 2014, establishing a Community framework for nuclear safety of nuclear installations.
- fulfill the action plan on optimization of state safety regulation of nuclear energy;
- ensure regulatory support to:
  - Comprehensive (Integrated) Safety Improvement Program for NPPs and safety review of operating power units and nuclear installations, including NPP long-term operation;
  - designs of new nuclear installations (CSFSF, ChNPP ISF-2, Neutron Source, KhNPP units 3 and 4);
  - projects for diversification of nuclear fuel supplies to Ukraine to ensure energy safety of the State;
- promote effectiveness of the state physical and civil protection system in high alert conditions;

- ensure state safety regulation in developing the infrastructure for long-term storage and disposal of radioactive waste, Shelter safety and decommissioning of Chornobyl NPP units 1, 2 and 3;
- implement Ukraine's international obligations related to nuclear weapon non-proliferation, safety and security.

The main challenges to nuclear regulation in Ukraine in 2014 were caused by the external threat: annexation of the Autonomous Republic of Crimea and military operations in Eastern Ukraine. The international community recognized violation of the Budapest Memorandum with respect to Ukraine. This was noted by the UN Secretary General Ban Ki-Moon in his speech at the Nuclear Security Summit held in The Hague on 24 March 2014. He noted that security safeguards were an important condition for Ukraine's joining the Non-Proliferation Treaty (NPT), but their reliability was seriously undermined by the events around Ukraine. The UN Secretary General expressed an opinion that this would have negative consequences for both regional safety and the non-proliferation regime.

Because of external aggression, Ukraine lost regulatory control in the Autonomous Republic of Crimea and some areas in the Donetsk and Luhansk regions. Communication with the Crimean State Inspectorate for Nuclear and Radiation Safety was actually lost in May-June, it was officially transferred to subordination of Russian Federation Rostekhnadzor in September. The Southeast State Inspectorate for Nuclear and Radiation Safety which was located in Donetsk continued its work and was transferred to the city of Zaporizhzhya in December 2014.

In the Autonomous Republic of Crimea, there are nuclear installations such as the IR-100 research reactor of the Sevastopol National University of Nuclear Energy and Industry (SUNEI) and two subcritical assemblies for low enriched and natural uranium. In addition, the Crimea has several enterprises and medical establishments using devices and containers with radiation shielding with depleted uranium and high-level radiation sources in five institutions, mainly oncological centers.

Fortunately, so-called Donetsk People's Republic and Luhansk People's Republic have no nuclear installations but only nuclear material in small amounts as radiation shields in containers for transport and storage of radiation sources and radiotherapy devices in cancer centers and highly radioactive sources.

3. OPTIMIZATION OF REGULATORY ACTIVITY

According to Article 5 of the Law of Ukraine 'On Nuclear Energy Use and Radiation Safety", state policy in the area of nuclear energy and radiation protection is exercised, in particular, through optimum national regulation of nuclear and radiation safety, applying a graded approach to safety requirements depending on potential nuclear and radiation hazards peculiar to specific activities at nuclear installations (sources). This is also the case with physical protection.

The graded approach is reflected in the laws of Ukraine, specifically, the Law of Ukraine 'On Authorizing Activity in Nuclear Energy' indicates that one of the main authorizing principles is that the graded approach should be applied to different activities and radiation sources, taking into account potential nuclear and radiation hazards (an example is release of radiation sources with minimum potential level of danger from licensing) and the Law of Ukraine 'On Physical Protection of Nuclear Installations, Nuclear Material, Radioactive Waste and Other Radiation Sources' states that physical protection of facilities must correspond to potential radiological consequences of illegal actions against them).

These requirements of Ukrainian laws comply with IAEA recommendations. In particular, IAEA General Safety Requirements Part 1, Governmental, Legal and Regulatory Framework for Safety, envisages that national safety policy and strategy are based on a graded approach, taking into account radiological risks, to be considered to establish regulatory requirements, issue permits, conduct inspections and assess facilities and activities. In addition, such requirements in Ukrainian laws comply with EU regulations, such as Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure and cancelling Council Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

The SNRIU applies the optimization principle in state safety regulation. The optimization of state safety regulation in the area of nuclear energy is not regarded as just deregulation, i.e. cancellation or reduction of regulation, but as an attempt to find the optimum level of state regulation considering the graded approach to regulation of various activities with specific facilities (sources) in accordance with their nuclear and radiation hazard. Implementation of the results will in general favorably influence state regulation since SNRIU resources released in state deregulation will focus on enhanced regulation of activities characterized by a high level of nuclear and radiation hazard and, hence, state regulation for the safety of nuclear energy will be optimized.

In order to optimize state regulation for the safety of nuclear energy, draft laws were prepared to amend the law of Ukraine and, in particular, to:

avoid the need to obtain authorization of the state nuclear regulatory authority for the use of land and water bodies located in the controlled area for general use since this regulation is excessive, taking into account that the Law envisages the potential use of lands and water bodies upon agreement with the operating organization with mandatory radiological monitoring of the products;

release radioactive material transport by rail, water and air; reloading (loading, unloading, dispatch) of packages and their transit storage in sea and river ports, airports and railway stations from licensing when the carriers and organizations dealing with the above operations have licenses for shipment of hazardous cargoes, in order to eliminate duplication in licensing;

remove receipt (purchase) and transfer (sale) of radiation sources, including that for supply purposes, from the list of activities related to the use of such sources that are subjected to licensing.

Implementation of these proposals will not decrease the level of nuclear and radiation safety during these activities since they are related only to authorization that does not exclude the application of other state controls to these activities, such as establishment of regulatory criteria and requirements that determine conditions in the area of nuclear energy (rule-making) and state supervision over compliance with legislation, rules and regulations on nuclear and radiation safety and physical protection requirements, including enforcement measures (state supervision). Along with amendment of laws, awareness of the nuclear entities regarding their direct responsibility for nuclear and radiation safety will be increased.

There are also important proposals for laws related to state supervision over nuclear and radiation safety under SNRIU implementation. These proposals include amendments intended to extend some state supervision measures not only to licensees but also to other nuclear entities whose activities are subject to state regulation and are not licensed or are licensed but they still have not become the licensees; and also amendments intended to conduct state supervision over compliance with nuclear and radiation safety requirements in compliance with legislation governing the safety of nuclear energy. Supervision over the use of radiation sources will be exercised in accordance with the Law of Ukraine "On Basic Principles of State Supervision (Control) of Economic Activities". The last proposal is associated with a Law adopted by the Verkhovna Rada (Government) of Ukraine to extend the Law of Ukraine "On Basic Principles of State Supervision (Control) of Economic Activities" in full scope to state supervision over compliance with nuclear and radiation safety requirements, which contradicts international agreement of Ukraine and European Union and IAEA requirements.

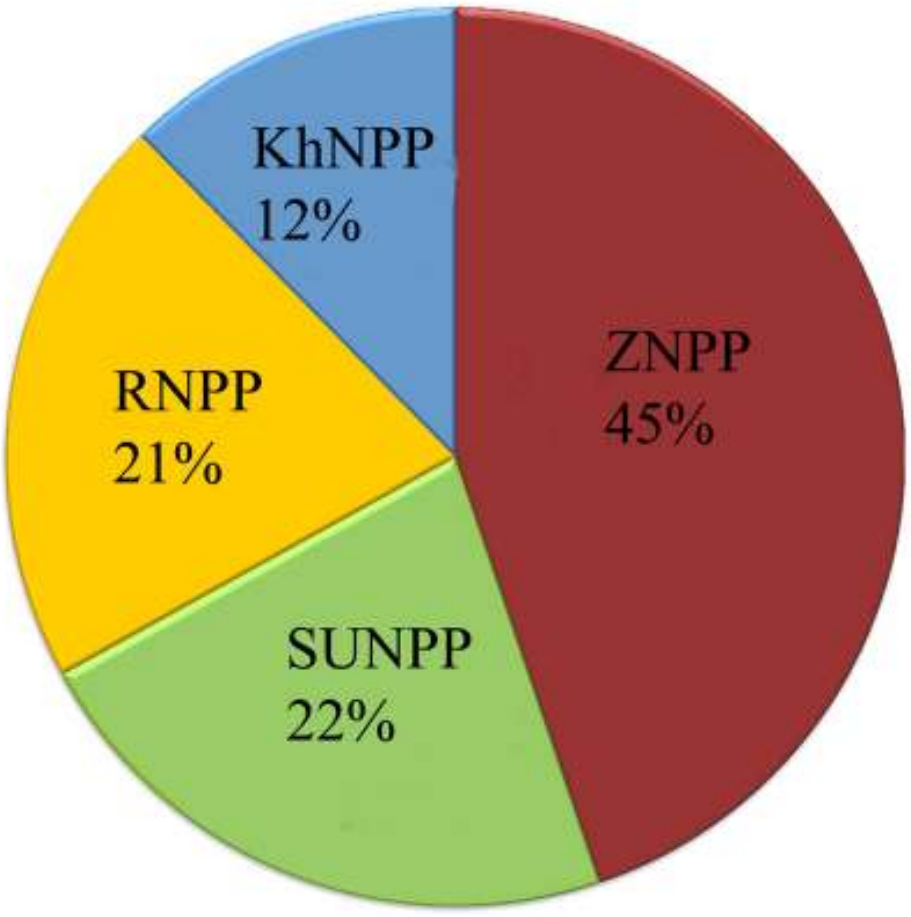
The above measures will allow the SNRIU to focus attention on the most hazardous activities, in view of nuclear and radiation safety, and will reduce the regulatory pressure on economic entities, in line with the state policy being implemented in Ukraine.

4. SAFETY OF NUCLEAR INSTALLATIONS

4.1. NPP Safety Improvement

Ukraine operates 15 power units, ranks the tenth in the world for this indicator and takes the seventh place in the installed capacity. The only operator of all operating nuclear power plants in Ukraine is the National Nuclear Energy Generating Company *Energoatom* The *Energoatom* Company includes four nuclear power plants.

The total installed capacity of operating Ukrainian power units in 2014 is 13,835 MW.



Share of each NPP in nuclear energy production in 2014

Ukraine ensures stable and safe operation of NPPs under the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Convention on Nuclear Safety. Safety improvement measures are under implementation at operating nuclear power plants of Ukraine on a systematic basis in compliance with national regulations and standards on nuclear and radiation safety and recommendations of the International Atomic Energy Agency (IAEA), taking into account best international practices.

Peer reviews of WANO[1] and IAEA confirmed operational safety of Ukrainian NPPs and validity of safety upgrades implemented under safety improvement and long-term operation programs.

The safety improvement measures at Ukrainian NPPs are under implementation in compliance with the "Comprehensive (Integrated) Safety Improvement Program for Operating Nuclear Power Units" (C(I)SIP), approved by a Cabinet Resolution in 2011. The C(I)SIP objective is to:

- further improve operational safety of NPP units;
- decrease risks of NPP accidents during natural disasters or other hazards;
- improve the effectiveness in management of design-basis and beyond design-basis accidents at NPPs, minimize their consequences.

The C(I)SIP is based on safety improvement measures of the previous program "Concept for Safety Improvement of Operating Nuclear Power Units" (approved by a Cabinet Resolution in 2005) that were not implemented by the operating organization till the end of the Concept and safety upgrades for Khmelnitsky-2 and Rivne-4 that were implemented during commissioning of these units.

The C(I)SIP also takes into account results and recommendations of the IAEA design safety review mission conducted at all NPPs under the Memorandum of Understanding in the Field of Nuclear Energy between Ukraine and EC.

[1] WANO is the World Association of Nuclear Operators

Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs

Cabinet Safety Improvement Concept (2006-2010)
Comprehensive Safety Improvement Program-2008
IAEA-EU-Ukraine Project
Safety Analysis Reports
Safety-Important Equipment with Expired Life
Equipment Qualification Program
Stress Tests

After the Fukushima accident, the C(I)SIP included additional measures upon extraordinary in-depth safety reassessment for Ukrainian NPPs (stress tests) and additional fire safety measures. Safety improvement measures are among conditions for long-term operation of NPPs. The design-basis lifetime of nine Ukrainian NPP units expires in a period from 2014 to 2020 (see Table 4.1).

Table 4.1. Service Life of NPP Units in Ukraine

NPP	Unit No.	Reactor Type	Expiration of design-basis/long-term operation period
ZNPP	1	WWER-1000/320	23.12.2015
	2	WWER-1000/320	19.02.2016
	3	WWER-1000/320	05.03.2017
	4	WWER-1000/320	04.04.2018
	5	WWER-1000/320	27.05.2020
	6	WWER-1000/320	21.10.2026
SUNPP	1	WWER-1000/302	02.12.2013 / 02.12.2023
	2	WWER-1000/338	12.05.2015
	3	WWER-1000/320	10.02.2020
RNPP	1	WWER-440/213	22.12.2010 / 22.12.2030
	2	WWER-440/213	22.12.2011 / 22.12.2031
	3	WWER-1000/320	11.12.2017
	4	WWER-1000/320	07.06.2035
KhNPP	1	WWER-1000/320	13.12.2018
	2	WWER-1000/320	07.09.2035

In 2014, within C(I)SIP regulatory support, the SNRIU agreed 33 reports on implementation of measures out of the 85 ones planned to be completed in 2014 and 10 reports on measured planned for 2015÷2017. In addition, 15 reports were returned for revision upon review.

According to C(I)SIP scheduled, the main efforts of the operating organization in 2014 were focused on the development and implementation of measures for SUNPP unit 2 and ZNPP units 1 and 2 within long-term operation activities. The experience in measures taken at the so-called pilot units is further extended to other power units.

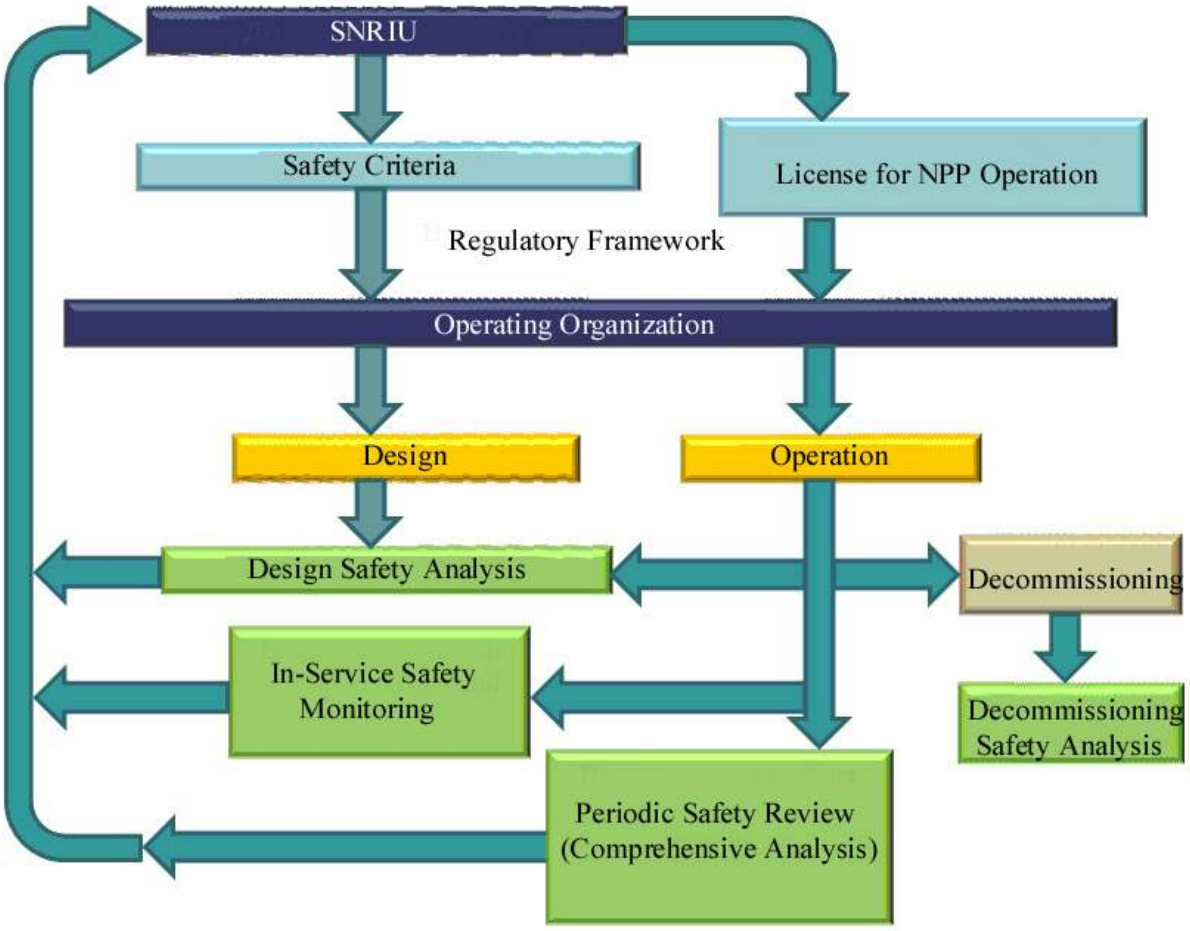
Equipment qualification, technical state assessment and emergency response improvement measures are underway at all operating units. The reports are gradually

submitted to the SNRIU for regulatory review. It should be noted that instrumented seismic analyses are in their final stage for ZNPP. The results of these seismic analyses and safety margins will be used to establish the seismic level of ZNPP site (similar efforts were completed for SUNPP, introduction of seismic monitoring system is underway for KhNPP and RNPP).

Modifications important to safety of nuclear installations (change in nuclear installation configuration, bringing a nuclear installation into compliance with current regulations and standards, changes in operational documents, modification of the operating organization's structure) are implemented upon agreement with the SNRIU.

The State Nuclear Regulatory Inspectorate of Ukraine constantly monitors all stages of modifications (concept development, installation and pre-commissioning, introduction into trial and/or commercial operation) through safety assessment of submittals and agreement of appropriate technical decisions, as well as through direct supervision over modifications, introduction of changes to operational documentation and staff training. The results are discussed at open meetings of the SNRIU Board involving all stakeholders, including the public and mass media.

Hence, the Board meeting on 6 February 2014 analyzed the status of NPP safety upgrades completed in 2013 in compliance with the detailed schedule for implementation of C(I)SIP measures developed by the operating organization and agreed by the SNRIU.



Safety Assessment System for NPP Units

During the year, the SNRIU conducted comprehensive inspections of each NPP site, also involving international experts. One of the main tasks is to check implementation of safety improvement measures.

At the beginning of 2013, the SNRIU jointly with the Ministry for Energy and Coal Industry, Ministry of Defense, Ministry for Environment and Natural Resources and State Agency for Exclusion Zone Management developed the National Action Plan upon Stress-Test Results aimed at improving the safety of Ukrainian NPPs.

This document was developed in compliance with the National Action Plan (NAcP) Guidance as directed within the ENSREG Stress test Action Plan.

The National Action Plan upon Stress-Test Results incorporates:

- ENSREG recommendations and proposals set forth in the "Compilation of recommendations and suggestions. Peer review of stress tests performed on European nuclear power plants" in areas such as external extreme hazards, loss of safety functions and management of severe accidents;
- basic issues of the Extraordinary Meeting of the contracting parties to the Convention on Nuclear Safety (August 2012, Vienna, Austria) in areas such as national organizations, emergency preparedness and response and international cooperation.

The draft National Action Plan was presented at the open meeting of the SNRIU Board with involvement of interested ministries/departments/organizations and the public. The National Plan revised to incorporate stakeholder's proposals was submitted by the SNRIU to ENSREG for further joint discussion by all stress-test countries.

The National Plan of Ukraine was positively evaluated by the 'stress-test' countries, recognized as transparent and complying with the structure proposed by ENSREG, and covering all the aspects mentioned in the ENSREG action plan. The National Plan was discussed and approved at an ENSREG public meeting with stakeholders, including non-governmental organizations and mass media.

EU states and neighboring countries that took part in the stress tests (Ukraine and Switzerland) reached agreements for further periodic exchange of information on the implementation of the National Action Plans and transparency and openness of the process.

It is planned to review and discuss the current status of national action plans upon stress tests of the participating countries during the ENSREG workshop in April 2015. In preparation for the ENSREG workshop, the National Action Plan upon Stress-Test Results (2013) was updated to take into account recommendations set forth in the "ENSREG Post-Fukushima National Action Plans Workshop 20÷24 April 2015. Terms of Reference". It should be noted that the number of measured planned for operating NPPs and Chornobyl NPP and the scope of measured remained unchanged in the updated National Action Plan. The updated National Action Plan specified the status of safety upgrades and their schedule.

It should be pointed out that a series of safety upgrades for operating NPPs that require substantial funding were extended in connection with the events that occurred in Ukraine during the last year and with the decision made by the operating organization to shut down power units after expiration of their design-basis life in order to ensure

implementation of all safety upgrades at these power units to justify their long-term operation.

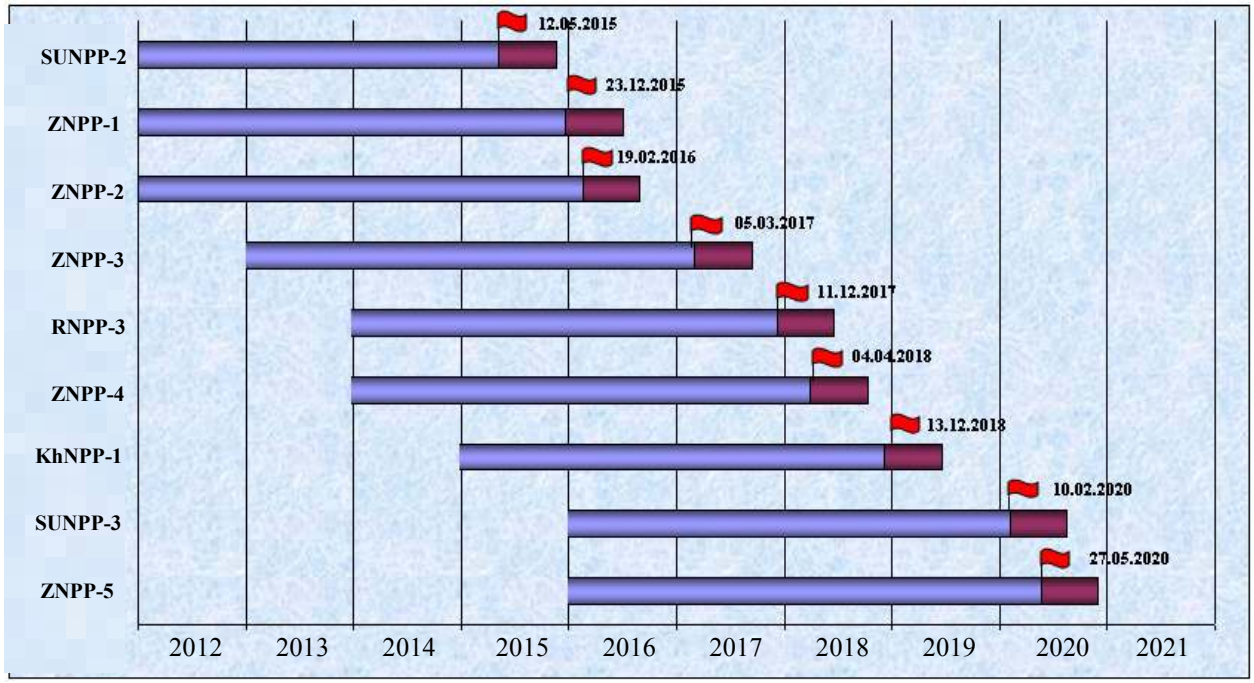
The updated National Action Plan upon Stress-Test Results can be found on the SNRIU official website.

4.2. Safety Review and Long-Term Operation of Nuclear Installations

4.2.1. Safety Review and Long-Term Operation of NPP Units

Most Ukrainian NPPs were commissioned in the 1980s and their 30-year design-basis life is to expire in the near future. The Government of Ukraine decided to continue operation of NPP units as reflected in the "Energy Strategy of Ukraine until 2030" and "Comprehensive Work Program for Long-Term Operation of Nuclear Power Plant Units". The *Energoatom* Company together with the WWER General Designer *Hydropress* revised the schedule for beginning of commercial operation and established the dates for completion of the design-basis life (see Table 4.1).

In a period from 2015 to 2020, the design-basis life of nine NPP units in Ukraine (see the schedule) expires. It will be required to take a decision in 2015, 2017, 2018 and 2020 on life extension of two power units at the same time.



- completion of design-basis life

- last scheduled outage for implementation of long-term operation measures

- period of preparation for long-term operation

In accordance with current legislation, a decision on long-term operation of a power unit is made by the SNRIU based upon conclusions of the state nuclear and regulatory safety review of the periodic safety review repot (PSRR) by amending the license for its operation. Long-term operation may be allowed only if the safety level of the NPP unit is not lower than that established by current regulations and rules on nuclear and radiation safety.

The PSRR is based upon a substantial scope of efforts, in particular, related to:

- assessment of current technical state of components and structures and their lifetime extension;
- elimination of deviations from NRS regulations, rules and standards adopted during the last years;
- implementation of safety upgrades planned under C(I)SIP;
- implementation of measures upon results of NPP operational events and stress tests;
- equipment qualification for harsh environments and seismic events and seismic evaluation of NPP piping, buildings and structures;
- implementation of the ageing management program for NPP components and structures;
- in-depth safety analysis applying deterministic and probabilistic methods;
- enhancement of operational safety through improvement of operational and emergency documentation;
- improvement of the management system to be in compliance with NRS regulations and rules, IAEA recommendations and best international practice;
- improvement of emergency preparedness system.

In accordance with NRS regulations, rules and standards, the PSRR is finalized as individual reports based upon assessment of 14 safety factors:

- plant design;
- current condition of systems and components;
- equipment qualification;
- ageing;
- deterministic safety analysis;
- probabilistic safety assessment;
- internal and external hazard analysis;
- safety performance;
- use of experience from other plants and research findings;
- organization and administration;
- operating procedures;
- human factor;
- emergency preparedness and response;
- environmental impact.

This approach complies with IAEA recommendations and best international practice and allows a comprehensive assessment of the power unit safety to make a sound decision on further operation of the power unit, including long-term operation.

For SUNPP unit 2 and ZNPP units 1 and 2, whose design-basis life expires in 2015÷2016, the operating organization chose the option for preparing for long-term operation in which a power unit is to be shut down after its design-basis life expires and organizational and technical measures are to be taken to continue and recommence operation. The SNRIU agreed long-term operation programs and licensing plans for the above power units. Safety upgrades, equipment qualification and technical condition assessments are underway at these power units. The respective reports are gradually submitted to the SNRIU for state nuclear and radiation safety review.

As of the end of 2014, the SNRIU conducted state nuclear and radiation safety review:

- reports on assessment of all 14 factors in the SUNPP-2 PSRR, among them the reports on eight safety factors were agreed by the SNRIU after the operating organization resolved comments of state NRS review;
- reports on assessment of 12 factors in the ZNPP-1 PSRR, among them the reports on eight safety factors were agreed by the SNRIU after the operating organization resolved comments of state NRS review;
- reports on assessment of 9 factors in the ZNPP-2 PSRR, among them the reports on eight safety factors were agreed by the SNRIU after the operating organization resolved comments of state NRS review.

The safety review of Ukrainian NPPs and preparation for long-term operation undertaken by the operating organization are under strict supervision of the SNRIU.

4.2.2. Safety Review and Long-Term Operation of Nuclear Research Reactor VVR-M of Nuclear Research Institute, National Academy of Sciences of Ukraine

The Nuclear Research Institute (NRI) of the National Academy of Sciences of Ukraine (NASU) operates a nuclear installation including the VVR-M nuclear research reactor and spent fuel storage facility in compliance with License EO No. 000051 for operation for a period until the operational stage expires.

Based on review of the PSRR for VVR-M reactor, current technical condition of systems and components important to safety and inspection findings, the lifetime of the VVR-M nuclear research reactor was limited to 31 December 2013 and conditions for its further operation after 2013 were identified in accordance with decision of the SNRIU Board No. 11 of 21 May 2009.

The possibility and conditions for further VVR-M operation were addressed at the SNRIU Board meeting on 26 December 2013. The Board stated that the justification material submitted by the operating documentation was not sufficient to make a decision on further operation of the research reactor and was to be revised. At the same time, state nuclear and radiation safety review showed that there were no reasons to make a decision on impossibility of further operation of the VVR-M nuclear research reactor.

In this regard, SNRIU Board Resolution No. 25 of 26 December 2013 stated that further operation of the VVR-M reactor would be reconsidered only if the operating organization tool the following measures:

- revise the "Decision on Possibility and Conditions of Further Safe Operation of the VVR-M Nuclear Research Reactor of the NRI NASU No. RE.5-023-13";
- complete revision of Section 8 "Analysis of Design-Basis and Beyond Design-Basis Accidents at VVR-M Nuclear Research Reactor" of PSRR for NRI VVR-M;
- revise the report on stress tests at VVR-M research reactor of NRI NASU;
- provide new strength analyses for the reactor tank elements and primary piping;
- complete elimination of the defect in primary piping.

During 2014, the SNRIU conducted state nuclear and radiation safety review and agreed all justifications and decisions of the operating organization required by SNRIU Board Resolution No. 25 of 26 December 2013.

In a period from 15 to 16 December 2014, the SNRIU commission conducted comprehensive inspection to verify NRI preparedness for VVR-M operation and found the following:

- NRI submittals for amendment of License EO No. 000051 of 22 May 2002 were complete and reliable and reflected the actual state of affairs;
- NRI was fully capable of VVR-M operation until 31 December 2023.

The final decision to continue VVR-M operation until 31 December 2023 was made at the SNRIU Board meeting on 29 December 2014.

4.3. Implementation of New Nuclear Installation Designs

Ukraine currently implements several designs of new nuclear installations in compliance with nuclear and radiation safety requirements:

- Khmelnitsky NPP units 3 and 4 (see para. 4.3.1.);
- Nuclear Fuel Fabrication Plant (see para. 4.3.2.);
- Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator (see para. 4.3.3.);
- Centralized Spent Fuel Storage Facility (see para. 5.3.1.);
- Dry Interim Storage Facility for Spent Fuel at Chornobyl NPP (see para. 5.3.2.).

4.3.1. Construction of Khmelnitsky NPP Units 3 and 4

The construction of KhNPP units 3 and 4 was suspended after the feasibility study for construction of these units was developed and approved by Cabinet Resolution No. 498-r of 4 July 2012 and Verkhovna Rada of Ukraine adopted Law No. 5217-VI of 6 September 2012 "On Siting, Design and Construction of Units 3 and 4 of Khmelnitsky Nuclear Power Plant".

Taking into account the political relations between Ukraine and the Russian Federation, Energoatom currently considers the construction of these units using the WWER-1000/320 design of **AT Skoda JS a.s.** (Czech Republic).

On 17 October 2014, to ensure compliance of Skoda JS a.s. WWER-1000 with national requirements and rules and to improve technical and economic indicators compared to operating NPPs of Ukraine, Energoatom developed the "Conceptual Decision on Construction of Khmelnitsky NPP Units 3 and 4 and agreed it with the SNRIU, Ministry for Energy and Coal Industry and Ministry for Regional Development, Construction and Housing & Utility Services. According to the Conceptual Decision, additional safety upgrades are to be incorporated in the design of these units:

- use of additional systems to ensure containment integrity (filtered venting system, hydrogen recombiners);
- use of fuel assemblies of alternative supply;
- improvement of electrical part through increase in reliability;
- use of up-to-date instrumentation & control;
- implementation of features envisaged by C(I)SIP and stress tests for Ukrainian NPPs in KhNPP-3 and KhNPP-4 designs;
- use of additional cooling systems for the reactor pressure vessel to prevent potential development of severe accidents involving radioactive releases outside the reactor compartment above regulatory values;
- capabilities for power uprate to 107%.

The *Energoatom* Company currently takes actions to revise the feasibility study and prepare a draft Law to amend Law of Ukraine No. 5217-VI "On Siting, Design and Construction of Units 3 and 4 of Khmelnitsky Nuclear Power Plant".

4.3.2. Construction of Nuclear Fuel Fabrication Plant

Construction of the Nuclear Fuel Fabrication Plant hardly took place in 2014. There is the following information on construction of the Nuclear Fuel Fabrication Plant as of 31 December 2014.

Creation of a nuclear fuel fabrication plant in Ukraine is envisaged by the State Target Economic Program "Nuclear Fuel of Ukraine", developed in compliance with the Energy Strategy of Ukraine until 2030 and approved by Cabinet Resolution No. 1004 of 23 September 2009.

Construction of the Nuclear Fuel Fabrication Plant was planned on the territory of the Smolino Village Council in Malovyskiv District of Kirovograd Region in accordance with Cabinet Resolution **No. 437-r of 27 June 2012** "Siting, Design and Construction of the WWER-1000 Nuclear Fuel Fabrication Plant", which approved the feasibility study for this nuclear installation.

In compliance with legislation, construction of a nuclear fuel fabrication plant (and any other nuclear installation) can be started only under a license issued by the SNRIU for construction and commissioning. In turn, two main conditions for issuing this license is agreement of the preliminary safety analysis report (PSAR) by the SNRIU and approval of the design for this nuclear installation by the Cabinet of Ministers of Ukraine.

The first condition was fulfilled by the operating organization, Private Corporation "Nuclear Fuel Fabrication Plant" (PSAR of the Plant was approved in accordance with SNRIU Board Resolution No. 18 of 4 December 2013), and the second condition still remains to be met, in spite of the positive expert review report on the design documentation "Construction of Nuclear Fuel Fabrication Plant", No. 00-1085-13/PB, submitted by *Ukrderzhbudekspertiza* on 12 December 2013.

4.3.3. Construction of Neutron Source Based on Subcritical Assembly Driven by Linear Electron Accelerator

The Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator (Neutron Source) is being constructed on premises of the National Scientific Center "Kharkiv Institute of Physics and Technology" (KIPT) in accordance with the agreement reached at the Washington Security Summit and outlined in the Joint Statement of the Presidents of Ukraine and USA in April 2010 and Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America on nuclear safety cooperation signed on 26 September 2011. The Neutron Source is under construction with support of the U.S. Argonne National Laboratory.

The Neutron Source is intended for scientific study and applied research in the fields of nuclear physics, radiation material science, biology, chemistry and production of medical radioisotopes. The Neutron Source was described in detail in the "Report on Nuclear and Radiation Safety in Ukraine for 2012".

This nuclear installation is created under SNRIU License EO No. 001018 for construction and commissioning issued on 10 October 2013.

According to the License, the KIPT operating organization took efforts to construct the Neutron Source during 2013÷2014 as well as to develop and agree working documentation (technical specifications for equipment important to safety) with the SNRIU.

As of 1 January 2015, the SNRIU preliminary agreed 36 documents out of the 78 reviewed.

The Neutron Source is expected to be commissioned in the third quarter of 2015.

4.4. NPP Operational Events

Accounting and analysis of NPP operational events are an integral part of the operating experience feedback system, which in turn is a contributor to NPP safe operation.

Ten operational events occurred at operating Ukrainian NPPs in 2014. They include:

- 4 events at ZNPP;
- 3 events at RNPP;
- 2 events at KhNPP;
- 1 event at SUNPP.

Figure 4.4.1 presents the distribution of operational events at Ukrainian NPPs from 2000 to 2014 and shows that the number of events in 2014 slightly decreased as compared to the previous year.

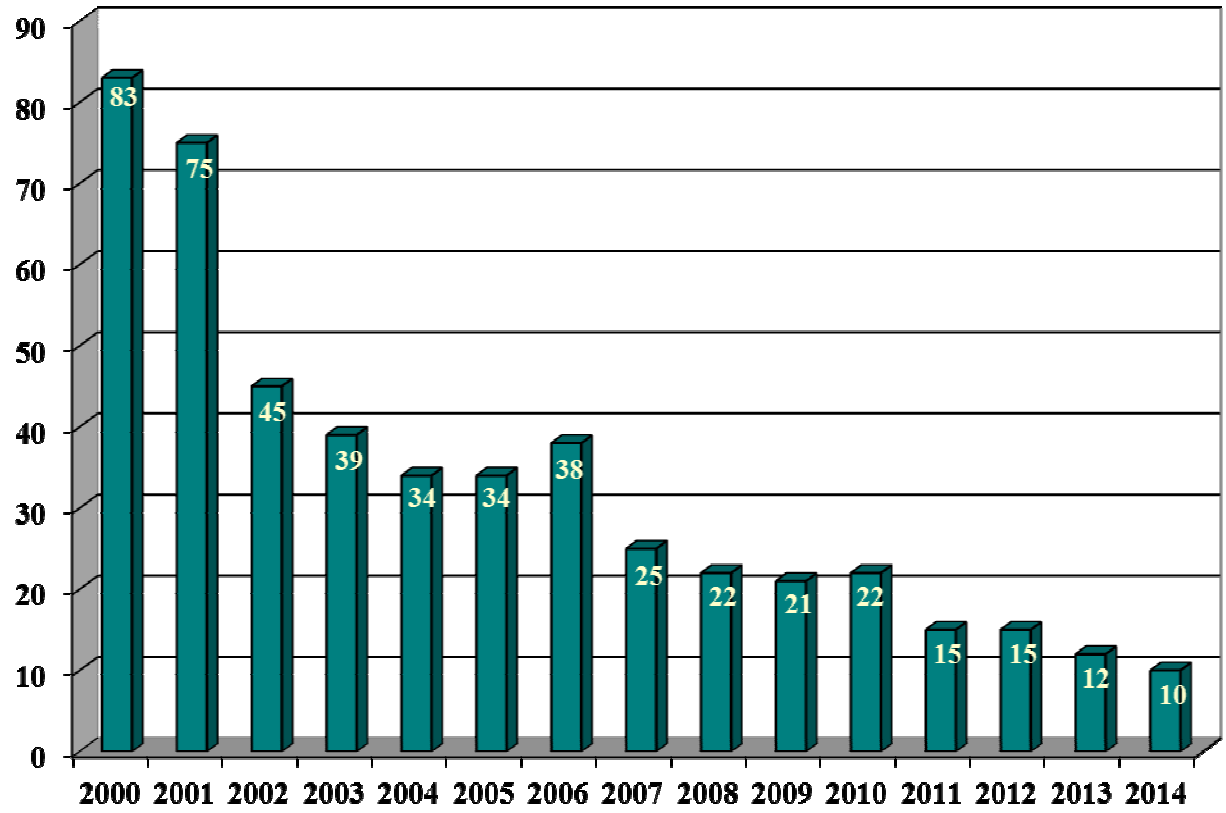


Figure 4.4.1. Number of operational events at Ukrainian NPPs in 2000÷2014

Figure 4.4.2 presents distribution of events by NPP sites in 2000÷2014.

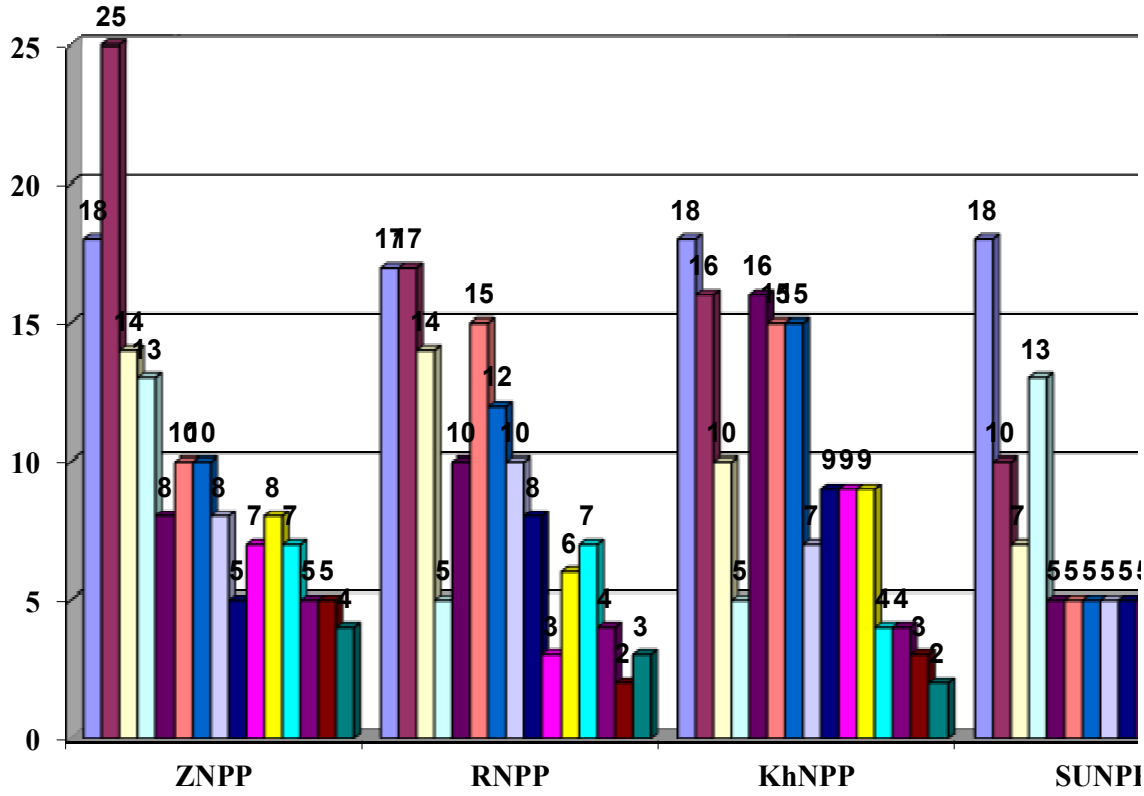


Figure 4.4.2. Distribution of events by NPP sites in 2000÷2014

The number of operational events decreased at ZNPP and SUNPP, has not changed for KhNPP and increased at ZNPP compared to the previous year.

All power units under commercial operation are divided into two groups according to reactor types: WWER-1000 (13 units) and WWER-440 (2 units).

According to INES (Annex 4), the worldwide instrument developed to inform the public on significance of nuclear and radiological events for safety, Ukraine had no events higher than "below scale/level 0" (insignificant for safety) in 2014.

Depending on features and consequences, NPP operational events in 2014 included the following:

- reactor shutdown with scram, preventive protection, power limiter – 20 % (2 events);
- power unit disconnection from the grid by emergency automatics, turbine and turbine generator protection – 20% (2 events);
- failure of group A and B equipment and piping important to safety and safety class 1 and 2 components – 20% (2 events);
- power decrease by 25% Nel and higher from the previous level – 30% (3 events);
- actuation of any safety system or safety system train in standby – 10% (1 event).

During an NPP operational event, there is deviation from normal operation (abnormal event) that can be caused by equipment failure, external impact, human error or procedural drawbacks. Figure 4.4.3 presents the distribution according to systems that failed or were affected during abnormal events.

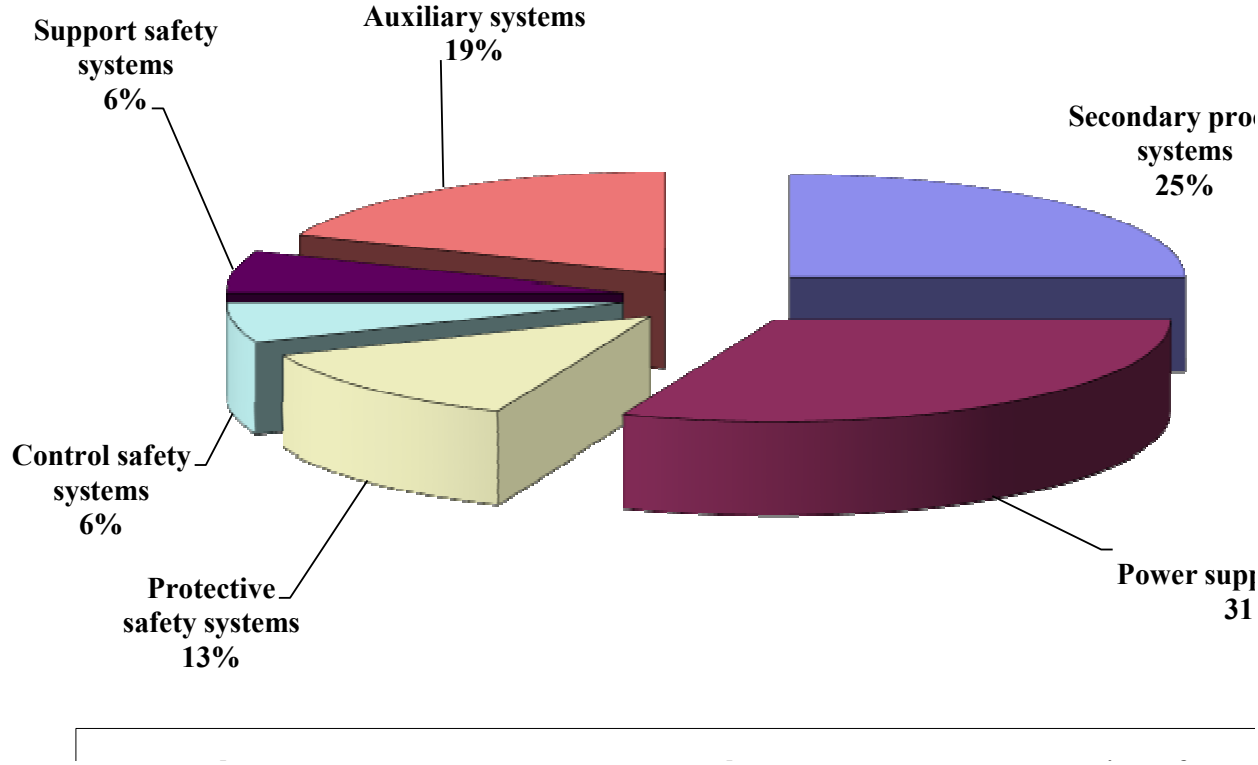


Figure 4.4.3. Distribution according to systems that failed or were affected during abnormal events

The following systems failed the most in 2014:

- power supply systems;
- secondary process systems.

Figure 4.4.4 presents the distribution of root causes of abnormal events in 2008÷2014.

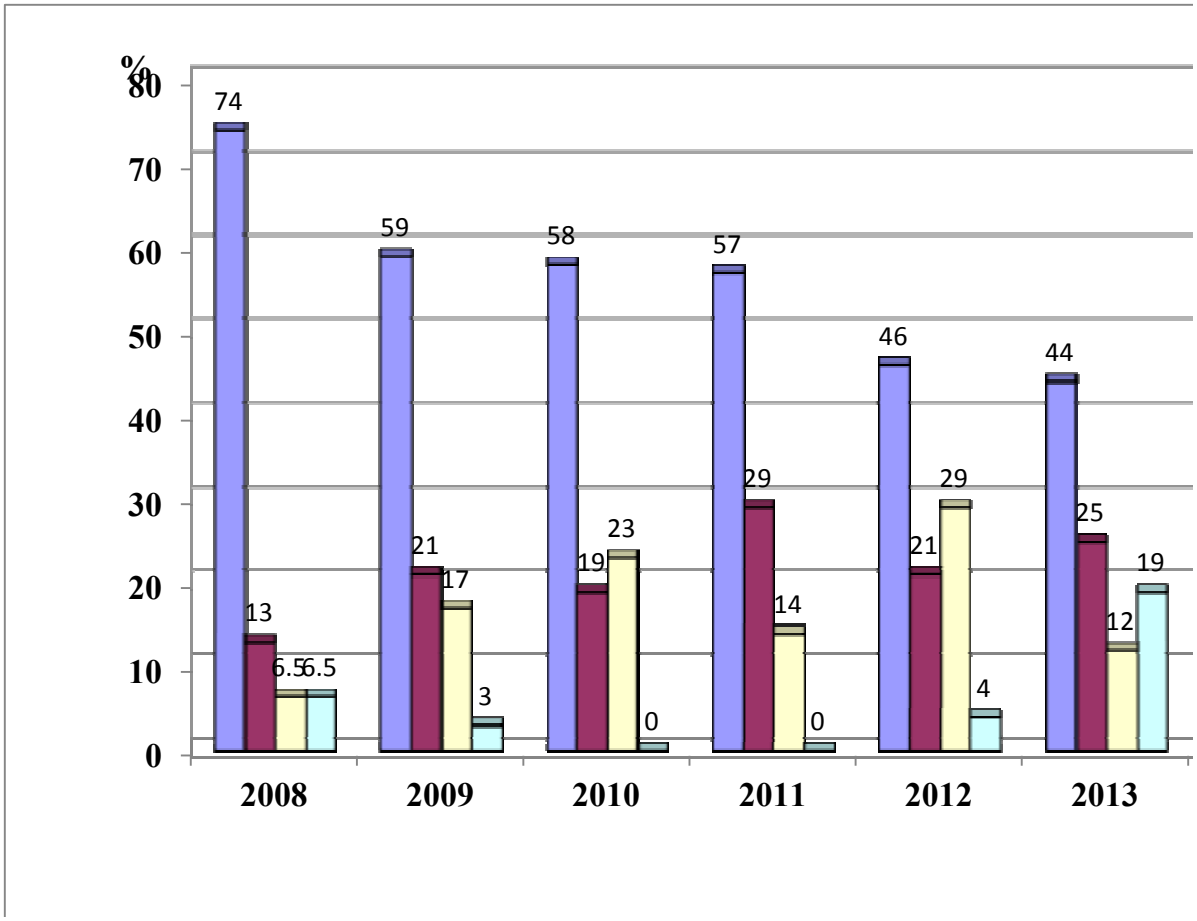


Figure 4.4.4. Distribution of root causes of abnormal events

As a rule, causes related to equipment failures make the greatest contribution (37.5 %). The share of root causes related to personnel increased in the last year.

The root causes related to equipment mainly occurred due to:

- design drawbacks;
- fabrication drawbacks.

4.5. Releases, Discharges and Exposure Doses

NPP environmental impact is assessed through analysis of radiological and non-radiological factors. Impact of NPP radiological factors is assessed from data on airborne releases and water discharges into the environment, doses of NPP personnel and radiological state of environmental objects in the NPP location area.

The main criterion for assessing of radiological impact is doses of personnel and the public.

Radiation safety involves compliance with permissible limits of radiation impact on personnel, the public and the environment established in safety regulations, rules and standards. Radiation protection is a series of radiation health & safety, design & engineering and technical & and organizational measures aimed at ensuring radiation safety.

NPP radiation protection includes a series of protective barriers on the path of radionuclides toward the environment. The values of airborne releases and water discharges from NPP characterize the state of protective barriers.

Effectiveness of radiation protection at Energoatom NPPs is assessed by the following parameters of radiation safety:

- airborne release per 1000 MW of installed capacity;
- water discharge of radionuclides per 1000 MW of installed capacity;
- indexes of radioactive releases and discharges to the environment.

Table 4.5.1. Dose limit quotas

Source	Dose limit quota for all dose pathways from releases		Discharges: dose limit quota for critical water use		Total dose limit quota for individual enterprise	
	%	μSv	%	μSv	%	μSv
NPP, nuclear steam power plant, heat-supply NPP	4	40	1	10	8	80
RWDS, uranium mines	2	20	1	10	4	40
RT plants	10	100	5	50	20	200
Other sources, reference industrial source	4	40	1	10	8	80

4.5.1 Radioactive Airborne Releases to Atmosphere

The levels of NPP airborne releases to the atmosphere are determined upon:

- continuous monitoring of inert radioactive gases, long-lived aerosols and iodine radionuclides in NPP ventilation stacks by automated airborne release systems and regular automated radiation monitoring equipment;
- gamma spectrometry of aerosol samples deposited on filters taken from NPP ventilation stacks;
- gamma spectrometry of gas and aerosol fractions of radioactive iodine taken from NPP ventilation stacks.

There are limits for radioactive releases and reference levels (RLs) for airborne releases to the environment approved for each NPP. The reference levels and limits for airborne releases of inert radioactive gases, long-lived nuclides or iodine radionuclides to the environment were not exceeded in 2014.

RNPP and KhNPP mastered the guidance for a facility for monitoring of airborne tritium releases to the environments through NPP ventilation stacks and accepted it into commercial operation. The contribution of this radioisotope to the total release indicator was ~ 58% at RNPP and ~ 36% at KhNPP.

The airborne releases from operating NPPs were much lower than limits established for each NPP in 2014.

Therefore, the total indexes of airborne radioactive releases from NPPs to the environment remain stably low and change vary insignificantly, being no more than one percent of permissible limits.

4.5.2. Radioactive Discharges to External Water Bodies

Radioactive discharges of radionuclides from nuclear power plants to external water bodies (cooling ponds) are mainly formed by residual waters from chemical demineralization tanks and blowdown essential spray ponds.

Radioactive discharges to the cooling pond are mainly formed by residual waters from radiation monitoring tanks, water treatment tanks and blowdown of essential service water supply systems.

RNPP has a process water treatment system for cooling of turbine condensers (cooling towers instead of cooling pond) which is different from other NPPs. Hence, the volume of total discharges 137Cs per 1000 MW installed capacity at RNPP to the environment are much higher than at other NPPs because of continuous blowdown of the cooling tower basin.

Radioactive discharges at SUNPP are monitored and accounted in dump of residual waters from spray ponds and cooling towers to the NPP cooling pond.

Spray pond waters and residual waters are discharged into the KhNPP cooling pond. The main contribution to discharges is made by blowdown of spray ponds.

The total indexes for radioactive water discharges for the reporting period for all reliably recorded radionuclides (3H, 137Cs, 134Cs, 60Co, 54Mn, 90Sr) were as follows: 1.6% for ZNPP, 0.55% RNPP, 4.45% for SUNPP and 0.27% for KhNPP.

It should be noted that the "Permissible Radioactive Water Discharges from NPP to the Environment" for ZNPP and KhNPP were revised in 2013, their numerical values changes. This circumstance explains substantial improvement in the discharge index at KhNPP in 2013.

Radioactive water discharges to open ponds were not exceeded at any Energoatom NPP for 2014.

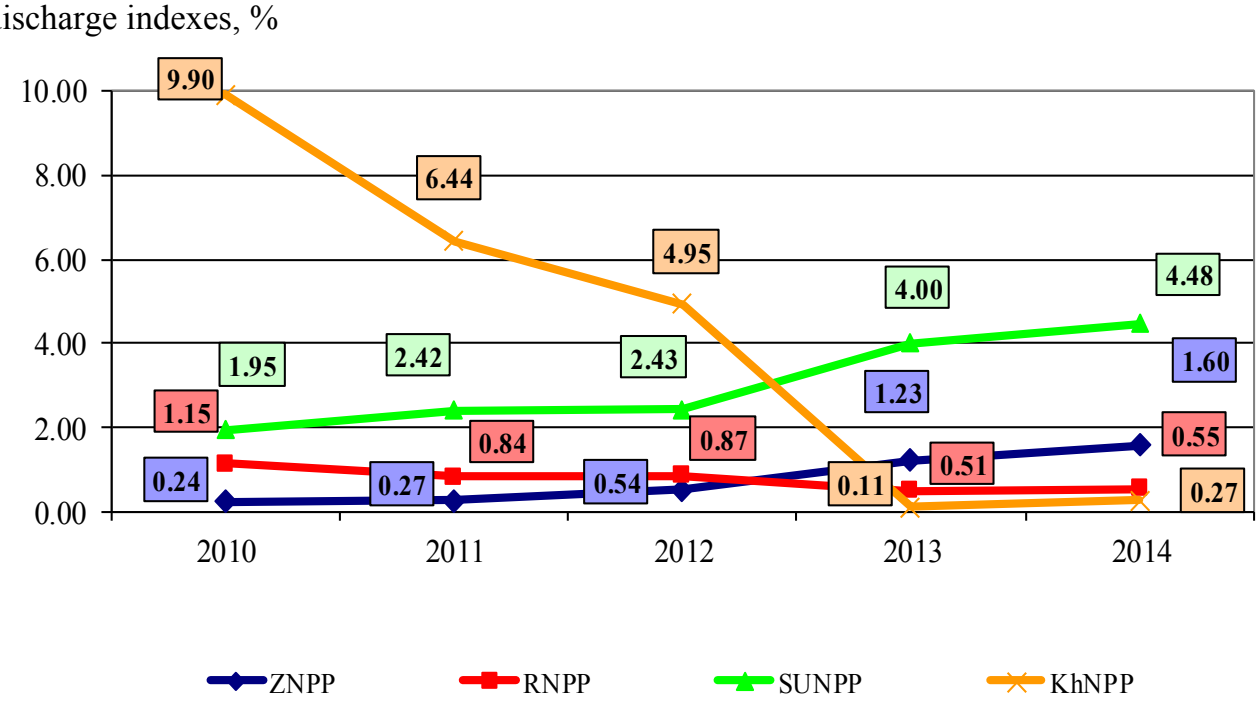


Figure. 4.5.1. Total indexes of radioactive water discharges for NPPs in 2010÷2014

4.5.3. Results of Personnel Dose Monitoring

4.5.3.1 Personnel External Doses

In the reporting year, individual external doses of ZNPP, RNPP and SUNPP personnel were measured with the RADOS dose measurement system with RE-2000 readers and thermoluminescent dosimeters (with MCP-N gamma and beta detectors and MCP-6,7 neutron detector) and with Harshaw 8814/0110 thermoluminescent dosimeters at KhNPP.

In addition, for prompt monitoring of external doses, NPPs used DMC-2000S electron dosimeters (MGPI, France) in 2014.

Table 4.5.2 shows administrative process levels for individual doses of NPP personnel and reference levels of annual collective doses for two groups of personnel whose individual dose exceeds 6 mSv/y (RL6) and 15 mSv/y (RL15).

Table 4.5.2. Administrative process (administrative) levels for individual effective doses of NPP personnel and reference levels for annual collective doses of NPP personnel with individual doses higher than 6 mSv/y (RL6) and 15 mSv/y (RL15)

Plant	Administrative process levels for individual doses of personnel		Reference levels for annual collective doses of personnel	
	Personnel, mSv/y	Women to 45 years of age, mSv	RL6	RL15
ZNPP	15.0 (18.5*)	-	4.50	1.80
RNPP	15.0 (19.0*)	1.90 (for 2 months)	3.60	0.83
SUNPP	15.0	1.40 (for 2 months)	3.30	0.41
KhNPP	15.0 (18.0*)	1.40 (for 2 months)	1.60	0.32

* - *for personnel involved in hazardous radiological work*

Table 4.5.3 provides distribution of individual doses and collective and average doses of Energoatom NPP personnel and temporary duty staff for 2014.

Table 4.5.3. Distribution of individual effective external doses of NPP personnel (with temporary duty staff), collective and average individual doses for 2014

NPP	Number of persons monitored	Doses for 2014							
		<1	1-2	2-6	6- 10	10-15	15-50	Collective, man-mSv	Average individual, mSv/y
ZNPP	4806	4182	277	299	47	1	0	2154.29	0.448
incl. temp. staff	637	586	36	15	0	0	0	160.20	0.251
RNPP	3732	3221	232	250	23	6	0	1712.64	0.459
incl. temp. staff	629	555	39	35	0	0	0	208.84	0.332
SUNPP	3080	2511	231	291	36	11	0	1978.26	0.642
incl.	676	549	57	45	15	10	0	532.19	0.787

temp. staff									
KhNPP	2800	2315	271	205	9	0	0	1454.58	0.519
incl. temp. staff	700	634	34	32	0	0	0	207.62	0.297
Energoatom	14418	12229	1011	1045	115	18	0	7299.77	0.506

Table 4.5.3 shows that none member of personnel or temporary duty staff at NPP received an individual effective dose in the range 15-20 mSv, which is close to the limit for individual effective dose (20 mSv).

In recent years, there is positive dynamics of decrease in the annual collective doses of personnel per one unit at Energoatom NPPs.

General trends in changes of absolute values of collective doses for NPP personnel and their contribution to the total dose for Energoatom NPPs for the recent decade are presented in Figure 4.5.3.

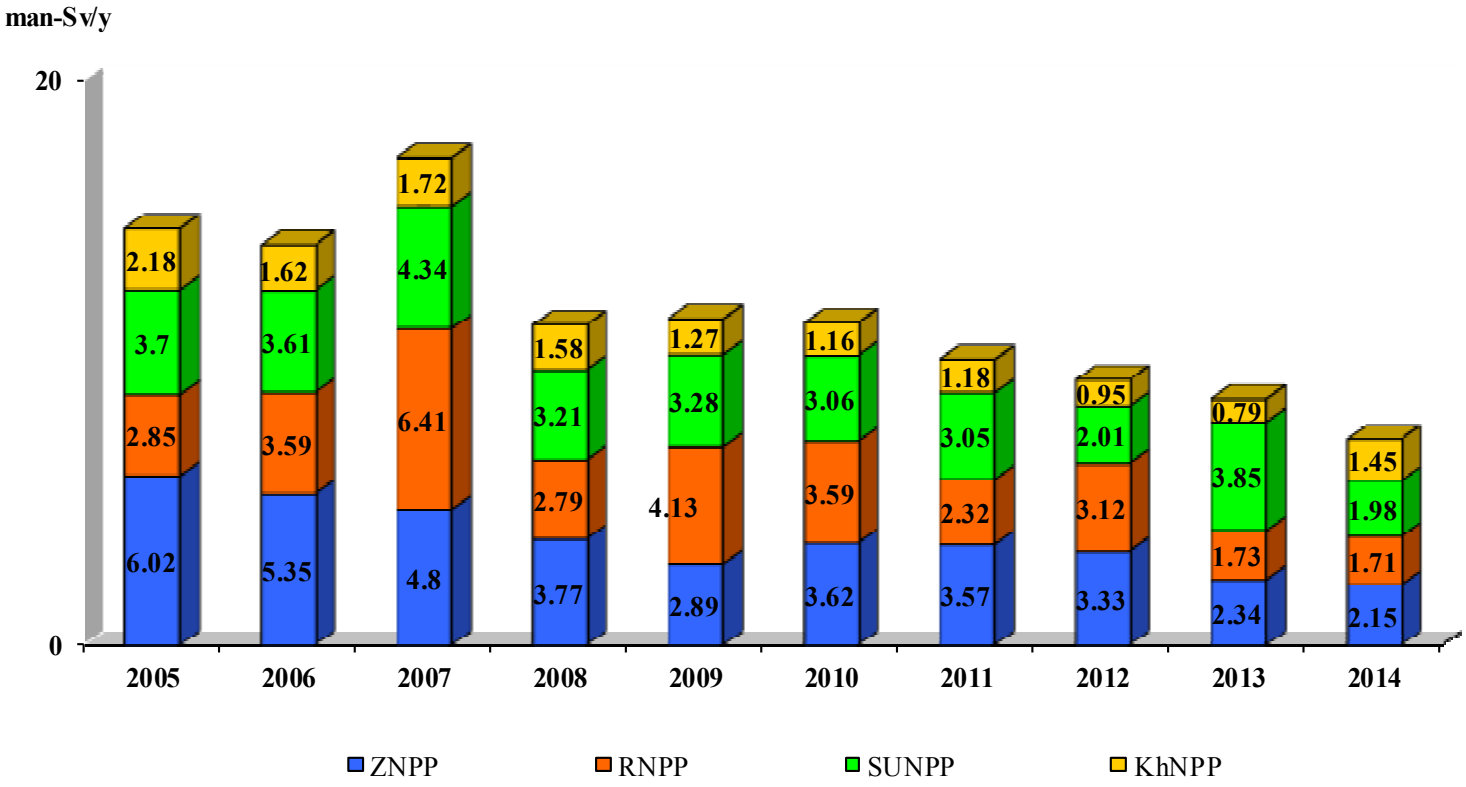


Figure. 4.5.3. Collective doses for NPP personnel (including temporary duty staff) for 2005 - 2014

The total collective dose for personnel of operating NPPs in 2014 was 7.300 man-Sv, which is 1.408 man-Sv lower than in 2013, when the total collective dose of personnel was 8.708 man-Sv. It should be pointed out that the total annual collective dose of NPP personnel has decreased in recent years starting from 2008 and was the lowest in 2014.

4.5.3.2. Personnel Internal Doses

According to NRBU-97, permissible levels of radionuclide inhalation are established for category A personnel, while instrumentation used at NPPs determines the content of radionuclides in critical human organs. Internal exposure was monitored by direct measurement of radionuclide activity in human body (critical organ) using human radiation spectrometers based on scintillation and semiconductor detectors with subsequent conversion of the results into expected effective dose.

Permissible levels of individual annual inhalation of radionuclides established by NRBU-97 for category A personnel are 400 kBq/y for ^{131}I, 200 kBq/y for ^{60}Co, 100 kBq/y for ^{137}Cs and 200 kBq/y for ^{134}Cs.

Content of ^{137}Cs and ^{60}Co radionuclides in human body and lungs and of ^{131}I in thyroid gland was monitored at all NPPs.

Table 4.5.4 shows distribution of individual internal doses and collective internal dose of NPP personnel in 2014.

Table 4.5.4. Distribution of individual doses and collective internal doses of NPP personnel in 2014

NPP	Number of monitored persons	Number of persons with dose received in 2014 (mSv)		Collective dose, man-mSv
		< 1	> 1	
ZNPP	7621 (2211)	15	0	1.08
RNPP	4950 (667)	4	0	< 1.00
SUNPP	3447 (994)	3	0	1.21
KhNPP	2933(695)	14	0	1.45
Energoatom	18951(4567)	36	0	4.24

( ) - Staff of other organizations*

The collective annual internal dose of ZNPP personnel in 2014 was 1.08 man-mSv, which is the same as in 2013.

Based on monitoring of internal radionuclide content in critical organs of RNPP personnel, all individual internal doses were lower than 0.25 mSv. The maximum internal dose in this personnel group was 0.22 mSv.

The annual collective dose of SUNPP personnel in 2014 increased as compared with 2013 and was 1.45 man-mSv (0.66 man-mSv in 2013). 80% in this value was the dose of maintenance staff engaged in work with reactor equipment during scheduled outages.

The annual collective internal dose of KhNPP personnel was 1.45 man-mSv (0.71 man-mSv in 2013).

5. NUCLEAR FUEL MANAGEMENT

5.1. Nuclear Fuel Transport

On the territory of Ukraine, there is transport of fresh and spent nuclear fuel of Ukrainian NPPs and transit transfers of fuel between the Russian Federation and East European Countries – Slovakia, Hungary and Bulgaria. Transport is undertaken in compliance with a number of intergovernmental agreements on cooperation in nuclear material transport, particularly between the governments of the following countries:

- Ukraine, Russian Federation (1996);
- Ukraine, Russian Federation, Bulgaria (2006);
- Ukraine, Russian Federation, Slovakia (2010);
- Ukraine, Russian Federation, Hungary (2012).

The agreements identify basic legal and organizational principles of cooperation in nuclear material transport – competent authorities involved in implementation of the agreements, international documents used in the transport of nuclear materials, procedure for cargo escort, physical protection and security issues, reloading points, guard change points, responsibility for loss of cargo, civil liability for nuclear damage, mitigation of accident consequences and procedure for notification about transport.

Legislation also identified cases when transit of nuclear materials and radioactive waste cannot be undertaken: in cases of potential threats related to military actions, armed conflicts, civil war, uprisings, political or civil unrest, strikes, acts of terrorism; in cases of force majeure including natural phenomena, which are exceptional, inevitable and unpredictable; during events of national importance in Ukraine (national holidays, international cultural and sports events, etc.).

In view of the events in early 2014, the SNRIU introduced a ban on the transport of nuclear materials for the period from 19 February to 6 March 2014.

The SNRIU granted 19 authorizations in 2014 for the transport of nuclear fuel of Ukrainian NPPs and 9 permits for transit of nuclear fuel of Slovakian, Hungarian and Bulgarian NPPs.

To ensure physical protection during nuclear fuel transport, measures are taken to provide information security and protection of shipments by the National Guard throughout the route of spent fuel transport through Ukraine.

Spent fuel is transported by rail in special cars and in transport packaging sets that are able to withstand transportation accidents. Although the transport of spent nuclear fuel is potentially dangerous because of the extremely high-active content of containers, there have been no transportation accidents in history that would have resulted in radioactive release from containers or violation of nuclear safety requirements.

5.2. Westinghouse Nuclear Fuel

In order to diversify the supply of nuclear fuel and avoid dependence on the monopoly supplier, Energoatom has taken measures since 2000 on the development, delivery and qualification of an alternative supplier of nuclear fuel, compatible with Russian-design fuel. These measures are taken within the Implementing Agreement between the Government of Ukraine and the Government of the United States of America on “Nuclear Fuel Qualification Project for Ukraine” signed on 5 June 2000.

In preparation for the implementation of the Qualification Project, the Core Design Center was established on the premises of KIPT, to which Westinghouse transferred technologies for design of nuclear fuel and reactor cores and guidance for safety analysis. Experts of the center successfully passed training and internship in the USA.

In the first phase of the Qualification Project in 2005–2009, trial operation of six fuel assemblies manufactured by Westinghouse (FA-W) was conducted at SUNPP unit 3. In addition, the computer system for the in-core monitoring system was assembled and put into operation.

Since March 2010, in the framework of the second phase of the Qualification Project, trial operation of the reload batch consisting of FA-W was started.

On 30 March 2008, a contract for supply of nuclear fuel for annual reloading of three WWER-1000 units in 2011 ÷ 2015 was signed between Energoatom and Westinghouse Electric Sweden AB (Västerås, Sweden).

In 2011 ÷ 2012, under the contract and with potential extension of the FA-W pilot operation, four batches of nuclear fuel were supplied; two of them were loaded into the reactor cores of SUNPP units 2 and 3 in 2011.

In 2012, during scheduled outage, issues occurred during reloading of mixed cores at SUNPP units 2 and 3, which were caused by design features of fuel assemblies from both suppliers (TVEL and Westinghouse) that formed the core, namely:

- FA-W with damaged spacer grids were revealed;
- reactor cores could not be loaded as planned.

In this connection, extension of Westinghouse fuel operation under the contract was terminated. Beginning from 2013, FA-W operation continued only in the SUNPP-3 core. According to the work program for FA-W trial operation, all fuel assemblies in the core were subjected to visual examination and integrity check using regular instrumentation of the power unit during each scheduled outage. Part of FA-W was inspected in more detail with use of the inspection and maintenance test bench supplied by Westinghouse.

At the end of 2014, four-year operating cycle expired for a number of FA-W, i.e., the full cycle envisaged by design documentation. Inspection of these fuel assemblies, including integrity check, revealed no issues.

Therefore, it can be noted that no loss of integrity was revealed during operation of Westinghouse fuel during 2010÷2014, in spite of the damage of spacer grids during handling operations.

After the events in 2012, in order to recommence FA-W trial operation, Energoatom and Westinghouse, upon agreement with the SNRIU, identified a series of measures, including required upgrades to fuel design.

In 2013÷2014, Westinghouse upgraded the fuel assembly design and conducted comprehensive testing of the upgraded robust assemblies (FA-WR).

Licensing of the upgraded assemblies was started in parallel. For this purpose, Energoatom and Westinghouse developed a package of justification documents, which was strictly required by Ukrainian regulations, and submitted it to the SNRIU for review. The first stage of this processes completed with an authorization issued by the SNRIU for loading of batch consisting of 42 FA-WR into the SUNPP-3 core in 2015.

In August 2014, the Energoatom commission, with an SNRIU representative, confirmed that Westinghouse Electric Sweden AB would ensure the required quality of products to be supplied to Ukrainian NPPs within the audit of quality control system of

this company and acceptance of the FA-WR batch for SUNPP-3. As of the end of 2014, the reload batch was supplied to the SUNPP site and passed acceptance inspection, which revealed no issues that would prevent FA-WR loading into the SUNPP-3 core.

5.3. Spent Nuclear Fuel Management Facilities

Spent nuclear fuel (SNF) generated during electricity production in nuclear reactors is an important component of the NPP process cycle.

The period for which nuclear fuel is used in the reactors is determined by allowable burnup. After planned burn up is reached, nuclear fuel is unloaded from the reactor and is considered spent fuel since it cannot be used directly to produce electricity.

After unloading from the core, SNF is placed into spent fuel pools (SFP). SNF is cooled down in these pools for a time period needed to decrease residual heat resulting from radioactive decay of fission products to allowable values. When SNF is stored in SNP for a limited time, spent fuel assemblies (SFAs) are to be removed from the NPP unit and sent for storage (disposal) or processing. This is done because the capacity of NPP SFPs is limited and they must always have free volume for nuclear fuel unloading from the core or periodic inspections of the WWER reactor pressure vessel and internals.

At the same time, factors that are determined by specific features of SNF are to be taken into account in its management: high radioactivity and presence of valuable elements in SNF (uranium, plutonium, germanium, erbium, palladium, zirconium etc.), which can be used prospectively, including that in other nuclear cycles (nuclear fuel for fast neutron reactors, MOX fuel for light-water reactors).

The state of nuclear energy all over the world shows that, given the current development of technologies, one cannot make ultimate conclusions on economic feasibility of SNF reprocessing or disposal, i.e., on the final stage in the nuclear fuel cycle (NFC). In this regard, Ukraine, like most countries with developed nuclear energy, accepted the so-called deferred decision, providing for long-term SNF storage. The deferred decision allows the State to make a decision on the final NFC stage later, to benefit from the development of global technological and national economic feasibility.

Ukraine currently operates two interim storage facilities for spent fuel: wet storage facility for SNF – ISF-1 at the Chornobyl NPP – and dry storage facility for SNF – DSFSF at the Zaporizhzhya NPP.

In addition, two other storage facilities are under construction in Ukraine: dry interim spent fuel storage facility – ISF-2 at the Chornobyl NPP – and centralized storage facility for SNF of national WWER NPPs – CSFSF.

5.3.1. Management of WWER Spent Nuclear Fuel

The ZNPP was the first plant that had to deal with a lack of space in SFP for SNF. To solve this issue, ZNPP started implementation of DSFSF in 1996.

The DSFSF design is based on the licensed and proven spent fuel storage technology of Duke Engineering & Services (USA). SNF is stored in the following way: 24 fuel assemblies with low decay heat (<1 kW) after five-year cooling in SFP are placed into a special canister, which is filled with helium (inert gas with high thermal conductivity) and sealed, then the canister is placed into a ventilated concrete storage cask (VSC). The storage facility is designed to accommodate 380 VSC, which may contain 9000 assemblies with SNF.

The first stage of DSFSF for 100 VSC was commissioned in 2001 and the second stage, for 280 VSC, at the end of 2011.

Figure 5.3.1. Zaporizhzhya NPP DSFSF

As of 1 January 2015, there are 124 VSC on the DSFSF site.

SNF from the Rivne, Khmelnitsky and South Ukraine NPPs is currently transported to the Russian Federation. WWER-1000 spent fuel is sent for storage and WWER-440 spent fuel (RNPP-1, 2) for reprocessing.

To implement the "Action Plan for 2006-2010 for Implementation of the Energy Strategy of Ukraine until 2030" (approved by Cabinet Resolution No. 427 of 27 July 2006), Energoatom concluded a contract with U.S. Holtec International for construction of a centralized storage facility in Ukraine to accept SNF from the Rivne, Khmelnitsky and South Ukraine NPPs employing the dry storage technology proven at the Zaporizhzhya NPP.

In compliance with legislative requirements, Energoatom developed the "Feasibility Study for Investments into Construction of Centralized Storage Facility for Spent Nuclear Fuel (CSFSF) of National WWER Nuclear Power Plants". The Feasibility Study was approved by Cabinet Resolution No. 131-r of 4 February 2009 after comprehensive regulatory review.

The Feasibility Study proved that long-term SNF storage in Ukraine was economically sound as compared to fuel transfer to the Russian Federation and justified the construction of one centralized spent fuel storage facility as compared to any other spent fuel storage options.

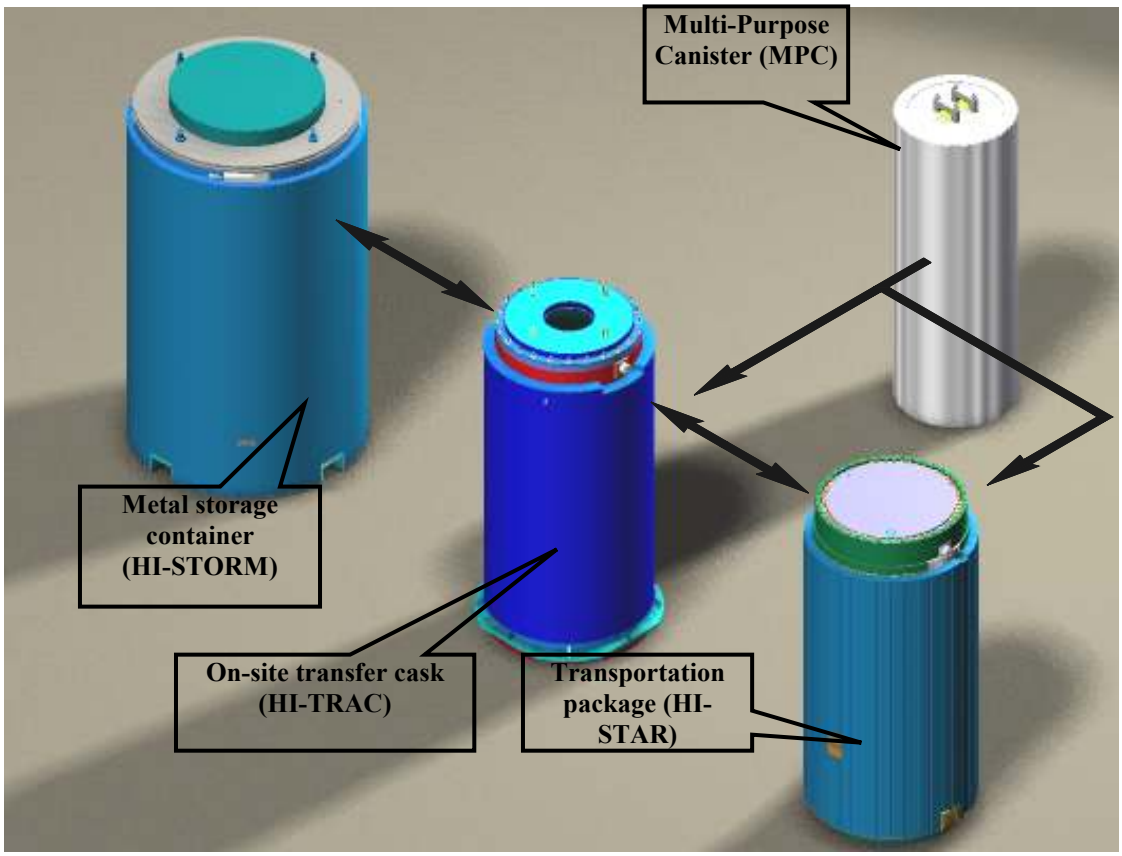


Figure. 5.3.2. CSFSF main equipment

It is planned to store 12,500 WWER-1000 SFAs and WWER-440 4000 SFAs for 100 years in CSFSF.

9 February 2012, Verkhovna Rada of Ukraine made a decision on CSFSF siting in the exclusion zone and its design and construction by adopting Law of Ukraine No. 4383-VI "On Management of Spent Nuclear Fuel in Siting, Design and Construction of Centralized Storage Facility for Spent Nuclear Fuel of National WWER Nuclear Power Plants".

30 March 2012. The SNRIU agreed the "Licensing Plan for CSFSF Construction" developed by Energoatom.

30 April 2013. The SNRIU agreed the Energoatom document "Statement of Work on Upgrading the Technology of Spent Nuclear Fuel Unloading from WWER-1000 (M V-320) for Transfer to CSFSF".

23 April 2014. Cabinet Resolution No. 399-r authorized Energoatom to develop a land utilization project and to allocate lands with a total area of 45.2 ha, located between the former villages of Stara Krasnitsa, Buryakivka, Chistogalivka and Stechanka of the Kyiv region in the exclusion zone affected by the Chornobyl area, to transfer them subsequently to Energoatom for permanent use with change of their purpose for the construction of CSFSF and access railway.

5.3.2. Management of RBMK Spent Nuclear Fuel

The RBMK design envisaged the following sequence of SNF management:

- after operation in the reactor, fuel was to be reloaded into SFPs to be cooled down for at least 1.5 years to reduce radioactivity and decay heat;
- after storage in SFP, RBMK was to be sent for a wet spent fuel storage facility.

As of 1 January 2015, there are 21,284 FAs on the Chornobyl NPP site. Among them:

- 21,231.5 SFAs stored in ISF-1 SFP;
- 32 damaged fuel assemblies stored in unit 1 SFP;
- 20.5 damaged fuel assemblies stored in unit 2 SFP.

ChNPP unit 3 has no SNF and further use of its SFP for SNF is not envisaged. In this connection, on 7 December 2012, the SNRIU agreed the SSE ChNPP decision "On Recognition of Power Unit 3 as Radioactive Waste Management Facility". Therefore, since ChNPP unit 3 has been regarded as a radwaste management facility since 8 December 2012.

There is no fresh nuclear fuel on the ChNPP site.

ISF-1 is operated under SNRIU License EO No. 000859 for operation of the nuclear installation – spent fuel storage facility of 25 June 2008.

Figure. 5.3.3. ChNPP ISF-1

The operating organization SSE Chornobyl NPP currently makes efforts to implement:

- Action Plan to Improve ISF-1 Safety, agreed by the SNRIU on 24 June 2008;
- Action Plan to Improve Safety of SSE ChNPP Nuclear Installations, agreed by the SNRIU on 12 December 2011;
- Action Plan for Stabilization, Transfer and Storage of Special Canisters with Damaged Spent Nuclear Fuel, agreed by the SNRIU on 25 March 2014 (in accordance with this Action Plan, it planned to transfer and store damaged fuel assemblies from unit 1 and 2 SFPs to ISF-1 SFP in 2015).

At the same time, the ISF-1 lifetime determined upon safety review conducted in 2011 expires at the end of 2025. Therefore, a new dry interim storage facility (ISF-2) is under construction to ensure long-term safe storage of all SNF on the ChNPP site.

Figure. 5.3.4. Storage of canisters with spent nuclear fuel in ISF-1

ISF-2 is constructed under SNRIU License EO No. 001002 for construction and commissioning of the nuclear installation (interim spent fuel storage facility (ISF-2)) of 20 February 2013.

The ISF-2 design provides for the following sequence of SNF management:

1. First SNF will get into the facility for spent fuel treatment before storage, where each spent fuel assembly will be cut into two parts (bundles) and each bundle will be placed into a fuel cartridge.

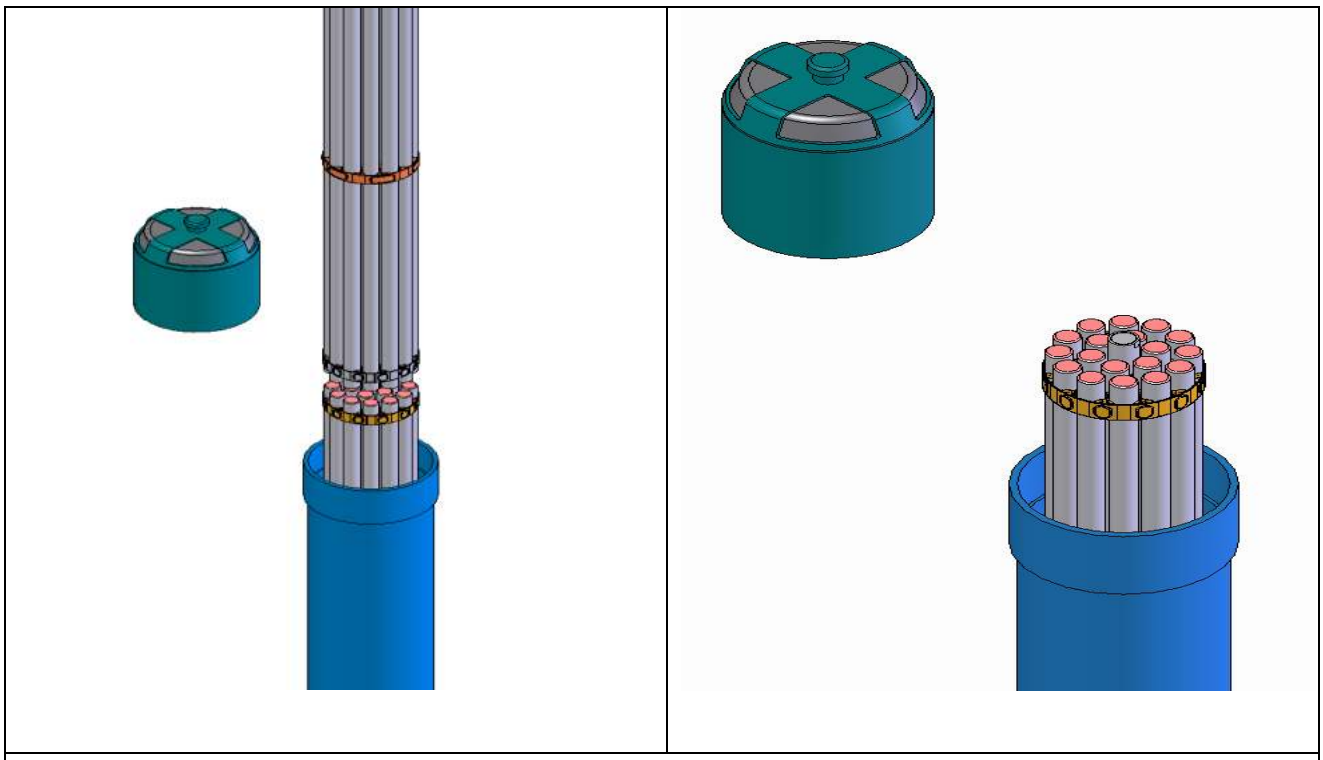


Figure. 5.3.5. Fuel cartridge

2. Then the cartridges will be placed into stainless-steel double-walled dry shielded canisters (DSC), each containing 186 bundles.

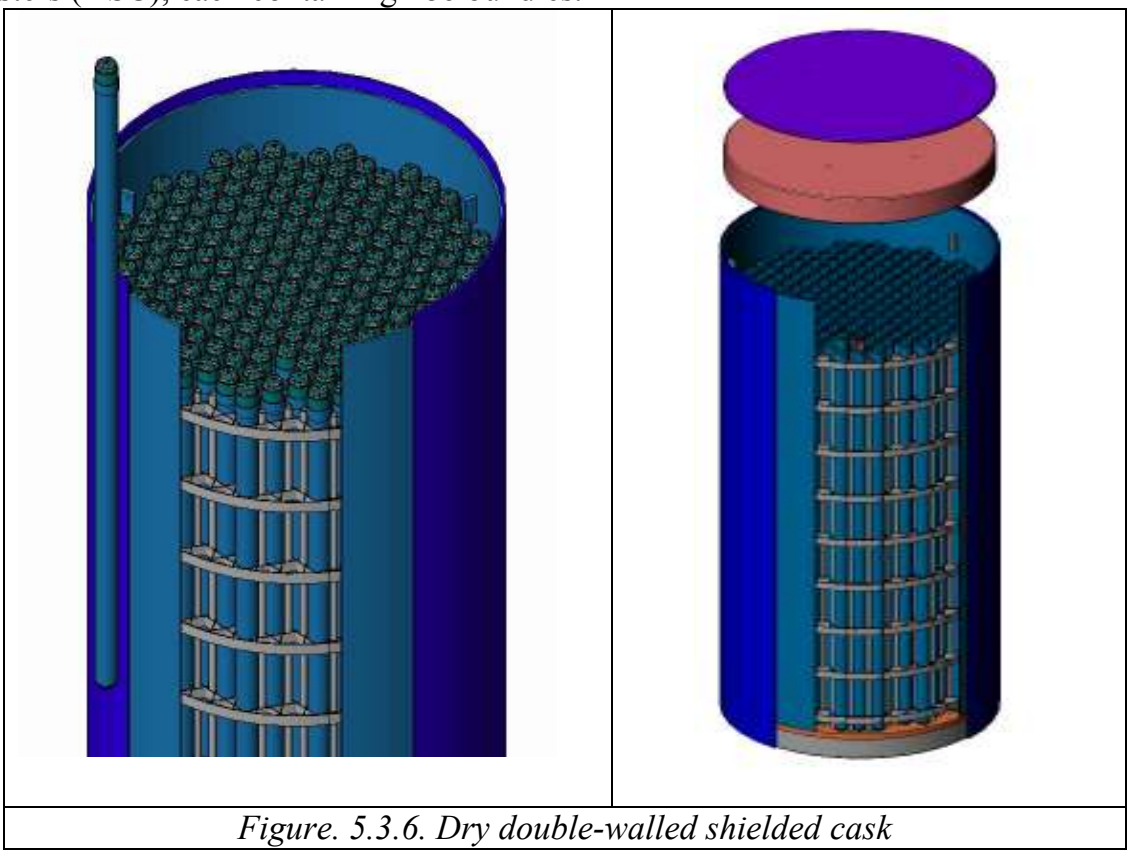


Figure. 5.3.6. Dry double-walled shielded cask

3. After filling with fuel cartridges with SFA bundles, DSCs will be transported to a special facility for complete spent fuel drying and filling of the canister with inert gas helium.

4. After drying, helium filling and integrity check, DSCs with SNF will be sent to the spent fuel storage area, where they will be placed into concrete storage modules (CSMs).

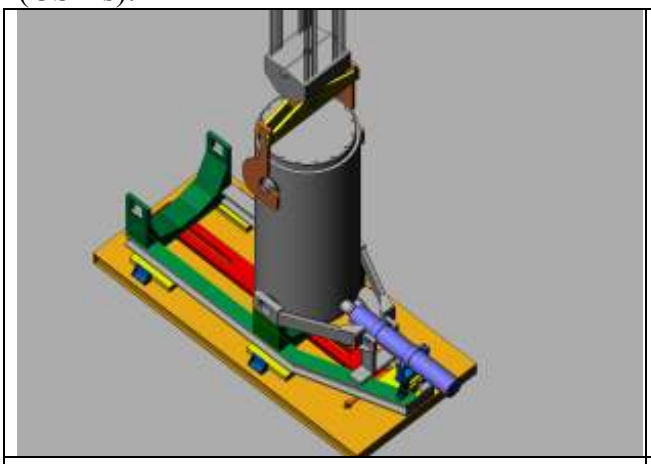


Figure 5.3.7. Placement of dry double-walled shielded canister with spent fuel onto transport carrier for transfer to spent fuel storage area

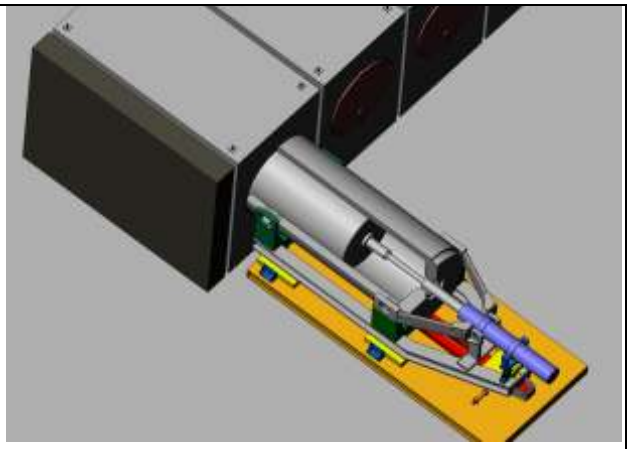


Figure 5.3.8. Placement of dry double-walled shielded canister with spent fuel into concrete storage module

5. DSCs with SNF will be stored in CSMs for 100 years.

Moreover, the ISF-2 design provides for:

- potential removal of DSC form CSM for technical inspection and repacking (if needed);
- equipment for management of damaged SNF.

During 2014, the SSE Chornobyl NPP continued the developed and agreement of a package of technical specifications and design documentation on systems and equipment important to safety. According to the ISF-2 design, it is required to develop:

- 42 technical specifications for equipment important to safety, 27 specifications were preliminary agreed by the SNRIU as of 1 January 2015;
- 7 technical specifications for system important to safety, all of them were preliminary agreed by the SNRIU as of 1 January 2015;
- 49 acceptance inspection programs for equipment and systems, 2 of them were agreed by the SNRIU as of 1 January 2015.

Commissioning of ISF-2 is planned for the fourth quarter of 2016.

6. SAFETY IN MANAGEMENT OF RADIATION SOURCES

Management of radiation sources in each area of national economy has its specifics and requires human protection against ionizing radiation. Radiation protection of people and the environment in use of radiation sources is a priority for state regulation of nuclear and radiation safety.

State safety regulation of radiation sources is exercised by establishing legislative requirements and safety criteria, authorization (licensing of activities with radiation sources and their state registration), supervisory activity and application of enforcement actions if regulations and standards on radiation safety are not met.

For reference. Radiation sources are physical objects, except for nuclear installations, that contain radioactive substances or technical devices that create or can create ionizing radiation in certain conditions.

The SNRIU and State Nuclear and Radiation Safety Inspectorates conduct regulatory control over activities of 4167 entities using radiation sources. Among them, 2481 entities use radiation sources that are not exempt from licensing and have appropriate licenses. The other entities use radiation sources with low potential hazard and ensure only their state registration in the State Register of Radiation Sources as an authorizing procedure established by law.

One of the state regulatory principles is to apply a graded approach to different activities with radiation sources considering their potential hazard, in particular:

1) Radiation sources with low potential hazard are exempt from regulatory control. The levels and procedure for exemption from regulatory control are identified in Cabinet Resolution No. 1174 of 16 November 2011 and SNRIU Order No. 84 of 1 July 2010;

2) Radiation sources with relatively low potential hazard are subject only to state registration (i.e., they are exempt from licensing) according to the procedure approved by Cabinet Resolution No. 1718 of 16 November 2000. The list of radiation sources whose use is exempt from licensing is approved by SNRIU Order No. 138 of 3 December 2013. Criteria applied to exempt radiation sources from licensing are approved by Cabinet Resolution No. 1174 of 16 November 2011;

3) Activities with radiation sources with medium and high potential hazard are mandatory licensed according to the procedure established in the Law of Ukraine “On Authorizing Procedure in Nuclear Energy”.

If radiation source safety is not ensured or safety culture in society does not correspond to the level of potential source hazard, useful properties of ionizing radiation turn out to be harmful consequences of radiological accidents for people.

As of December 2014, 4167 entities use 28,728 radiation sources, including 11,784 radionuclide sources and 16,944 radiation generators.

The highest number of nuclear entities is concentrated in the North part, including Kyiv and Kyiv, Cherkassy, Vinnitsa, Zhitomir and Chernihiv regions. Regarding the entities that use radiation sources, their number is almost 30% higher than in the North Part of Ukraine, such as South-Eastern (Donets, Luhansk and Zaporizhzhya regions) and Eastern (Kharkiv, Sumy and Poltava regions). In the North part and Autonomous Republic of Crimea, a part of their territory being a recreation area of Ukraine, radiation sources are mainly used by medical establishments. Most of these entities are medical establishment applying X-ray apparatus for diagnosis.

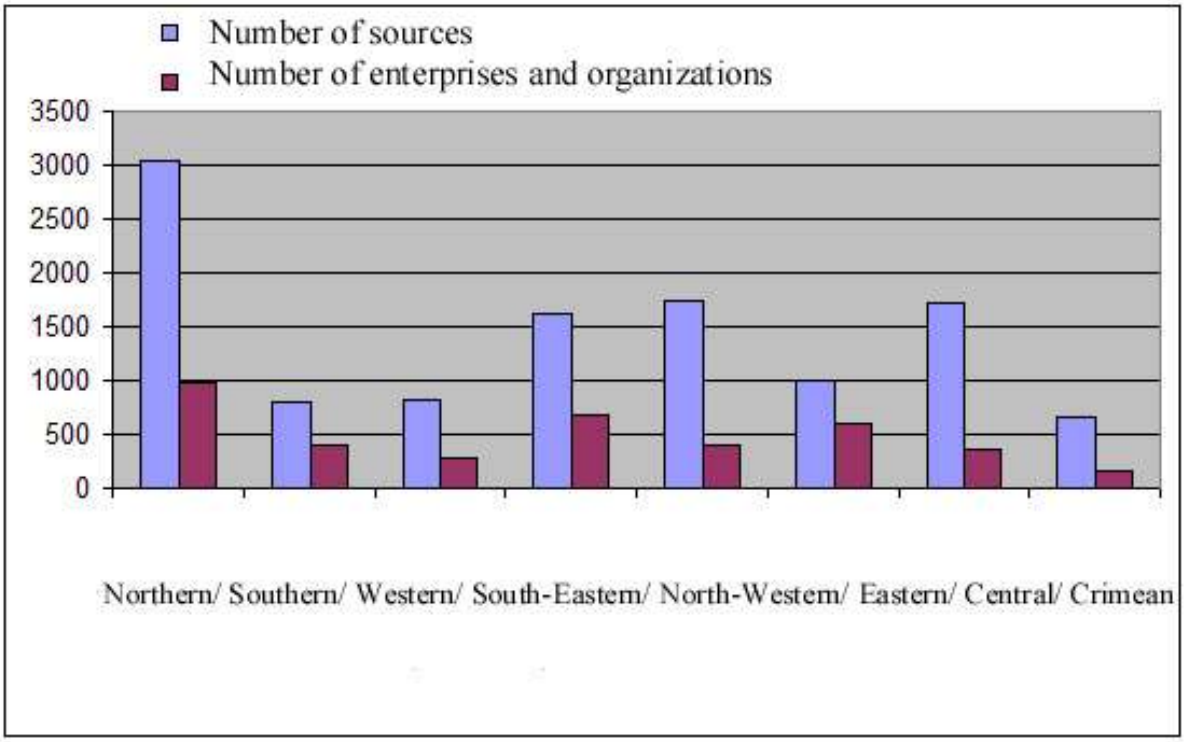


Figure. 6.1. Number of radiation sources

24,582 sources have been registered, including 9,654 radionuclide sources and 14,928 radiation generators.

In 2014: 1237 new sources were registered and 480 sources were reregistered for new owners in the State Register of Radiation Sources; 1005 sources were removed from record (713 sources were transferred to specialized radwaste management enterprises, 11 were transferred from Ukraine and 281 generating device was put out of operation); service life of 1447 sources was extended.

The number of radiation sources registered in regions is shown in the table below:

Location, region	Radionuclide sources, pcs.	Radiation generators, pcs.	Total, pcs.
Northern State Inspectorate	2560	3449	6009
Eastern State Inspectorate	1515	2 332	3847
Central State Inspectorate	1291	1450	2741
South-Eastern State Inspectorate	1602	2526	4128
North-Western State Inspectorate	477	1238	1715
Western State Inspectorate	384	1730	2114
Southern State Inspectorate	1571	1304	2875
Autonomous Republic of Crimea	277	870	1147

Ukraine does not produces radionuclide sources. In 2014, 166 radionuclide sources were imported to Ukraine (30% fewer as compared with 2013). The main producers of radionuclide sources imported to Ukraine in 2014 were enterprises in Poland, Russia,

Belarus, Germany, Netherlands and USA. The following Ukrainian enterprises supplied these radiation sources: *Izotop* Enterprise, Kyiv; *ShimUkraine* Ltd, Kyiv; VATEK Ltd., *Impuls* Foreign-Trade Ltd.; Schlumberger Services Ukraine Ltd., Kyiv; *Khartron* Company, Kharkiv.

The distribution of the main users of radionuclide sources in 2014 was as follows: medical applications – 18.1%; industrial application, customs and other controls – 80.1%; research institutions and other organizations – 1.8%.

As of December 2014, Ukraine uses 2240 sources with a life more than 35 years, including: 23 sources produced in the 1950s and 173 sources produced in the 1960s.

In 2014, open radiation sources based on Tc-99m for medical applications with a total activity of 4151.33 GBq were imported to Ukraine.

For medical institutions of Ukraine, I-131, I-125, P-32, Sr-89 and Sm-153 sources were provided with radio pharmaceuticals with the following total activity:

	2014	**For comparison**	
		2013	**2012**
I-131	1192.138 GBq	2049.08 GBq	1548.0016 GBq
I-125	966.75668 MBq	16,452.246 MBq	1780.082 MBq
P-32	8391.97 MBq	7816.879 MBq	13,003.46 MBq
C-14	-	-	37.00 MBq
H-3	-	9.25 MBq	9.25 MBq
Sr-89	4500 MBq	1050 MBq	8735.00 MBq
Sm-153	198 MBq	24,036 MBq	8020.00 MBq
S-35	-	-	86.00 MBq

In 2014, 193 X-ray units were produced in Ukraine, including: 60 for Ukraine and 133 were transferred aboard.

In 2014, the following equipment was imported to Ukraine: 10 computer tomography systems, 1 mobile surgical system, 1 densitometer, 4 mobile X-ray units, 2 X-ray mammography systems, 8 portable X-ray apparatus, 2 X-ray television introscopes, and other X-ray devices for various purposes for medical institutions.

In addition, 281 generating devices were taken out of service in such a way as to make their recovery impossible.

In 2014, response to 14 radiological accidents and other events associated with loss of control over radiation sources was ensured; in particular, 10 of these events happed in the South-Eastern region:

2 January: at Metallurgical Plant *Azovstal* (Mariupol, Donetsk region), a railroad car with metal scrap that arrived from the Sumy station of the Southern Railway from *Uktrans Consulting* Ltd. (cargo owner was *Poseidon Trade* Ltd., Kyiv) was arrested during acceptance radiological inspection. After radiological inspection, the contaminated fragment was transported to the Donetsk SISP storage for temporary placement. Gamma exposure dose rate at a distance of 0.1 m from the tube was 10.0 μSv/y and specific activity of ^{226}Ra was 4.9×10^4 Bq/kg.

23 January: at the control point at the state border of Ukraine in the Donetsk airport, the regular YANTAR-2P radiological monitoring system actuated in customs control of Istanbul–Donetsk Flight No. 453. After radiological monitoring, the suspicious material was transferred to the Donetsk SISP storage for temporary placement. Specific activity of

^{226}Ra was 2.9x10^{4} Bq/kg and exposure dose rate at a distance of 0.1 m from the radioactive material was up to 3 μSv/y.

12 February: three gamma flow detectors of Gammarid-192/120 type were found during scheduled inspection of the State Enterprise *Skyper*. One of the devices was equipped with a cesium-137 source. The other device and shielded container had no radiation sources. The State Enterprise *Skyper* does not currently work, and the industrial buildings belong to *Mariupolstalkonstruktsiya* Ltd. Information on the inspection was submitted to the Department of the Security Service of Ukraine in Donetsk region and to the Mayor of Donetsk for making an appropriate decision.

18 March: in the town of Vilnyansk in Zaporizhzhya region, radioactive material was revealed in a private house, with signs of smuggling from the Russian Federation to Ukraine.

27 March: at *Hamadey* Tobacco Company (83047, Donetsk, 2-2A Andropov St.), a radioisotope device with a radionuclide source (strontium-90) with activity of 925 MBq was revealed. According to personnel, the device arrived in a parcel with equipment from the Great Britain.

15 April: at Metallurgical Plant *Azovstal* (Mariupol, Donetsk region), railroad car No. 68750918 with metal scrap that arrived from the Akhtyrka station of the Southern Railroad from Energy Industry Ltd. (74 Rivne St., the village of Strumivka, Lutsk district, Volyn region) was arrested during acceptance radiological inspection. After radiological inspection, the contaminated fragment was transferred to the Donetsk SISP storage for temporary placement. Gamma exposure dose rate at a distance of 0.1 m from the tube was 2.5 μSv/y and specific activity of ^{226}Ra was 1.4x10^{4} Bq/kg.

9 May: at Metallurgical Plant *Azovstal* (Mariupol, Donetsk region), railroad car No. 60503174 with metal scrap that arrived from the Khriplin station of the Lviv Railroad was arrested during acceptance radiological inspection. The owner was MEGA-MET Ltd. (Donetsk, 4 Ovtanyan St.). Personnel of the Donetsk SISP removed fragments of metal tubes 168 kg in weight from the metal scrap, contaminated with radioactive material (226Ra isotope).

12 October: at the Mariupol Metallurgical Plant (Mariupol, Donetsk region), railroad car No. 68824002 with metal scrap arrived from the Talalaivka station of Chernigiv region was arrested during acceptance radiological inspection. The carbo owner was METAL-KOM Ltd. (Chernigiv, 27-A Ripkinska St.). Personnel of the Donetsk SISP removed 37 fragments of metal pipes 420 in weight contaminated with radioactive material from the metal scrap. Gamma exposure dose rate inside some fragments was 2.5 μGy/h and beta-particle flux was 300 β-part./min×cm^{2}.

17 October: at Metallurgical Plant *Azovstal* (Mariupol, Donetsk region), railroad car No. 67702514 with metal scrap that arrived from the Kalmius station in Donetsk Railroad was arrested during acceptance radiological inspection. The consignor was ALFAMET Ltd. (Donetsk, 2a Rozdolna St.). Donetsk SISP personnel removed the contaminated fragments.

3 December: at Zaporizhhzya Metallurgical Plant Zaporizhstal (Zaporizhzya), a railroad car with metal scarp arrived from the Shostka station of the Kyiv Railroad was arrested during acceptance radiological inspection. The consignor was *Ukr-Trans-Invest* Ltd. (Kyiv region, Kyiv-Svyatoshin district, the town of Vyshneve). Ferrous metal fragments were removed – 14 tubes with a total weight of 190 kg, contaminated with radioactive material. Gamma exposure dose rate on the surface of tubes was 30.0 μSv/y and beta-particle flux was 220 β-part./min×cm^{2}.

6.1. Management of Radioactive Waste Resulting from Use of Radiation Sources

Same management of radiation sources at the end of their life cycle is an important condition to eliminate the risk of their lost and transfer to places acceptable to the public. Spent radiation sources even after expiration of their service life remain hazardous because they contain radioactive material, which may seriously affect human health in case of its spreading or inadvertent use. Spent radiation sources are transferred to the category of radioactive waste and further managed in compliance with safety requirements for radwaste treatment at state specialized plants of the Ukrainian State Association *Radon*.

There are six interregional specialized plants (SISPs) for radwaste management in Ukraine: Kyiv, Kharkiv, Dnipropetrovsk, Odessa and Donetsk SISPs. The specialized plants deal with collection, transport and safe storage of spent radiation sources and radwaste in devoted facilities for waste container-type storage prior to transfer of spent radiation sources to the centralized facility for long-term storage of spent sources being constructed at the *Vektor* site in the exclusion zone.

At the same time, there are waste storages on sites of the specialized plants that were constructed, commissioned and filled in the Soviet era, without compliance with all safety requirements to be met today. Permanent measures are taken to maintain, keep in safe stage, monitor and control these storages. They are currently regarded as 'historical' ones, and plans and measures for their further liquidation and reclamation are to be based on safety review, taking into account modern international approaches to management of legacy sites. For this purpose, with support of the European Commission, the regulatory body's recommendations "Guideline for Safety Review of Existing Radwaste Storge Facilities and Criteria for Making Decisions on Further Actions at These Facilities" were developed within the Instrument for Nuclear Safety Cooperation (INSC). The specialized plants conduct safety reviews in compliance with the licenses issued by the SNRIU and with account of this Guideline.

Figure 6.1. Storage at Khakriv SISP for radwaste container-type storage

The specialized plants are also involved into actions of competent authorities to mitigate emergencies when orphan radiation sources are found or illicit trafficking of radiation sources is revealed. All these radiation sources are sent to storages of the specialized plants for their safe and monitored storage.

For the entire service period of SISPs, a great quantity of radiation sources and radwaste has been accumulated. The relevant data are provided in Table 6.1.

Table 6.1. Quantities of spent radiation sources and radwaste

Radon SISP	Number of spent radiation sources, psc.	Activity, Bq	Amount of solid radwaste, m^3	Activity, Bq
Donetsk SISP	*220318*	*8.64E+14*	*531*	*7.49E+14*
Kyiv SISP	*93656*	*1.25E+15*	*2094*	*6.04E+15*
Lviv SISP	*96383*	*2.55E+14*	*695*	*6.53E+12*
Odesa SISP	*20134*	*2.61E+16*	*474*	*5.25E+14*
Kharkiv SISP	*109237*	*1.54E+14*	*2070*	*6.8E+12*
TOTAL	***539728***	***2.86E+16***	***5864***	***7.28E+15***

In connection with the counterterrorist operation in the Donetsk region, the Donetsk SISP turned out to be located on the territory that is currently out of Ukrainian control and its operation was terminated by a decision of the control body in the area of radwaste management. Since Donetsk SISP transported only small batches of radwaste to the Kharkiv or Dnipropetrovsk SISPs, no radwaste that could pose a serious threat was located on its territory. At the same time, the plant infrastructure was damaged and will require recovery actions. Until termination of military actions, the function of the Donetsk SISP on the territories under Ukrainian control were transferred to the Dnipropetrovsk SISP.

7. ACTIVITIES IN EXCLUSION ZONE

7.1. Chornobyl NPP Decommissioning

The Chornobyl NPP is decommissioned and associated projects are implemented under License No. 000040, Series EO, issued by the SNRIU on 22 March 2002.

ChNPP is planning to transfer to the next decommissioning stage – final closure and safe storage. In 2014, the SNRIU conducted state nuclear and radiation safety review of the design documentation "Final Closure and Safe Storage of Chornobyl NPP Units 1, 2, 3" as part of the design review. The draft Cabinet Resolution "On Approval of the Construction Design on Final Closure and Safe Storage of Chornobyl NPP Units 1, 2, 3" was agreed. The SNRIU considers the ChNPP application and documentation package submitted to obtain an individual written authorization to proceed with the final closure and safe storage of ChNPP units 1, 2 and 3.

Putting the Chornobyl NPP cooling pond out of operation

The cooling pond is a process water body constructed by creating an artificial dam on the floodplain area of the Prypyat river, separating the cooling pond from the Prypyat river in order to provide the necessary volume of service water for cooling of ChNPP systems in power unit operation. After the 1986 accident, the cooling pond became contaminated. Upon termination of ChNPP operation, water use from the pond substantially reduced.

In 2014, the SNRIU agreed the "Feasibility Study for Putting the Cooling Pond out of Operation".

At the same time, insufficient funding does not allow to put the cooling pond out of operation in the planned scope, and water level decreases because of inoperable makeup pumps. In this connection, the SNRIU imposed conditions for taking measures on radiological monitoring of the cooling pond before it is put out of operation taking into account its actual characteristics.

ChNPP is provided with service water in accordance with the agreed design "Service Water Supply System. Service Water Source (Service Water Pond) with Pump Makeup Station".

Facilities for radwaste management at ChNPP

At the ChNPP site, within international technical assistance projects, a number of radwaste management facilities have been constructed and are being commissioned. Commissioning of these facilities will allow treatment of radwaste that has been accumulated and is being generated to make it suitable for safe storage.

Liquid Radioactive Waste Treatment Plant (LRTP) is designed for treatment of liquid radwaste accumulated in liquid waste storages and in liquid and solid waste storages as well as liquid radwaste to be generated in decommissioning.

The LRTP building and main equipment were constructed even before. However, analysis of the LRTP design carried out in 2009 with involvement of KIEP revealed a number of drawbacks in the design, and appropriate changes and upgrades were introduced.

On 28 March 2014, the SNRIU issued individual authorization No. 000040/5 OD for LRTP commissioning. Upon completion of basic commissioning efforts, individual permit No. 000040/7 OD was issued for LRTP operation on 11 December 2014.

State nuclear and radiation safety reviews were conducted for the Final Safety Analysis Report on LRTP, Technical Specifications on Radioactive Waste Package of the Liquid Radioactive Waste Treatment Plant (200-liter drum), Rev. 2 and a number of other operational documents.

Industrial Complex for Solid Radioactive Waste Management (ICSRM) on the ChNPP site combines a series of radwaste management facilities*. Construction of the ICSRM facilities has been completed, and they are being commissioned.

In order to test and ensure performance of all systems, including equipment for radwaste sorting and characterization, three stages are envisaged for commissioning of the **Solid Radwaste Retrieval Facility** (SRRF) and **Solid Radwaste Treatment Plant** (SRTP): stage 1 – radwaste testing in sealed packages with predetermined characteristics, stage 2 – testing with "open" radwaste with known characteristics, stage 3 – testing of radwaste retrieved from compartments of the solid waste storage facility. The SNRIU issued individual authorization No. 000040/6 for stage 2.

Radwaste will be accepted and placed for storage in compartments of the temporary storage for low- and intermediate-level long-lived and high-level waste after commissioning of the solid radwaste treatment plant.

***Temporary storage facility for low- and intermediate-level long-lived and high-level waste** is designed for intermediate (30 years) storage of long-lived and high-level waste to be generated n sorting at the solid radwaste treatment plant and in preparation for the Shelter New Safe Confinement. This storage facility was created by reconstruction and re-equipment of the room located at upper levels of the ChNPP liquid and solid storage which has not been in operation to date;*

***SRRF** – facility for retrieval of solid radwaste from the existing ChNPP solid waste storage and transfer of waste for treatment to SRTP;*

***SRTP** – solid radwaste treatment plant for sorting of solid waste of all categories and treatment (fragmentation, incineration, pressing, cementation) of low- and intermediate-level short-lived solid waste retrieved from the solid radwaste storage and waste resulting from ChNPP decommissioning and Shelter transformation into an environmentally safe system. SRTP also envisages packing of long-lived and high-level waste that will result from sorting and transport of these packages to temporary storage.*

Modernization of production facilities for cutting of long waste

Under the TACIS project for modernization of production facilities for cutting of long waste at the Chornobyl NPP, construction of a facility was started for cutting long waste removed from reactor rooms during decommissioning of ChNPP units 1, 2 and 3 according to the agreed working design. The facility is to be assembled at unit 2 and then moved to units 1 and 3. The main function of the facility is fragmentation (cutting) of long elements of the reactor core with expired life. The long elements are peculiar in that they are from 6 to 22 m in length and 145 mm in diameter, which requires special equipment and management technologies in power unit decommissioning.

In 2014, the project was terminated as the AMEC company, project performer, stopped its activities. The Licensing Plan for the project on modernization of production facilities for cutting of long waste is not complied with. Further prospects for implementation of the project as well as schedule for commissioning of the facility will depend on a decision of the European Commission regarding allocation of additional funding to complete the effort.

Design and research have been started for creation of **additional facilities** for ChNPP radwaste management:

- facility for removal of organics and transuranium elements from Shelter liquid radwaste;

- sections for sorting, fragmentation and decontamination of dismantled structures and equipment;

- facility for removal of dismantled materials from regulatory control.

For further development of the radwaste management system for ChNPP decommissioning, ChNPP developed the "Feasibility Study for Justification of Creation and Siting of Additional Facilities for Management of Radioactive Waste and Radioactive Material in 2014 and submitted it to the regulatory authorities for review.

Existing radwaste management facilities

Radioactive waste accumulated during Chornobyl NPP decommissioning, mitigation of the 1986 accident and waste generated in decommissioning of units 1, 2 and 3 and Shelter transformation into an environmentally safe system are stored in existing radwaste storages on the ChNPP site, such as solid waste storage and liquid and solid waste storage, or are transferred for disposal to *Buryakivka* RWDS.

The liquid waste storage system consists of the following storages interconnected with special piping for liquid waste pumping:

- liquid radwaste storage designed for 26,000 m^3, including five reception tanks for 5000 m^3 and two reception tanks for 500 m^3 made of corrosion-resistance steel;
- liquid and storage radwaste storage, which is operated only for liquid waste storage and is designed for 12,000 $м^3$, including 12 reception tanks for 1000 m^3, made of corrosion-resistance steel;
- storage for spent radioactive oil, consisting of two tanks for 72 m^3 each.

During 2014, 22.06 m^3 of liquid waste generated and was sent for storage at ChNPP including: 12.5 m^3 of evaporation bottoms; 3.66 m^3 of spent ion-exchange resins; 5.90 m^3 of pearlite pulp. As a total, 13,504.70 m^3 of evaporation bottoms, 4,082.36 m^3 of spent ion-exchange resins, 2290.03 m^3 of pearlite pump and 144.75 m^3 of contaminated oil-fuel mixture were accumulated in the liquid waste storages at the end of 2014.

Low- and intermediate-level solid waste generated during decommissioning and Shelter transformation into an environmentally safe system is transferred for disposal to *Buryakivka* RWDS. During 2014, 4146.40 m^3 (5805.40 t) of low-level waste and 13.80 m^3 (15.50 t) of intermediate-level waste were transferred to *Buryakivka* RWDS.

High-level waste is collected into special containers (KTZV-0.2) and placed into the temporary storage for solid high-level waste arranged in the former fresh nuclear fuel storage building. During 2014, 0.03 m^3 (0.012 t) of solid high-level waste generated and was transferred for storage. As a total, this storage houses 3.783 m^3 of high-level and long-lived waste, with activity of 8.59 TBq.

7.2. Construction of Shelter New Safe Confinement

According to the Sate Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System, approved by Law of Ukraine No. 886-VI of 15 January 2009, measures taken at the Shelter are qualified as its transformation into an environmentally safe system.

The Shelter is transformed through successive development and implementation of individual plans, projects and program. The most comprehensive among them is the Shelter Implementation Plan (SIP), international technical assistance project.

The main SIP design is creation of the new safe confinement for the Shelter (NSC).

The confinement is a protective structure including process equipment for retrieval of fuel-containing materials from the destroyed ChNPP unit 4, radwaste management and other systems and is intended to transform this unit into an environmentally safe system and ensure the safety of personnel, the public and the environment.

The confinement represents an arch structure with operating period of 100 years.

The NSC project is divided into two startup complexes (SC):

- NSC SC-1 - protective structure with process life support systems and necessary infrastructure;
- NSC SC-2 – infrastructure for dismantling of unstable Shelter structures.

NSC SC-1 is currently under implementation and NSC SC-2 design decisions are under development.

The contractor for design, construction and commissioning of NSC SC-1 is the French Consortium Novarka including VINCI Construction Grands Projets and Bouygues Travaux Publics. Other foreign companies and Ukrainian design, scientific and construction organizations are involved as subcontractors.

Consortium Novarka implements NSC SC-1 through individual projects combined in 6 licensing packages (LP). Preparatory work under projects developed within licensing packages LP1-LP4 have been completed. Licensing package LP4 – dismantling of ventilation stack VT-2 – was removed from the scope of Novarka activities and implemented by Corporation *Ukrtransbud*.

The main physical efforts are implemented within the following licensing packages:

- LP-5: Project – the main structure and systems of the main cranes;
- LP-6: Project – protective structure with process life support systems and necessary infrastructure.

  Authorizations to proceed with the above licensing packages were issued by the SNRIU to SSE ChNPP on 18 November 2011 (for LP-5) and 22 April 2013 (for LP-6) after nuclear and radiation safety review of the design documentation.

For reference. The NSC arc is assembled on a dedicated site to the west of the Shelter (at a distance more than 200 m) to reduce negative effect from the Shelter on personnel during work. The site is a free-access area.

According to the design, the eastern part of the arc was moved to the holding area after mounting; after completion of assembling, the two parts will be combined. Then the combined NSC arc will be moved and installed into the design position above the Shelter.

Successful lifting (jacking) of the eastern part of the arc in three stages was important for NSC SC-1 construction during 2012-2013:

- first lifting at a height about 53 m in November 2012;

- second lifting to a level of 85 m in June 2013;

- third jacking to a level of 109 m took several steps and was completed in Ocrober 2013.

During 2014, the following important efforts on NSC were completed at ChNPP in accordance with the documents agreed by the SNRIU:

- in a period from 31 March to 2 April 2014, the NSC eastern part was successfully moved to the holding area – the structure with a total weight of ≈ 12.6 thousand tons was moved for 72 h by 112 m toward the Shelter;
- in May, August and November 2014, the first, second and third (last) lifting of the NSC western part was done;
- at the end of November 2014, the NSC eastern part was moved back to the western part; the distance between the edges of metal structures of both arc parts is 1.35 m.

In the reporting period, ChNPP installed metal structures of the western part of the arc, mounted ventilation system air ducts, arranged external and internal cladding of NSC

arc, took efforts on construction of a process building and auxiliary structures, installed electric devices, access gateways for fire brigades, etc.

In 2014, SNRIU performed safety assessment of documents in the framework of regulatory assistance to construction of the NSC first startup complex of the Shelter (NSC SC-1):

- review of nuclear and radiation safety of updated safety assessment reports for the first startup complex of the New Safe Confinement and new ventilation pipe of ChNPP Stage 2 (NVP);
- technical assessment and regulatory decisions on seven projects for taking activities and three packages of operating documentation related to NSC construction;
- review and agreed terms of reference for the development of the NSC integrated management system.

Regarding the sidewalls of NSC, they will consist of existing and newly built structures. Strengthening and sealing of existing building structures that perform the function of NSC protective circuit are not included into the scope of the Consortium Novarca.

Developing of the project on strengthening of existing structures is financed from the Chornobyl Shelter Fund (CSF). The efforts on the project development are completed. The project developer is KSK Consortium (Kyiv Institute *Energoproject*, Research Construction Institute, NPP Operation Support Institute).

At the end of 2014, SNRIU completed review of the working project "Reconstruction of ChNPP Stage 2 Main Building (Units 3 and 4) with Strengthening and Sealing of Building Structures Functioning as NSC Protective Circuit" and acknowledged the project to be in general compliance with nuclear and radiation safety requirements.

On 31 March 2014, the expert report of the *Derzhbudekspertiza* for this project has been issued.

On 4 September 2014, SNRIU issued an individual permit of series OD No. 000033/9 to perform activities on strengthening and sealing of existing building structures in the framework of ChNPP Stage 2, since they function as a protective circuit of the New Safe Confinement.

As it is highlighted at the meetings of CSF Donor-Countries Assembly, physical activities on strengthening of existing structures have to be done at the expense of Ukraine. Timely financial support is needed to avoid delays in NSC project.

On 15 May 2014, the Verkhovna Rada of Ukraine ratified the Agreement on Increasing Contribution to the Chornobyl Shelter Fund (CSF). Ukraine confirmed its readiness to make an additional contribution to CSF in the amount of 63.4 million USD.

It is envisaged that these funds will be primarily forwarded to implementation of the above project.

In preparation for implementation of the NSC second startup complex, namely development of infrastructure for dismantling of unstable structures of the Shelter, ChNPP report on reassessment of the Shelter unstable structures to be early dismantled has been reviewed and provided with comments. Besides, two methodologies developed for implementation of the stated report have been developed.

7.3. Radioactive Waste Management Facilities in Exclusion Zone

The Chornobyl exclusion zone is the territory of Ukraine contaminated by radionuclides after the Chornobyl disaster and from which the population was evacuated during the first years after the accident.

At present, the exclusion zone is an important part of the whole branch of nuclear energy use in Ukraine. According to national strategic and program documents, key components of the infrastructure for ensuring the final stage of activities in nuclear energy use, radwaste and SNF management, safe storage and disposal, are planned to be created in the territory of the exclusion zone.

Creating of such an infrastructure is a condition without which it is impossible to ensure energy security of the state, further improvement of national nuclear and energy sector, use radiation technologies in the economy, science and medicine, meet international principles of ensuring safety and security commitments under the Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Safety of the final stage of activities in nuclear energy use is the priority in European countries, USA, Canada and other countries using radiation and nuclear technologies.

Information on existing and newly built spent nuclear fuel management facilities in the territory of the exclusion zone is presented in Section 5 “Nuclear Fuel Management”.

Creation of a set of radioactive waste management facilities in the exclusion zone in the framework of improving radioactive waste management system of Ukraine includes:

- radioactive waste management facilities at the Vektor site, which have to ensure final stage of radwaste management (centralized disposal and long-term storage) of all Ukrainian producers, and processing of some types of radioactive waste of the exclusion zone and small producers;
- radioactive waste management facilities at ChNPP site;
- siting of the geological repository.

Besides, there are urgent safety issues related to facilities intended for management of emergency Chornobyl origin radwaste generated during the first years of ChNPP accident elimination, and which became elements of system for treatment with large volumes of emergency radwaste. These facilities still to some extent provide confinement and isolation of radwaste from spreading into the environment. However, they require implementation of measures on maintenance, stabilization, safety improvement, monitoring, survey, remediation, safety reassessment.

Vektor Complex

The Vektor site is located in the territory of the exclusion zone at a distance of 11 km in the south-western direction from Chornobyl NPP. The Vektor complex is a set of facilities for decontamination, transport, processing and disposal of radioactive waste. Construction of the complex started in March 1998.

State Specialized Enterprise "Centralized Radioactive Waste Management Enterprise" (SSE CRME) is the operating organization (operator) of the radioactive waste management facilities of the Vektor complex.

Vektor Stage 1 is aimed at disposal of radioactive waste resulting from ChNPP accident. Stage 1 startup complex includes disposal facility for radwaste in reinforced concrete containers (**SRW-1**) and module disposal facility for unpacked and large radioactive waste in bulk (**SRW-2**) with the general capacity of 19 200 m^3 and required infrastructure.

Construction of near-surface disposal facilities of two types: **SRW-1** for radwaste disposal in metal-concrete containers, **SRW-2** for disposal of unpackaged and bulky radwaste with general capacity of 19 200 m^3, as well as equipping the required infrastructure, which ensures operation of the facility, is in progress. Unfortunately, completion of the construction was significantly delayed, all the facilities under construction since 1995 were at the final construction stage already in 2010 (preparedness is more than 90%). However, in the last four years, activities within this uncompleted construction were not conducted at all. The issue on SRW-1, SRW-2 safety assessment using current methodologies is not solved. This shows significant drawbacks in the radwaste management system. At the same time, in the situation when almost all the capacities of *Buryakivka* RWDS are exhausted the absence of new disposal facilities for low-level radwaste can result in blocking activities on ChNPP decommissioning, at the Shelter, in the exclusion zone. Capacities of Ukrainian NPPs for radwaste disposal are not developed.

Figure 7.3.1. Vektor site: near-surface radwaste disposal facilities (SRW-2, SRW-1, ENSDF) and infrastructure

Engineered near-surface disposal facility (ENSDF) with the capacity of 50 210 m^3 for disposal of ChNPP radwaste packages is already operated at Vektor site. The disposal facility consists of two parallel sections each having 11 metal-concrete compartments (modules). The facility is equipped with the central drainage gallery, two movable framed structures with traveling cranes to fill modules, radiation control and environment monitoring system.

Placement of radwaste packages from ChNPP liquid radwaste treatment plant in ENSDF started on 26 April 2014.

Possibility to accept radwaste packages in ENSDF from other suppliers (except ChNPP), in particular, Rivne NPP, Kharkiv SISP is under analysis. The SNRIU agreed relevant Technical Decisions and Acceptance Criteria.

It is planned to perform safety review taking into account practical experience gained during operation and radwaste package characteristics.

Figure 7.3.2. Loading of the first radwaste package lot in ENSDF

In compliance with the feasibility study for Vektor Stage 2 approved by Resolution of the Cabinet No. 1605-r dated 23 December 2009, Vektor Stage 2 envisages constructing a complex of radwaste management facilities:

– storage facilities for high-level and long-lived radwaste including facilities for long-term storage of vitrified waste returning from the Russian Federation after processing of SNF from Ukrainian NPPs;

– centralized facility for long-term storage of spent high-level radiation sources;

– centralized near-surface disposal facilities for radwaste generated during operation of Ukrainian NPPs and accumulated at Radon sites;

– treatment plants for radwaste from ChNPP and Radon sites.

Under assistance of the UK Department of Energy and Climate Change, draft project on construction of centralized long-term storage facility for spent radiation sources **(CLTSF)** is actively implemented. This facility currently has no analogues in the world and is a key element to improve the entire system of spent radiation source management in Ukraine. It should ensure centralized location for more than 500000 pcs. of spent radiation sources of different types and structures, which are now accumulated at Radon sites, as well as after use in medicine, science and industry.

Figure 7.3.3. Centralized long-term storage facility for spent high-level radiation sources

The main CLTSF systems ensuring the cycle on spent source processing (acceptance, sorting, and conditioning), location for long-term storage, and facility operation safety include: hot cells, glove box, encapsulation system, storage sections, radiation monitoring system, ventilation system. The SNRIU agreed technical documentation for components and equipment of these most important systems that confirms high safety standards of their production and functioning. In 2014, construction and mounting activities at the facility were completed; testing and adjustment of the systems were initiated. CLTSF commissioning should be terminated in 2015.

Designing of **long-term radwaste storage facilities** was initiated (with the storage term of over 30 years).

"Feasibility Study of Investment for Interim Storage of Vitrified High-Level Radwaste Returning from the Russian Federation after Processing of Spent Nuclear Fuel from Ukrainian NPPs" for WWER-440 SNF is developed. The SNRIU presented positive conclusion of the feasibility study state review and agreed Draft Resolution of the Cabinet on its approval. The following design stage is development and approval of the disposal facility design. Return of vitrified high-level radwaste to Ukraine is expected in 2018.

Within the projects of the Instrument for Nuclear Safety Cooperation (INSC), it is planned to design long-term storage facilities for high-level and long-lived radwaste before their disposal in geological repository. Generation of such radwaste is expected during removal of radwaste and fuel containing materials from the Shelter, ChNPP decommissioning, operation and decommissioning of other nuclear facilities.

Besides, within INSC, it is planned to design a comprehensive processing facility for radwaste from ChNPP and minor manufacturers, which comprises, in particular, incineration, pressing, and cementation installations.

Radwaste management facilities within exclusion zone territory

The facilities for disposal and confinement of the great amount of radwaste resulted from ChNPP accident were arranged starting from 1986 up to 1987 at implementation of the urgent measures on ChNPP accident elimination. These are the following radwaste disposal sites - *Buryakivka* RWDS, *Pidlisny* RWDS, ChNPP Stage 3 RWDS and radwaste interim confinement points (RICP).

The Ukrainian State Corporation Radon - national operating organization (Operator) for radwaste management at the stage of radwaste long-term storage and disposal - carries out operation of these facilities and implementation of safety support measures considering conditions of licenses issued by the SNRIU, certain permissions, approved designs and technical decisions.

***Buryakivka* RWDS** is under operation since 1987. *Buryakivka* RWDS consists of 30 near-surface radwaste disposal facilities (trenches). The specially arranged clay shield of 1 miter thickness is the main engineered barrier that ensures confinement of radionuclides. Starting from the beginning of *Buryakivka* RWDS operation the total

amount of ChNPP origin radwaste disposed in *Buryakivka* RWDS disposal facilities (trenches) makes approximately 683.1 thousands of m^3 of radwaste with total activity of $2.54x10^{15}$ Bq.

Buryakivka RWDS is one of the main elements of radwaste management system, designed for the management of the great amount of the radwaste resulted from ChNPP accident, constructed in the framework of implementation of urgent accident elimination measures. Up to now, the operation of this RWDS disposal facilities ensures disposal of the great amount of low-level radwaste generated as a result of works at ChNPP site and as a result of activity at contaminated territories of the exclusion zone. The current capacity of *Buryakivka* RWDS is almost exhausted, in 2014 the last of 30 disposal facilities was filled up.

The *Buryakivka* RWDS safety reassessment was carried out in 2013-2014 with the assistance of the European Commission in order to take possible decisions on its reconstruction (extension) and on corresponding nuclear and radiation safety review. In this direction the vital is to intensify efforts on the development and making of certain design decisions considering the requirements for this facility safety ensuring in the long-term perspective – 500 years and more, and for its location in the exclusion zone.

Besides, the specially equipped *Buryakivka* RWDS site includes technical equipment used at ChNPP accident elimination. In 2014, Radon performed dismantling, fragmentation and release from the regulatory control of this technical equipment in compliance with technical decisions approved by the SNRIU.

The *Pidlisny* RWDS* and ChNPP Stage 3 RWDS ** undergo maintenance and safety improvement. The radwaste resulted from ChNPP accident, disposed at these facilities, were classified as high-level long-lived radwaste that should be disposed in geological repository. Therefore, these RWDS are not considered as disposal facilities. It is necessary to ensure stabilization, degradation protection and confining functions of existing engineered barriers up to the moment when it will be possible to withdraw and redispose the radwaste in geological repository.

With this purpose, the agreed project "Closure of *Pidlisny* RWDS disposal facilities" was implemented in 2011-2012, also the service cover over modules, new banking, water removal system were constructed and 8 additional inspection wells were arranged.

At the same time, the implementation of the agreed project "Closure of ChNPP Stage 3 RWDS disposal facilities", that envisages construction of additional engineered barriers (new multilayer protection shield over existing modules with radwaste), of upgraded drain system and monitoring system and improvement of the facility infrastructure (access and drive ways, physical protection system, etc.), was stopped due to the lack of financing.

The additional survey and development of RWDS safety reassessment methodology were started in the framework of INSC and with the assistance of the European Commission in order to substantiate RWDS safety margin considering stabilization and safety improvement measures.

** Pidlisny RWDS was constructed in the framework of implementation of the urgent measures on ChNPP accident elimination. In 1986-1988 Modules A-1, B-1 of this RWDS contained the most hazardous high-level and long-lived radwaste resulted from the accident (fuel containing materials, radioactive graphite, etc., that were released from the reactor in the process of accident).*

*** ChNPP Stage 3 RWDS was arranged in the framework of implementation of the urgent measures on ChNPP accident elimination in partially constructed solid radwaste storage facility of unfinished ChNPP Stage III. In 1986-1988, the reinforced concrete modules of this facility contained low and intermediate-level radwaste resulted from the accident. Through the years appears the degradation of the upper banking, arranged in hurry, what requires constant maintenance.*

The works on survey of RICP*** area in the exclusion zone are carried out, also the trenches and pits are maintained in the safe state. The works on survey of RICP area with the use of Mobile Laboratory Complex, works on safety assessment and rehabilitation of these areas started in 2014 with the assistance of the European Commission in the framework of INSC. The survey and safety assessment goal is to find and clarify the location of trenches and pit with radwaste, to clarify composition and activity of the radwaste, to take decisions on dismantling (or preservation) of trenches and on subsequent rehabilitation of the territory.

The works on withdrawal and redisposal of the radwaste from RICP trenches and pits, that can have most negative effect on personnel of the exclusion zone and environment, are carried out. For the period of 2012, 8342,8 m^3 of the radwaste with total activity of 0,67 TBq were transferred for disposal in *Buryakivka* RWDS from of *Nova Budbasa* RICP trenches and pits located at construction site of ISF-2 and NSC, and also from *Naftobasa* RICP characterized with seasonal flooding.

*** *RICP (radwaste interim confinement points) – territories adjacent to ChNPP with total area of about 10 ha at which, in the framework of implementation of urgent measures on elimination of ChNPP accident, the trenches and pits for radwaste confinement were arranged. In general, such radwaste represent building structures, household stuff, top soil, etc., contaminated, as a result of the emergency release.*

Nine RICPs are located at the territory of the exclusion zone: "Yanov Station", "Naftobasa", "Pischane Plato", "Rudyy Lis", "Stara Budbasa", "Nova Budbasa", "Pripyat", "Kopachi", "Chistohalivka" with total area of about 10 ha which territory include trenches and pit with radwaste. The assessed quantity of RICP trenches and pits makes from 800 up to 1000, the exact location places of some of them should be clarified.

8. INTERNATIONAL ACTIVITY

SNRIU international cooperation is an integral part of developing the national system of nuclear and radiation safety regulation to achieve world standards on nuclear and radiation safety in Ukraine.

SNRIU implements a range of intergovernmental and interdepartmental agreements in the sphere of nuclear and radiation safety with both world's leading countries operating NPPs, and countries, which recently started the implementation of nuclear energy programs.

During many years of activity of the Ukrainian regulatory body, an efficient partnership has been developed with the regulatory authorities of the United States, Germany, France, Finland, Sweden, and cooperation with Norway is under development.

Multilateral treaty mechanisms and tools in which Ukraine is engaged, including its membership in the international organizations, are of great importance among the variety of areas of the international cooperation.

The world's leading organization aimed at achieving the widest nuclear energy use for peaceful purposes in the countries of the world is the International Atomic Energy Agency (IAEA). The IAEA is an international intergovernmental organization of the UN system. Ukraine is a state-founder of the IAEA and supports the Agency since its founding in 1957. Ukraine shares the statutory objectives of the Agency and supports the IAEA to ensure nuclear energy use for peaceful purposes.

Ukraine is a party of important international tools of the Agency such as the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, the Convention on Assistance in Case of Nuclear or Radiological Emergency, the Convention on Early Notification of a Nuclear Accident, the Convention on Physical Protection of Nuclear Materials, and Vienna Convention on Civil Liability for Nuclear Damage, etc.

Thus, under the Convention on Nuclear Safety, the Sixth Review Meeting of member countries has been carried out from March 24 to April 4, 2014 in Vienna (the Republic of Austria) aimed at reviewing the national reports on obligations under this Convention. The National Report of Ukraine prepared by SNRIU jointly with the Ministry of Energy and Coal Industry of Ukraine, the State Agency of Ukraine for Exclusion Zone Management, and *Energoatom* was presented during the meeting. Resulting from the Report, a number of comments was made for Ukraine to be considered during the next review cycle; the results of their consideration should be reported during the Seventh Review Meeting.

On May 12-13, 2014, in the city of Vienna (the Republic of Austria), the second extraordinary meeting of the member countries of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (hereinafter - the Joint Convention) was held, and on May 14-15, 2014, the first inception meeting on preparation to the Fifth Meeting on obligations under the Joint Convention was carried out. The objective of this extraordinary meeting was consideration of amendments to the Rules of the Procedure and Financial Rules of the Joint Convention (INFCIRC/602/Rev.4), Guidelines on the Review Process, and Guidelines on Form and Structure of the National Reports (INFCIRC/603/Rev.5 and INFCIRC /604/Rev.2 respectively). Within the Fifth Review Cycle of the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, the State Nuclear Regulatory Inspectorate of Ukraine jointly with the State Agency of Ukraine for

Exclusion Zone Management, Chornobyl NPP, and *Energoatom* prepared the Fifth National Report of Ukraine on the implementation of obligations under the Joint Convention, which was posted on the closed web portal of the Joint Convention.

In 2014, continued fruitful cooperation of SNRIU with the IAEA Secretariat related to implementation of the National Projects of the Technical Cooperation Program for 2014-2015 was provided. In 2014, four new project proposals for the cooperation projects for the period of 2016-2017 were developed and submitted to the IAEA. These new projects are aimed at strengthening of regulatory capabilities in the sphere of the state review, ChNPP decommissioning, radioactive waste management, establishment of the National Center of Biological Dosimetry, etc.

In response to temporary annexation of the territory of the Autonomous Republic of Crimea by the Russian Federation, and under the Resolution of the UN General Assembly of 27 March 2014 "The territorial Integrity of Ukraine" (A/Res/68/262), the SNRIU worked out a package of proposals on amending the existing international conventions and agreements such as the Agreement between Ukraine and the International Atomic Energy Agency on Safeguards related to the Treaty on the Non-Proliferation of Nuclear Weapons, the Convention on Physical Protection of Nuclear Material and Nuclear Facilities, and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. The proposals were sent through official channels for consideration to the IAEA management.

Figure 8.1. Report of Serhii Bozhko, SNRIU Chairman, at the 58th IAEA General Conference

During the 58th IAEA General Conference held on 22-26 September 2014 in Vienna (Austria), SNRIU Chairman had a number of officials meetings with IAEA Director General Yukiya Amano and Deputies of IAEA Director General, official delegates of European countries and USA to support Ukraine in proposed amendments to international documents.

During the Hague Nuclear Security Summit in 2014, Sweden and Norway stated that they were going to initiate trilateral cooperation in Ukraine in the field of nuclear safety and security as a response to new challenges posed not only before Ukraine but also world community. The Initiative was developed in 2014 through a number of high-level meetings, which resulted in agreement of four projects intended to ensure safety and security of Ukrainian NPPs, upgrades of the physical protection system and other NPP infrastructure, enhancement of regulatory supervision and control of nuclear safety and security, enhancement of inspection capabilities and improvement of legislation. Under the trilateral initiative, the trilateral statement of cooperation in the field of nuclear safety was signed between Ukraine, Norway and Sweden on 18 November 2014 in Kyiv (during visit of the Prime Minister of Norway, E. Solberg). The parties agreed to report on the implementation of joint projects during the next Nuclear Security Summit in the USA in 2016.

Figure 8.2. Signature of trilateral statement of cooperation in the field of nuclear safety and security between Ukraine, Norway and Sweden

In 2014, SNRIU initiated cooperation with the Norwegian Radiation Protection Agency (NRPA). Thus, Draft Agreement between SNRIU and NRPA on cooperation in the field of nuclear and radiation safety was agreed during the first consultations in October 2014 in Oslo. This Agreement was signed during the visit of Prime Minister of the Kingdom of Norway E.Solberg to Ukraine on 18 November 2014. At the same time three projects of cooperation for 2015-2016 were agreed by SNRIU and NRPA based on the meeting results. They envisage development of regulatory requirements for radioactive waste management safety before disposal and during final disposal, support to SNRCU in developing regulations on radiation protection in medicine and enhancement of the institutional control over uranium mining and processing facilities.

The program of bilateral cooperation with the Swedish Radiation Safety Authority (SSM) in 2014 included successful implementation of joint bilateral projects aimed at improving the regulatory framework for long-term operation of Ukrainian NPP units, supporting development of SNRIU information technologies, in particular development of website on nuclear safety and non-proliferation Uatom.org., supporting the system for accounting and control of nuclear material. In September and November 2014, SSM arranged two training courses in the George Kuzmycz Training Center within the personnel development program for SNRIU inspectors on physical protection of nuclear facilities, nuclear material and other radiation sources.

In 2014, cooperation with the United States became more active. A number of meetings with the management of the US Nuclear Regulatory Commission, US Department of Energy and State Department was held during the visit of SNRIU delegation to the USA in July. The US party expressed its full support to Ukraine and agreed a number of project proposals of SNRIU on cooperation. Thus, during the meeting in Kiev in December 2014, US NRC confirmed allocation of additional assistance to implement four new projects, among which the most important is to provide support to SNRIU in moving the state inspectors of the South-Eastern Inspection from Donetsk and Lugansk to Zaporizhzhya.

Figure 8.8. At the meeting between U.S. NRC and SNRIU Chairpersons

In 2014, the project on cooperation with the US Department of Energy was intensively implemented. It was aimed at improving security of radiation sources in Ukraine. Under the project for SNRIU, activities on establishing the main monitoring center to observe security in using radiation sources in medical institutions of Ukraine were performed.

International non-governmental organizations and associations achieve a special authority in implementing the international cooperation on nuclear and radiation safety. WENRA (Western European Nuclear Regulators Association) goes ahead among the leading European non-governmental organizations. It was established in 1999 on a voluntary basis by the regulatory bodies of EU Member States and Switzerland to develop common standards of nuclear and radiation safety in EU and establish assessment criteria of the regulatory sphere in the countries planning to join EU. Since 2009, Ukraine is an associate member of WENRA.

WENRA was founded in 1999 as an association of senior management (heads) of the Western European regulatory authorities of the countries having at least one nuclear facility under construction, operation or decommissioning. In 2003, the list of WENRA member states was extended due to membership of new countries in the European Union.

Today, WENRA Association includes: Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Lithuania, Netherlands, Romania, Slovenia, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom. Ukraine, Austria, Norway, Poland, and the Russian Federation are included to WENRA Association as observer countries.

The main WENRA tasks are to:

- develop and improve methods of independent safety assessment of nuclear installations based upon their in-depth knowledge;
- development of general approaches related to nuclear safety and its regulation as well as support to harmonization of requirements in practices.

To implement the above tasks, two WENRA work groups were established in 2002; one of the them is the work group on radioactive waste management and decommissioning (WGWD).

The objective of this work group is to develop the so-called safety reference levels (SRLs) and subsequent analysis of national legislation and development of National Action Plans to harmonize regulations of WENRA member states with the SRLs. The main documents for the development of SRLs are IAEA safety standards and experience in activities in the field of radwaste management and decommissioning.

Ukraine recognizes the importance of international cooperation between regulatory authorities for harmonization of regulatory requirements on NPP safety, safety in management of spent nuclear fuel and radioactive waste and NPP decommissioning and took an active part in WENRA plenary sessions and work groups. In October 2014, SNRIU Chairman officially applied to WENRA for Ukraine to acquire full membership. Announcement of the decision about WENRA membership is on the agenda of the spring plenary session in 2015 to be held in Geneva (Switzerland).

In order to ensure harmonization of Ukrainian regulatory requirements on decommissioning with the WENRA reference levels, SNRIU Order No. 174 of 11 November 2014 approved the “Schedule for Harmonization of Ukrainian Regulatory Requirements with WENRA Safety Reference Levels”.

Self-evaluation of Ukrainian regulations on decommissioning has started to verify their compliance with WENRA safety reference levels.

The WENRA safety reference levels on radioactive waste management are taken into account by the SNRIU in development of new regulations on general provisions on radwaste management, particularly for waste disposal and pre-disposal management.

Annex 1

VIOLATION OF BUDAPEST MEMORANDUM

In late February 2014, Russian troops invaded the Autonomous Republic of Crimea, thus cynically violating their obligations specified in the Budapest Memorandum. The paradox lied in the fact that the territorial integrity of Ukraine was violated by the guarantor of this territorial integrity, moreover, the aggression was made by the state possessing nuclear weapons.

The international community has recognized violation of the Budapest Memorandum provisions with respect to Ukraine. This was stated by UN Secretary General Ban Ki-Moon in his speech at the Nuclear Security Summit held in The Hague on March 24, 2014. He noted that security safeguards were an important condition for Ukraine's joining to the Non-Proliferation Treaty (NPT), but their reliability was seriously undermined by events around Ukraine. The UN Secretary General expressed the view that this will have negative consequences for both regional safety and the whole non-proliferation regime. Non-compliance with the Budapest memorandum conditions formed a dangerous precedent in the world nuclear safety system.

For immediate and coordinated resolving issues in the field of nuclear non-proliferation safeguards, physical protection of nuclear materials and facilities, nuclear and radiation safety on the temporarily occupied territory of the Crimea, SNRIU formed a temporary working group by Order No. 50 dated 24 April 2014, powers of this working group were extended also to the anti-terrorist operation areas by Order No.144 dated 03 October 2014. SNRIU also developed proposals to the Cabinet of Ministers of Ukraine to establish the Interagency Working Group (IWG) for resolving the issues on security and nuclear non-proliferation safeguards on the temporarily occupied territory of Crimea.

Such nuclear facilities as nuclear research reactor IR-100 of Sevastopol National University of Nuclear Energy and Industry (SNUYaEiP) and two subcritical assemblies for low enriched and natural uranium are located on the territory of Crimea. At the time of annexation, reactor was shut down. Security of the facility was provided by the security forces of the Internal Troops of the Ministry for Internal Affairs of Ukraine, 3042 troop unit formed of locals who under pressure began to come over to the RF side. Control over the object was completely lost in May. Moreover, in the Crimea there are several enterprises and medical institutions, which use equipment and containers with radiation protection of depleted uranium and high-level radiation sources (5 institutions, mainly oncological clinics).

SNRIU tried to keep the situation in the Crimea under control and perform its duties in nuclear security and nuclear non-proliferation safeguards on the temporarily occupied territory for the following several months. First of all, under the instruction, our territorial subdivision, the Crimean State Inspection, conducted urgent unscheduled inspection of physical protection, accounting and control of nuclear materials at the facilities listed above and physical protection at facilities using radioactive sources. Communication with the Crimean State Inspection on Nuclear and Radiation Safety was actually lost in May-June and in September it officially passed to the control of the Russian Rostekhnadzor. Any report on physical inventory of nuclear material for 2014 was not received from the licensees located in the Crimea.

South-Easter State Inspection on Nuclear and Radiation Safety located in Donetsk continued its work and in December 2014, it was transferred to Zaporizhzhya. As for

licensees located in the Donetsk and Lugansk regions, the reports were received almost from each of them. In the area of so-called Lugansk People's Republic and Donetsk People's Republic there are no nuclear facilities, only small amount of nuclear materials in the form of radiation protection of containers for transportation and storage of radiation sources and X-ray equipment in oncological clinics, as well as high-level radiation sources.

SNRIU activity on implementing the international agreements, due to which it is a competent authority, comes to the forefront. Consequently, on 26 March 2014, a special report pursuant to implementing Art. 68 of the Safeguards Agreement in connection with the Non-Proliferation Treaty ratified by Law of Ukraine No.737/97-VR dated 17 December 1997 was sent to the IAEA Secretariat. The report informed that Ukraine lost control over nuclear materials and facilities located on the Crimean territory, which meant the impossibility to fulfil the international obligations by Ukraine in full scope due to occupation of the part of Ukrainian territory by the Russian Federation.

Since March 2014, the SNRIU actively cooperates with the Ministry of Foreign Affairs and the Permanent Mission of Ukraine to the International Organizations in Vienna providing expert technical assistance and making joint solutions. In a letter to the Ministry of Foreign Affairs, SNRIU expressed its consent to proposed spread of the note of MFA of Ukraine No. 413/23-190-703 dated 22 March 2014 among the IAEA member states. At the same time, opinion of the Agency Secretariat on the need to comply with the IAEA Statute and current international standards in the application of IAEA safeguards was supported.

According to Art. 5 of the Convention on Physical Protection of Nuclear Material and Nuclear Facilities ratified by Ordinance of the Verkhovna Rada of Ukraine No. 3182-12 dated 05 May 1993, in case of receiving the information on any transfer, use or change of nuclear materials or if real risk of such actions occurred, Ukraine should inform IAEA and/or its member states. This information was provided to the Ministry of Foreign Affairs of Ukraine to further inform the IAEA.

On 27 March 2014, the UN General Assembly adopted Resolution 68/262 "The Territorial Integrity of Ukraine". One hundred of states voted for this Resolution.

In addition, according to the proposal, the National Security and Defence Council of Ukraine and the Permanent Mission sent a letter to the IAEA Director General on arranging a special IAEA inspection of the Crimean nuclear facilities. On 7 April 2014, a meeting was held of the Permanent Representative of Ukraine I.Prokopchuk and IAEA Director General Yu.Amano to discuss Ukraine's initiative on sending a special IAEA inspection to the Crimea. During this meeting, Mr. Amano specified that although Ukraine has lost control over nuclear materials on the peninsula, it has not violated its international obligations. He confirmed that IAEA will continue to apply nuclear non-proliferation safeguards in Ukraine based on the fact that the Autonomous Republic of Crimea is an integral part of Ukraine.

In practice, it turned out that the situation with the annexation of the Ukrainian territory was not regulated legally in the international documents on nuclear safety, physical protection of nuclear materials and facilities, as well as nuclear non-proliferation safeguards. SNRIU also developed proposals on amending the international agreements, which were submitted to the IAEA member states for consideration.

Meeting of IAEA Director General Yukiya Amano and SNRIU Chairman Serhii Bozhko

In the letter dated 22 September 2014, IAEA informed Ukraine on the extension of applying safeguards in compliance with its Statute and international law. This was confirmed during the meeting of the Ukrainian delegation and Mr. Yukiya Amano, IAEA Director General, under the 58th IAEA General Conference. Since the beginning of the Crimea occupation and anti-terrorist operation, IAEA inspections in these regions were not carried out.

Annex 2

SITUATION IN DONETSK AND LUHANSK REGIONS

On 14 April 2014, Decree of the President of Ukraine No. 405/2014 "On the Decision of the National Security and Defense Council of Ukraine dated 13 April 2014 "On Urgent Measures to Overcome the Terrorist Threat and Preserve Territorial Integrity of Ukraine" came into force.

Since June 2014, continuous battles have been conducted at some territories of the Donetsk and Luhansk Regions occupied by illegal armed groups using mortars, heavy cannon artillery, multiple launch rocket systems and small arms. Terrorists took under control large territories located under the South-Eastern State Inspectorate area of responsibility, including regional centers, namely Donetsk and Luhansk. These areas are the largest in Ukraine in the number of industrial coal, metallurgical, chemical and mining enterprises that belong to the economy branches with increased risk, since they can apply sealed radionuclide radiation sources. 65 facilities applying radiation sources (including eight institutions with category I high-level radiation sources of activity over 1000 Curie) remained without state regulatory control of nuclear and radiation safety by Ukraine.

However, employees of the South-Eastern State Inspectorate stayed at their working places and continued implementation of the state policy of Ukraine aimed at ensuring nuclear and radiation safety for almost seven months in 2014 (from June to December) in the face of conducted anti-terrorist operation and military actions. The analysis of radiation safety ensured by facilities using radiation sources (information received from licensee annual reports, communication with responsible individuals, indirect data, etc.) showed its significant degradation. This particularly applies to storage and physical protection of radiation sources. For example, the South-Eastern State Inspectorate has official data on at least two facts of destroyed sealed radionuclide radiation sources used in the international automobile checkpoints across the state border of Ukraine "Izvaryne" (device for detecting smuggle completed by radiation source with barium-133) and in PJSC "Aircompany Constanta" (radioisotope ice detector RIO-3A completed by radiation source with strontium-90+yttrium-90).

Automobile checkpoint "Izvaryne"

RIO-3A was installed in the aircraft Yak-40 UR-MMK, which landed in the Donetsk International Airport, and was under fire and burned completely increasing the risk of radioactive contamination of the environment.

Donetsk International Airport

Destroyed airplane

According to unofficial data, currently 15 radiation sources with strontium-90+yttrium-90, which were part of the radioisotope ice detectors RIO-3A used for monitoring aircraft icing and stored in separate rooms of the Luhansk International Airport and Luhansk Aircraft Repair Plant, are destroyed.

Luhansk International Airport

Luhansk Aircraft Repair Plant

RIO-3A Ice Detectors

Military actions lead to flooding of three coal mines of Donbass using radionuclide radiation sources due to damage of power supply systems. Currently the situation cannot be tracked.

Unfortunately, there is no information on radiation safety at two major coal enterprises of Donbass (Donetsk Coal Energy Company and SE Luhanskvuhillia), which combine 15 coal mines located in the territory not controlled by Ukraine. These mines use the total of 142 radiation sources (maximum rated activity of a single source reaches

2.35×10^{11} Bq). There is no information on the state of preserved radioactive waste storage facility located in the territory of the Donetsk State Plant of Chemical Products, which experienced a powerful explosion in the end of 2014.

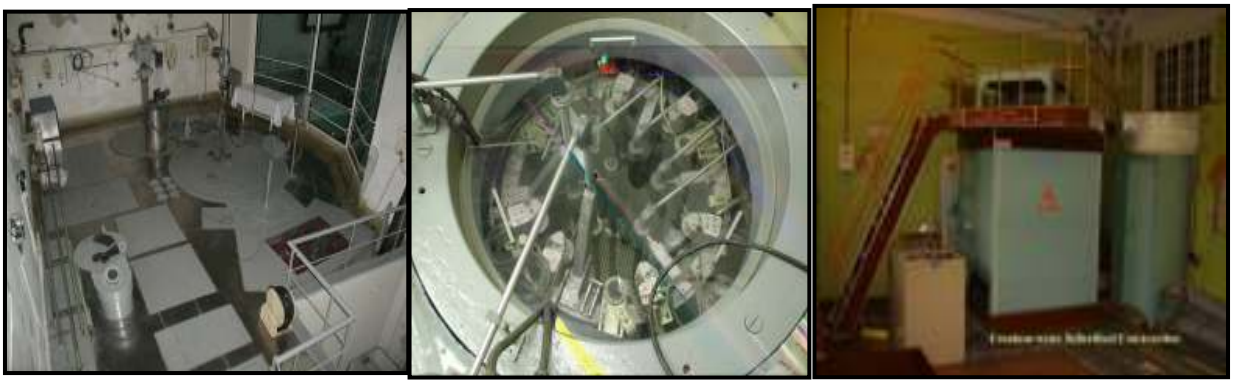
Besides, three licensees informed the South-Eastern State Inspectorate on the impossibility to ensure physical protection of radiation sources due to seizure of facilities by armed groups of so-called Donetsk People's Republic and Luhansk People's Republic.

Annex 3

NUCLEAR INSTALLATIONS IN AUTONOMOUS REPUBLIC OF CRIMEA

The following nuclear installations are located in the Autonomous Republic of Crimea (hereinafter called the Crimea):

1. Research reactor DR-100 with thermal power of 200 kW, physical start-up of which was performed on 18 April 1967;
2. Physical test facility (critical assembly) located in massive of DR-100 reactor biological protection. The facility was commissioned in 1974;
3. Subcritical uranium-water assembly (hereinafter called SUWA) located in the educational building of the university. The facility was commissioned in 1964.



General view of DR-100, critical assembly, SUWA correspondently

The same fuel elements with 10% enrichment of uranium-235 are used in the reactor and critical assembly cores. SUWA uses nuclear fuel with 0,7% enrichment of U-235.

DR-100 protection control system was updated in 1977.

All the above mentioned nuclear installations are operated by the Sevastopol National University of Nuclear Energy and Industry (hereinafter called SUNEI) according to SNRIU license of series EO No. 000131 dated 24 June 2003 on a right to perform activity “operation of nuclear installations” (hereinafter called License EO 000131).

In view of the fact that the design and engineering documentation did not define design operational lifetime for DR-100, its lifetime was extended (the last extension took place in 2007) based on assessment of the technical state of critical components, namely control and protection system, reactor tank, cable lines and switching devices of systems important to safety.

General view of DR-100

According to technical decisions agreed with SNRIU, lifetime of critical components was justified to 31 December 2012.

At the beginning of 2012, upon the expiration of justified lifetime of critical components, SNRIU obliged the operating organization to perform safety review of DR-100 and submit periodical safety review report (hereinafter called PSRR) in order to define new terms and conditions for DR-100 safe operation.

Since the stated requirement has not been performed within the established deadline, SNRIU sent a letter to SUNEI on 29 December 2012 with the **requirement** to operate DR-100 only in a shutdown mode from 01 January 2013 in accordance with requirements of operating documents, and the **prohibition** to perform any activity at the reactor facility related to "preparation for start-up" and "start-up" of the research nuclear reactor till the SNRIU final decision on possibilities and conditions of further safe operation of DR-100 according to results of nuclear and radiation safety state review.

General view of DR-100

During 2013-2014, SUNEI successfully continued efforts on justification of further DR-100 safe operation and PSRR revision in accordance with comments of state review of nuclear and radiation safety. In particular, in September 2014, SNRIU informed SUNEI about the absence of comments on two sections of PSRR: "Arrangement and management of DR-100 operation" and "Impact of DR-100 nuclear facility operation on the environment".

Unfortunately, efforts of PSRR revision have not been completed due to annexation of the Crimea by the Russian Federation.

SUWA, following completion of SNRIU requirements regarding replacement of polypropylene shell pipes for dural pipes envisaged by the design, since 2012 has been actively involved into training and research activities, modeling and experimental study of neutron processes in uranium-water lattices of uranium-water assembly in presence of the external source.

In April-June 2014, after annexation of the Crimea by the Russian Federation, SNRIU performed the following efforts in accordance with prescribed obligations:

On 01 April 2014 and 04 April 2014, in order to implement provisions of Article 5 of the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities ratified by Order of the Verkhovna Rada of Ukraine No. 3182-12 dated 05 May 1993 regarding informing of IAEA and/or member states in case of receiving any information on any transfer, use or change of nuclear material, or in case of real hazard of such an action (which exactly took place on the territory of the temporary occupied Crimea), SNRIU submitted the relevant information to the Ministry of Foreign Affairs of Ukraine for further informing of IAEA;

On 24 April 2014, in order to ensure prompt and coordinated solution of challenging issues in area of nuclear weapons non-proliferation safeguards, physical protection of nuclear materials and facilities, nuclear and radiation safety, SNRIU created temporary working group led by the Deputy Chairman;

On 21 May 2014, SNRIU submitted an appeal to SUNEI with the requirement for immediate correction of incompliance with regulations and rules of nuclear and radiation safety and physical protection, and unconditional compliance with the License EO No. 000131;

On 05 June 2014, SNRIU informed the management of the operating organization on unscheduled target inspection of SUNEI regarding the absence of any response to the previous appeal, but the latter has not confirmed its preparedness within the established deadline;

On 16 June 2014, taking into account absence of any response of the licensee to the request of the regulatory authority and failure to implement any corrective measures, SNRIU **terminated** License EO 000131 in accordance with the established procedure and informed the licensee by letter with stated terms of the license renewal;

As of 01 January 2015, none of the conditions stated for renewal of License EO 000131 have not been met.

It should be noted that issue on SUNEI nuclear facilities is under control of IAEA, which during numerous meetings and consultation confirmed that it finds radioactive materials and nuclear installation located in the Crimea and Sevastopol the property of Ukraine.

Annex 4

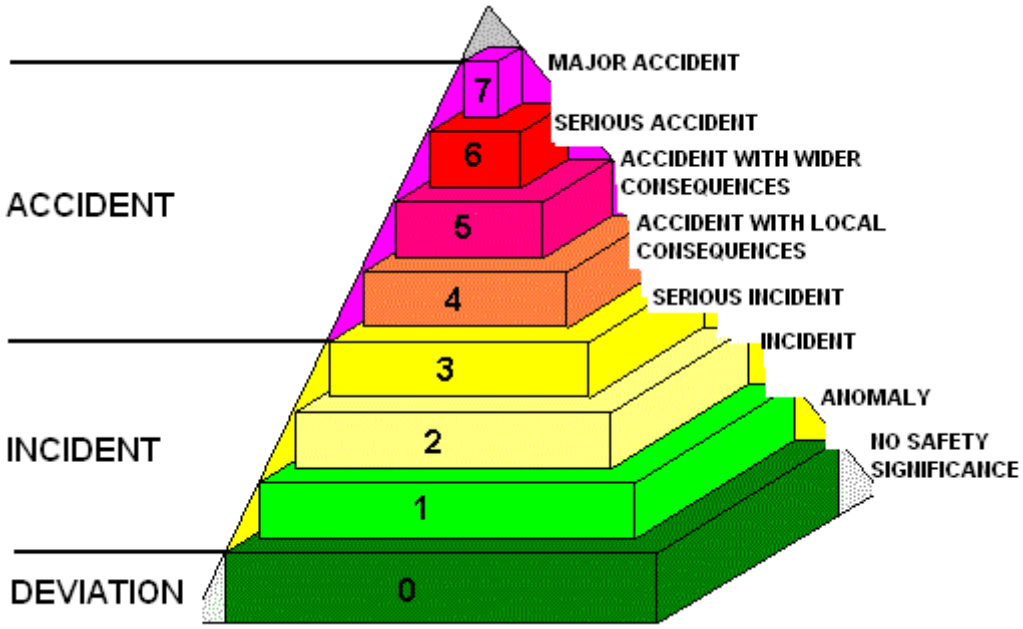
INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE

The International Nuclear and Radiological Event Scale (INES) is a worldwide tool for communicating to the public in a consistent way the safety significance of nuclear and radiological events.

The INES explains the significance of events from a range of activities, including industrial and medical use of radiation sources, operations at nuclear facilities and transport of radioactive material.

The INES was developed by the IAEA in 1988 and introduced in 1990 to rank events at NPPs. It was extended with time to apply to all civil nuclear installations. By 2006, it was adapted to meet the needs for communicating all significant events associated with the transport, storage and use of radioactive material and radiation sources.

Events are classified on the scale at seven levels: levels 1–3 are called 'incidents' and levels 4–7 'accidents'. The scale is designed so that the severity of an event is about ten times greater at each increasing level. Events without safety significance are called 'deviations' and are classified below scale/level 0.



The INES classifies nuclear and radiological accidents and incidents by considering three areas of impact:

People and the Environment considers the radiation doses to people close to the location of the event and the widespread, unplanned release of radioactive material from an installation.

Radiological Barriers and Control covers events without any direct impact on people or the environment and only applies inside major facilities. It covers unplanned high radiation levels and spread of significant quantities of radioactive materials confined within the installation.

Defense-in-Depth also covers events without any direct impact on people or the environment, but for which the range of measures put in place to prevent accident did not function as intended.

Examples of Events at Nuclear Installations

	People and Environment	Radiological Barriers and Control	Defense-in-Depth
Level 7 Major accident	*Chernobyl accident, 1986* *Fukushima-Daiichi accident (Japan), 2011* – severe consequences for public health and the environment. External release of a significant fraction of reactor core inventory.		
Level 6 Serious accident	*Kyshtum, Russia, 1957* – significant release of radioactive material to the environment from explosion of a high-activity waste tank.		
Level 5 Accident with wider consequences	*Windscale Pile, UK, 1957* – release of radioactive material to the environment following a fire in the reactor core	*Three Mile Island, USA, 1979* – severe damage to the reactor core	
Level 4 Accident with local consequences	*Tokaimura, Japan, 1999* – fatal overexposure of workers following a criticality event at a nuclear facility.	*Saint Laurent des Faux, France, 1980* – melting of one fuel channel in the reactor with no off-site release.	
Level 3 Serious incident	No examples.	*Sellafield, UK, 2005 – release of large quantity of radioactive material contained within the installation.*	*Vandellos, Spain, 1989* – near accident caused by a fire resulting in loss of safety systems at the nuclear power plant.
Level 2 Incident	*Atucha, Argentina, 2005* – overexposure of a worker at a power reactor exceeding the annual limit.	*Cadarache, France, 1993* – spread of contamination to an area not expected by design.	*Forskmark, Sweden, 2006* – degraded safety functions for common-cause failure in the emergency power supply system at the nuclear power plant.
Level 1 Anomaly			Breach of operating limits at a nuclear facility.

Examples of Events Involving Radiation Sources and Transport

	People and Environment	Defense-in-Depth
Level 7 Major accident		
Level 6 Serious accident		
Level 5 Accident with wider consequences	*Goiânia, Brazil, 1987* – four people died and six received doses of a few grays from an abandoned and ruptured highly radioactive Gs-137 source.	
Level 4 Accident with local consequences	*Fleurus, Belgium, 2006* – severe health effects for a worker of a commercial irradiation facility as a result of high doses of radiation.	
Level 3 Serious incident	*Yanango, Peru, 1999* – incident with radiography source resulting in severe radiation burns.	*Ikitelli, Turkey, 1999* – loss of a highly radioactive Co-60 source
Level 2 Incident	*USA, 2005* – overexposure of a radiographer exceeding the annual limit of radiation workers.	*France, 1995* – failure of access control systems at an accelerator facility. .
Level 1 Anomaly		Theft of a moisture-density gauge.

List of Abbreviations

C(I)SIP	–	Comprehensive (Integrated) Safety Improvement Program
ChNPP	–	Chornobyl NPP
CSFSF	–	Centralized Storage Facility for Spent Nuclear Fuel
DSFSF	–	Dry Storage Facility for Spent Nuclear Fuel
EC	–	European Commission
Energoatom	–	National Nuclear Energy Generating Company *Energoatom*
ENSDF	–	Engineered Near-Surface Disposal Facility for Solid Radioactive Waste at *Vektor* site
ENSREG	–	European Nuclear Safety Regulatory Group
EU	–	European Union
IAEA	–	International Atomic Energy Agency
ICSRM	–	Industrial Complex for Solid Radioactive Waste Management
INES	–	International Nuclear and Radiological Even Scale
ISF	–	Interim Storage Facility for Spent Nuclear Fuel
KhNPP	–	Khmelnitsky NPP
LRTP	–	Liquid Radioactive Waste Treatment Plant
NPP	–	Nuclear Power Plant
NRBU	–	Radiation Safety Standards of Ukraine
NRS	–	Nuclear and Radiation Safety
NSC	–	New Safe Confinement
Radon	–	Ukrainian State Association *Radon*
Radwaste	–	Radioactive Waste
RBMK	–	High-Power Channel-Type Reactor
RNPP	–	Rivne NPP
RWDS	–	Radioactive Waste Disposal Site
SAR	–	Safety Analysis Report
SFA	–	Spent Fuel Assembly
SFP	–	Spent Fuel Pool
SIP	–	Shelter Implementation Plan
SISP	–	State Interregional Specialized Plant
SNF	–	Spent Nuclear Fuel
SNRIU	–	State Nuclear Regulatory Inspectorate of Ukraine
SRW	–	Solid Radioactive Waste
SSE	–	State Specialized Enterprise
SUNPP	–	South Ukraine NPP
VSC	–	Ventilated Storage Cask
WWER	–	Water-Cooled Water-Moderated Power Reactor
ZNPP	–	Zaporizhzhya NPP

Appendix C21

State Nuclear Regulatory Inspectorate of Ukraine. No Date(b). Report on Nuclear and Radiation Safety in Ukraine for 2015.

REPORT ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2015

TABLE OF CONTENTS

1. INTRODUCTION 3
2. YEAR 2015 IN DETAILS 5
3. OPTIMIZATION OF REGULATORY ACTIVITY 8
   3.1. Optimization of Regulatory Activity 8
   3.2. EU-Ukraine Association Agreement 9
4. SAFETY OF NUCLEAR FACILITIES 12
   4.1. NPP Safety Improvement 12
   4.2. Safety Review and Long-Term Operation of Nuclear Facilities 16
   4.3. NPP Operational Events in Ukraine (2000-2015) 22
   4.4. Releases, Discharges into the Environment and Monitoring of Personnel Exposure Doses 29
   RNPP 32
5. IMPLEMENTATION OF NEW NUCLEAR FACILITY DESIGNS 36
   5.1. Construction of Khmelnytsky NPP Unit 3 and 4 36
   5.2. Construction of Nuclear Fuel Fabrication Plant 37
   5.3. Construction of Neutron Source Based on Subcritical Assembly Driven by Linear Electron Accelerator 37
6. NUCLEAR FUEL MANAGEMENT 38
   6.1. Diversification of Nuclear Fuel Supply 38
   6.2. Spent Nuclear Fuel Management Facilities 39
   6.3. Transport of Nuclear Fuel and Radioactive Materials 47
7. SAFE MANAGEMENT OF RADIATION SOURCES 50
   7.1 International Standards, Approaches and Practice of Safety Regulation of Radiation Sources, Conceptual Changes and Prospects 50
   7.2 State Safety Regulation of Radiation Sources in Ukraine 52
8. ACTIVITY IN THE EXCLUSION ZONE 57
   8.1. Chornobyl NPP Decommissioning 57
   8.2. Construction of the Shelter New Safe Confinement (NSC) 59
   8.3. Radwaste Management Facilities in the Exclusion Zone 62
9. EMERGENCY PREPAREDNESS AND RESPONSE 68
   9.1. Emergency Preparedness and Response 68
   9.2. Fire Suppression in the Exclusion Zone 70
10. NUCLEAR SECURITY ISSUES 75
11. INTERNATIONAL COOPERATION IN NUCLEAR AND RADIATION SAFETY 79
Annex 1. REGULATORY ASPECTS IN INDIVIDUAL TERRITORIES OF UKRAINE 83
Annex 2. PUBLIC HEARINGS ON LONG-TERM OPERATION OF SUNPP UNIT 2 87

The SNRIU wants to express gratitude for the assistance in preparing the Report on Nuclear and Radiation Safety in Ukraine for 2015 to the *Energoatom* Company, Zaporizhzhya NPP, State Agency for Exclusion Zone Management, and O. Kosharna, Deputy Head of SNRIU Public Council.

Dear Readers!

European standards, requirements and values are the priorities for each economy sector of Ukraine. They identify the main activities of state authorities, including nuclear and radiation safety area. The year of 2015 was full of events that will not only affect nuclear and radiation safety in our country in the coming years, but will also have long-term consequences.

In connection with the signing of the EU-Ukraine Association Agreement, efforts on the adaptation of Ukrainian nuclear laws to EU legislation were intensified. The SNRIU developed and, at the beginning of 2015, the Government of Ukraine approved plans for the implementation of EU nuclear and radiation safety laws: Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure, Council Directive 2006/117/Euratom on the supervision and control over shipments of radioactive waste and spent nuclear fuel and Council Directive 2014/87/Euratom establishing a Community framework for nuclear safety of nuclear facilities.

The main step for Ukraine's transfer to EU standards in the regulation of nuclear and radiation safety was made on 26 March 2015 when the State Nuclear Regulatory Inspectorate of Ukraine became a full member of the Western European Nuclear Regulators' Association (WENRA). The participation in WENRA allows Ukraine to improve national legislation on nuclear and radiation safety in accordance with EU standards (WENRA reference levels) and to participate in their development. Ukraine has become the only state that is not an EU member, except for non-aligned Switzerland, which came into full membership of this Association.

In 2015, activities were underway to improve the authorizing procedures and bring them into compliance with adopted laws of Ukraine taking into account international documents and best practices of other countries. A number of draft laws have been developed with the aim of decreasing the regulatory pressure and eliminating the problems that occurred in the deregulation process that ignored the issues of nuclear industry.

Regulatory support of efforts on improving the operational safety of Ukrainian NPPs, long-term operation of SUNPP unit 2, ZNPP units 1 and 2 and RNPP unit 3 was rendered in 2015, as was envisaged by the Comprehensive (Integrated) Safety Improvement Program to ensure the energy safety.

Regulatory support to the diversification of nuclear fuel supplies for Ukrainian NPPs remains a strategic task. In 2015, the SNRIU reviewed a number of the operator's documents that justify extension of trial operation of Westinghouse nuclear fuel to other Ukrainian NPPs. This decision should be followed by positive results of fuel operation and inspection during the scheduled outage at SUNPP-3 in 2016.

One of the largest projects supported by the SNRIU has approached the final stage, namely the construction of the New Safe Confinement (NSC) above the destroyed ChNPP-4 and its transformation into an environmentally safe system. An important stage of the NSC project was to connect the Western and Eastern parts of the arch, which was completed in July 2015. The NSC is to be put into the design position in November 2016. The construction of the Dry Interim Spent Fuel Storage Facility is underway in the ChNPP Exclusion Zone, and shall be completed at the end of 2016. Activities related to the Centralized Spent Fuel Storage Facility to ensure storage of spent nuclear fuel of Ukrainian NPPs were boosted.

Taking into account the ongoing military actions in Eastern Ukraine, the SNRIU together with relevant ministries and institutions continued efforts on improving physical protection of nuclear facilities. The existing state security institutions are able to ensure NPP

protection against external threats, such as military aggression, sabotages, terroristic acts and criminal assaults. A number of exercises were held at all NPPs in 2015 to train the sequence of actions in case of sabotage in different situations. All special-purpose units at NPPs were involved with relevant rotation into anti-terroristic operations to gain combat experience during the missions. Documents on security of the most important facilities were revised and improved at all Ukrainian NPPs.

Unfortunately, loss of regulatory control in some areas of Donets'k and Luhans'k regions with military actions ongoing led to a situation where radiation sources pose threat to human health and life. The SNRIU does not have reliable information on radiation safety of enterprises located there, which use radiation sources in their production processes.

The SNRIU developed measures to improve monitoring over transfer of radiation sources and radioactive waste from territories beyond the control. This will reduce the threat of their illicit trafficking. For the emergencies affecting the public, we implemented mutual information exchange between the South-Eastern Regional Inspectorate and Regional State Administrations of Donets'k, Luhans'k and Zaporizhzhya regions.

We plan to appeal to Western partners with a proposal to implement the project "Countering Illicit Use and Trafficking of Radioactive Materials in Eastern Ukraine in the Area of Anti-Terroristic Operations" within the Initiative "Global Partnership against the Spread of Weapons and Materials of Mass Destruction" after completion of anti-terroristic operations in separate areas of Donets'k and Luhans'k regions.

I believe that in 2016 the SNRIU will continue establishing the all-European security system, ensuring regulatory support of projects aimed at improving energy independence of Ukraine, will successfully overcome challenges and threats arising in the use of nuclear technologies and will further be a reliable guarantor of nuclear and radiation safety in Ukraine.

Sincerely Yours

Chairman

State Nuclear Regulatory
Inspectorate of Ukraine **Serhii Bozhko**

2. YEAR 2015 IN DETAILS

Date	Month/Event
	January
26-27	International Round Table on the Emergency Preparedness and Response in Nuclear Sphere arranged by the SNRIU together with the All-Ukrainian Environmental Public Organization "MAMA-86" under the auspices of the European Public Network *Nuclear Transparency Watch* with support of the Swedish International Development Cooperation Agency.
28	Provision on the List of Documents to be Submitted by the Operator to Get a License for Taking Activities on a Certain Lifecycle Stage of Nuclear Facility approved by SNRIU Order No. 12 registered in the Ministry of Justice of Ukraine under No. 152/26597 dated 12 February 2015.
	February
18	Plans on Implementation of Some EU Regulatory Documents developed by the SNRIU were approved by the Ordinance of the Cabinet of Ministers of Ukraine No. 110-r.
	March
24	Concept for Regulation of Nuclear and Radiation Safety of Nuclear Facility put into force by SNRIU Order No. 52
26	Regulatory document of WENRA signed by Ukraine and WENRA member states and SNRIU entry into WENRA full membership
31	ChNPP issued individual permit OD No. 000040/8 to perform activities on the stage of final closure and temporary shutdown of ChNPP-1,2,3
	April
16	Forms of Registration Cards for Radiation Sources approved by SNRIU Order No. 69 registered in the Ministry of Justice of Ukraine under No. 716/27161 dated 18 June 2015
16	Procedure for Using the State Register of Radiation Sources approved by SNRIU Order No. 70 registered in the Ministry of Justice of Ukraine under No. 717/27162 dated 18 June 2015
17	General Requirements for Long-Term Operation of NPPs Based on Periodical Safety Review Results as amended by SNRIU Order No. 71 registered in the Ministry of Justice of Ukraine under No. 504/26949 dated 07 May 2015
	May
14	Requirements for Operator's Activity Management System as amended by SNRIU Order No. 90 registered in the Ministry of Justice of Ukraine under No. 781/27226 dated 03 July 2015
20	SNRIU Access Control Rules approved by SNRIU Order No. 668/27113 registered in the Ministry of Justice of Ukraine under No. 668/27113 dated 05 June 2015
27	Safety Requirements and Conditions (Licensing Conditions) for Uranium Ore Processing Activities approved by SNRIU Order No. 101 registered in the Ministry of Justice of Ukraine under No. 700/27145 dated 12 June 2015
11-22	National Report of Ukraine presented during the Fifth Meeting of the Parties on Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

	June
8	Order of the Ministry of Environmental Protection and Nuclear Safety of Ukraine and the Ministry of Industrial Policy of Ukraine No. 17/21 dated 18 January 2000 became ineffective by joint Order of the SNRIU and the Ministry of Economic Development and Trade of Ukraine No. 110/580 registered in the Ministry of Justice of Ukraine under No. 718/27163 dated 18 June 2015
15	Order of the Ministry of Environmental Protection and Nuclear Safety and the Ministry of Health of Ukraine No. 15/7 dated 18 January 2000 became ineffective by joint Order of the SNRIU and the Ministry of Health of Ukraine No. 111/337 registered in the Ministry of Justice of Ukraine under No. 719/27164 dated 18 June 2015
16	Reissued license No. OV 000932 for State Enterprise "Eastern Ore Mining and Enrichment Plant" for uranium ore processing activities
17	Commission on Harmonization of National Standards and Nuclear and Radiation Safety Rules of Ukraine with WENRA Reference Levels approved by SNRIU Order No. 115
	July
1	Opening of the Central Analytical Laboratory of the Measuring Center of Radiation and Environmental Monitoring and Dosimetric Control *Ecocenter*, ChNPP Specialized Plant
22	Nuclear and Radiation Safety Requirements for Instrumentation and Control Systems Important to NPP Safety approved by SNRIU Order No. 140 registered in the Ministry of Justice of Ukraine No. 954/27399 dated 06 August 2015
24	Successfully completed activities on the connection of Western and Eastern parts of the New Safe Confinement (the Shelter)
24	State Specialized Enterprise for Exclusion Zone Capital Construction Management completed activities on the construction and mounting of systems and equipment of the Centralized Long-Term Storage Facility for Spent Radiation Sources
	August
13	Safety Requirements and Conditions (Licensing Conditions) for Production of Radiation Sources are approved by SNRIU Order No. 148 registered in the Ministry of Justice of Ukraine under No. 1054/27499 dated 03 September 2015
19	Dnipropetrovsk SISP, amended license OV No. 000948 dated 26 January 2011 for radwaste processing and storage according to which there is authorized operation of the Mobile complex of technical means on safe discharge of spent radiation sources from biological shielding units BGI and E
	September
2-4	22nd Meeting of WWER Regulators Forum
10	Board Meeting devoted to "Improvement of State Nuclear and Radiation Safety Review System"
14-18	Ukrainian delegation participated in 59th IAEA General Conference Session
	November
23	Requirements for Defining Dimensions and Boundaries of NPP Observation Area as amended by joint order of SNRIU and the Ministry of Health of Ukraine No. 206/765 registered in the Ministry of Justice of Ukraine under No. 1567/28012 dated 15 December 2015

25	Public Hearings on Long-Term Operation of SUNPP unit 2
28	Possibility for SUNPP-1 operation at power levels defined by the design to 2 December 2023 justified by SNRIU Board Ordinance No. 17
	December
4	Workshop on urgent issues of nuclear and radiation safety devoted to 15th anniversary of SNRIU creation
7	Taking into account positive results of nuclear and radiation safety state review of the Report on Periodical Safety Review and Comprehensive Inspection of SUNPP unit 2, SNRIU Board recognized justification for safe operation of this unit to 31 December 2025
21	Procedure for State Inventory of Radioactive Waste as amended by SNRIU Order No. 228 registered in the Ministry of Justice of Ukraine under No. 83/28213 dated 16 January 2016
24	Requirements for Emergency Nuclear Fuel Cooling Systems and Heat Removal to the Ultimate Heat Sink approved by SNRIU Order No. 233 registered in the Ministry of Justice of Ukraine under No. 77/28207 dated 16 January 2016
24	Requirements for Power Supply Systems Important to NPP Safety approved by SNRIU Order No. 234 registered in the Ministry of Justice of Ukraine under No. 78/28208 dated 16 January 2016

3. OPTIMIZATION OF REGULATORY ACTIVITY

3.1. Optimization of Regulatory Activity

According to Article 6 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", state policy in the area of nuclear energy and radiation protection is exercised, in particular, through optimum regulation of nuclear and radiation safety. This optimality is achieved, among other, by safety requirements differentiation depending on potential hazard peculiar to specific activities at nuclear installations (sources). The same concerns physical protection and the Law of Ukraine "On Physical Protection of Nuclear Installations, Nuclear Material, Radioactive Waste and Other Radiation Sources" envisages the physical protection system that, in particular includes administrative and legal measures, shall be formed using the graded approach that ensures compliance of physical protection level of system objects with their categories and potential radiological consequences of illegal actions against them.

In addition, the Law of Ukraine "On Authorizing Activity in Nuclear Energy Use" envisages that one of the main authorizing principles is the graded approach to different activities and radiation sources taking into account potential nuclear and radiation hazards related to them. It may be specified as an example that such principle is applied in this Law under establishing legal standards to license activity with the use of radiation sources, namely, Article 7 of the Law envisages release of this activity from licensing under certain conditions associated with the graded approach taking into account potential radiation hazard related to the use of radiation sources.

These requirements of Ukrainian laws comply with IAEA recommendations. In particular, IAEA General Safety Requirements Part 1, Governmental, Legal and Regulatory Framework for Safety, envisages that national safety policy and strategy are based on a graded approach, taking into account radiological risks, to be considered to establish regulatory requirements, issue permits, conduct inspections and assess facilities and activities. In addition, such requirements in Ukrainian laws comply with EU regulations, such as Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure and cancelling Council Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

The SNRIU as a state nuclear regulatory body applies the optimization principle in its activity.

The efforts started after analysis of the authorizing activity in 2014, in particular regarding compliance of the authorizing procedure with the Ukrainian legislation, international documents and practice of other countries were underway in 2015.

Within the abovementioned efforts, the SNRIU developed the Draft Law "On Amending Certain Laws of Ukraine in Nuclear Energy Use", which proposes to amend the Laws of Ukraine and, in particular:

- release from licensing some activities on radioactive material transport and entities having licenses for shipment of hazardous cargoes;
- release from licensing activity on processing, storage of radioactive waste by producers of radioactive waste before waste transfer to specialized enterprises on radioactive waste management and activity of contracting organizations rendering services on radioactive waste processing, storage to specialized enterprises on radioactive waste management, if services are rendered within the scope of licensed activity of these clients;
- it is also proposed to exclude activities belonging to the use of radiation sources to be licensed, receipt (purchase) and transfer (sale) of radiation sources including that for supply

purposes.

In addition, it is proposed to avoid the need to obtain authorization for the use of land and water bodies located in the controlled area. At the same time, standards of the Law on control of the products manufactured in these areas remain.

The Draft Law was submitted by the Cabinet to the Verkhovna Rada, No.4285 dated 22 March 2016.

The above measures will enable the SNRIU not only to focus on the most hazardous activities in terms of nuclear and radiation safety, but will reduce the regulatory burden on economic entities that complies with the state policy currently implemented in Ukraine.

In 2015, under deregulation of economic activity, the Cabinet of Ministers and deputies of Ukraine developed and adopted amendments to various laws, which to some extent concerned state regulation of nuclear safety, however, the peculiarities of activity in this area and peculiarities of state safety regulation for this activity in this area were not always considered.

On 2 March 2015, the Law of Ukraine "On Licensing Economic Activities" (in force since 28 June 2015) was adopted.

This Law envisages that nuclear energy related activity shall be licensed in compliance with this law taking into account peculiarities defined by the Law of Ukraine "On Authorizing Activity in Nuclear Energy Use".

Thus, procedures established to license business activity partly cover licensing procedures in nuclear energy use. The use of the above standards of the Law of Ukraine "On Licensing Economic Activities" for licensing in nuclear energy use will violate the national and international standards on independence of the regulatory body in decision-making.

On 15 July 2015, the Verkhovna Rada registered draft Law No.2360a developed involving the SNRIU and submitted by deputies. This draft law proposes to amend the Law "On Licensing Economic Activities" that eliminates the above issues. The draft Law was supported by the Governmental Committee of the Cabinet and the Parliamentary Committee. The SNRIU continues to support the adoption of this draft law.

Besides, as amended on 22 July 2014 the Law "On Basic Principles of State Oversight (Control) of Economic Activity" stipulates that state oversight of radiation safety shall be carried out according to the Law "On State Oversight (Control) of Economic Activity" and state oversight of nuclear safety in compliance with the Law of Ukraine "On Nuclear Energy use and Radiation Safety".

Thus, oversight of nuclear and radiation safety was divided into two types to be carried out following different procedures. This division by safety of nuclear energy use is not justified and oversight of safety of nuclear energy use by procedures of the Law regulating oversight of business activity does not consider provisions of the international standards. In particular, these provisions are as follows: independent nuclear regulatory body in decision-making, safety priority over others, including commercial interests, right of access to oversight facilities for state inspectors, and regarding the list of grounds for unscheduled inspections, the right to suspend activities not meeting the safety requirements.

On 15 July 2015, the Verkhovna Rada registered draft Law No.2360a developed involving the SNRIU and submitted by deputies. This draft Law suggests amending the Law "On Licensing Economic Activities" that resolves the above issue.

3.2. EU-Ukraine Association Agreement

Due to signing the EU-Ukraine Association Agreement between Ukraine, of the one part, and the European Union, the European Atomic Energy Community and its Member

States, of the other part and its ratification by the Verkhovna Rada of Ukraine and the European Parliament on 16 September 2014, the SNRIU intensified adaptation of Ukraine legislation to EU legislation in nuclear safety.

To fulfil the Action Plan approved by the Cabinet Ordinance No.847-r dated 17 September 2014 on implementation of this Agreement, the SNRIU developed plans, which were approved by the Cabinet Resolution No. 110-r dated 18 February 2015 for implementing some regulatory documents of the EU:

1. Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure and cancelling Council Directives 89/618/Euratom, 90/641/Euratom 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

2. Council Directive 2006/117/Euratom of 20 November 2006, on the supervision and control over shipments of radioactive waste and spent nuclear fuel.

3. Council Directive 2014/87/Euratom of 8 July 2014, establishing a Community framework for nuclear safety of nuclear installations.

In 2015, the SNRIU took certain efforts to implement the EU regulatory documents. Thus, to fulfil the Action Plan for implementation of Council Directive 2013/59/Euratom, the SNRIU developed the Draft Law of Ukraine "On Amendments to Some Laws of Ukraine in Nuclear Energy Use", which suggests amending four Laws: "On Nuclear Energy Use and Radiation Safety", "On Authorizing Activity in Nuclear Energy Use", "On Human Protection Against Ionizing Radiation", and "On Mining and Processing of Uranium Ores".

In particular, the Draft Law envisages the following amendments:

- taking into account the peculiarities of process cycle of uranium concentrate production that includes both mining and processing of uranium ores, it is proposed to amend the above Laws and extend state regulation in nuclear energy use to uranium ore production and implement licensing for mining of uranium ore;

In addition, the Draft Law:

- proposes to establish the main dose limits for trainees and students who have contact with radiation sources during work or training;
- proposes to define characteristics of equipment containing radiation sources under which this equipment use for medical exposure is allowed (to significantly reduce exposure doses of patients);
- and proposes to supplement Cabinet powers with development and approval of the Action Plan aimed at decreasing public exposure by radon and its decay products..

The Draft Law was submitted by the Cabinet to the Verkhovna Rada, No.3858 dated 01 February 2016.

To fulfil the Action Plan on implementing Council Directive 2014/87/Euratom, the SNRIU:

- developed Ordinance "On Amending Procedure for Development and Approval of Standards, Rules and Regulations on Nuclear and Radiation Safety", which was approved by the Cabinet under No. 89 of 27 January 2016;
- in compliance with Directive requirements and to strengthen independence and institutional ability of the regulatory body, the SNRIU started developing the Draft Law of Ukraine on the body for state safety regulation in nuclear energy use, in particular a working group was established by SNRIU Ordinance, national and international legislation on establishment and functioning of state body for safety regulation in nuclear energy use were analyzed, Revision 1 of the Draft Law was under development.

Pursuant to the Action Plan on implementing Council Directive 2006/117/Euratom, the draft Cabinet Resolution "On Amending the Procedure to Issue Permit for International Transport of Radioactive Materials" was developed. This document establishes procedures to agree transport of radioactive waste and spent nuclear fuel by Ukraine and EU member states with competent bodies in the countries of origin, destination and transit that will contribute to oversight and control of such transport to ensure appropriate protection of the public and the environment.

4. SAFETY OF NUCLEAR FACILITIES

Ukraine operates 15 power units 13 of which are WWER-1000 and 2 are WWER-440. Ukraine ranks the tenth in the world for this indicator and takes the seventh place in the installed capacity that is 13.835 MW.

The only operator of all operating nuclear power plants in Ukraine is the National Nuclear Energy Generating Company *Energoatom*. The *Energoatom* Company includes four nuclear power plants.

In 2015, the NPPs generated 87.8 billion kWh representing 55.6% of total electricity production in Ukraine. Efficiency of the installed NPP capacity in 2015 was 72.3%.

Ukraine ensures stable and safe operation of NPPs under the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Convention on Nuclear Safety. Safety improvement measures are under implementation at operating nuclear power plants of Ukraine on a systematic basis in compliance with national regulations and standards on nuclear and radiation safety and recommendations of the International Atomic Energy Agency (IAEA), taking into account best international practices.

Peer reviews of WANO1 and IAEA confirmed operational safety of Ukrainian NPPs and validity of safety upgrades implemented under safety improvement and long-term operation programs.

4.1. NPP Safety Improvement

The safety improvement measures at Ukrainian NPPs are under implementation in compliance with the "Comprehensive (Integrated) Safety Improvement Program for Operating Nuclear Power Units" (C(I)SIP), approved by a Cabinet Resolution No. 1270 of 7 December 2011. The Cabinet approved a Resolution No. 776 of 30 September 2015 "On Amending the Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Units", which envisages extension of the C(I)SIP to 2010.

The C(I)SIP objectives are to:

- further improve operational safety of NPP units;
- decrease risks of NPP accidents during natural disasters or other hazards;
- improve the effectiveness in management of design-basis and beyond design-basis accidents at NPPs, minimize their consequences.

The C(I)SIP is based on safety improvement measures of the previous program "Concept for Safety Improvement of Operating Nuclear Power Units" (approved by a Cabinet Resolution No. 515-r of 13 December 2005) that were not implemented by the operating organization till the end of the Concept validity period and safety upgrades for Khmelnitsky-2 and Rivne-4 that were implemented during commissioning of these units.

The C(I)SIP also takes into account results and recommendations of the IAEA design safety review mission conducted at all NPPs under the Memorandum of Understanding in the Field of Nuclear Energy between Ukraine and EC.

After the Fukushima accident, the C(I)SIP included additional measures upon extraordinary in-depth safety reassessment for Ukrainian NPPs (stress tests) and additional fire safety measures. Safety improvement measures are among conditions for long-term operation of NPPs.

The design-basis lifetime of nine Ukrainian NPP units expires in a period from 2014 to 2020 (see Table 4.1).

Table 4.1. Data on NPP Units in Ukraine

NPP	Unit No.	Reactor Type	Expiration of design-basis/long-term operation period
ZNPP	**1**	**WWER-1000/320**	**23.12.2015**
	2	**WWER-1000/320**	**19.02.2016**

	3	**WWER-1000/320**	**05.03.2017**
	4	**WWER-1000/320**	**04.04.2018**
	5	**WWER-1000/320**	**27.05.2020**
	6	**WWER-1000/320**	**21.10.2026**
SUNPP	**1**	**WWER-1000/302**	**02.12.2013/02.12.2023**
	2	**BBEP-1000/338**	**12.05.2015/31.12.2025**
	3	**WWER-1000/320**	**10.02.2020**
RNPP	**1**	**WWER-440/213**	**22.12.2010/22.12.2030**
	2	**WWER-440/213**	**22.12.2011/22.12.2031**
	3	**WWER-1000/320**	**11.12.2017**
	4	**WWER-1000/320**	**07.06.2035**
KhNPP	**1**	**WWER-1000/320**	**13.12.2018**
	2	**WWER-1000/320**	**07.09.2035**

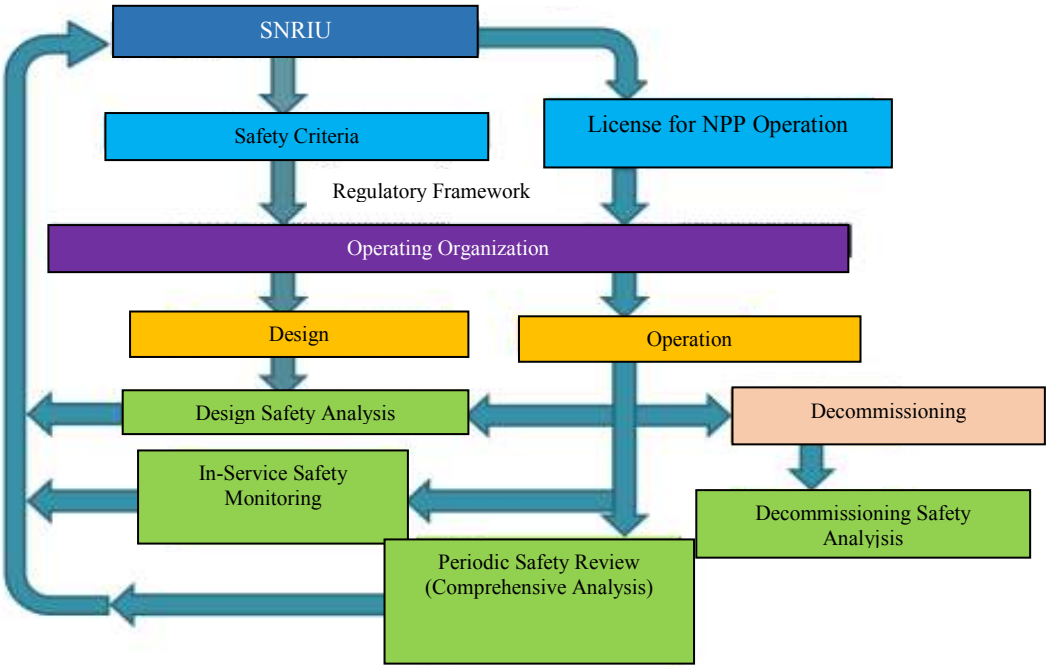
In 2014, within C(I)SIP regulatory support, the SNRIU agreed 54 reports on implementation of measures out of the 83 ones planned.

According to C(I)SIP scheduled, the main efforts of the operating organization in 2015 were focused on the development and implementation of measures for ZNPP units 1 and 2 within long-term operation activities. The experience in measures implementation obtained at the so-called pilot units is further extended to other power units.

Modifications important for safety of nuclear installations (change in nuclear installation configuration, bringing a nuclear installation into compliance with current regulations and standards, changes in operational documents, modification of the operating organization's structure) are implemented upon agreement with the SNRIU.

The State Nuclear Regulatory Inspectorate of Ukraine constantly monitors all stages of modifications implementation (concept development, installation and pre-commissioning, introduction into trial and/or commercial operation) through safety assessment of submittals and agreement of appropriate technical decisions, as well as through direct supervision over modifications, introduction of changes to operational documentation and staff training. The results are discussed at open meetings of the SNRIU Board involving all stakeholders, including the public and mass media.

Safety Assessment System for NPP units



During 2015, the SNRIU conducted comprehensive inspections of each NPP site, also involving international experts. One of the main tasks is to check implementation of safety improvement measures.

At the beginning of 2013, the SNRIU jointly with the Ministry for Energy and Coal Industry, Ministry of Defense, Ministry for Environment and Natural Resources and State Agency for Exclusion Zone Management developed the National Action Plan upon Stress-Test Results aimed at improving the safety of Ukrainian NPPs in full compliance with ENSREG recommendations.

EU states and neighboring countries that took part in the stress tests (Ukraine and Switzerland) reached agreements for further periodic exchange of information on the implementation of the National Action Plans and transparency and openness of the process.

The status of National Action Plans upon stress tests of the participating countries was presented during the ENSREG workshop in April 2015. In preparation for the ENSREG workshop, the National Action Plan upon Stress-Test Results (2013) was updated to take into account recommendations set forth in the "ENSREG Post-Fukushima National Action Plans Workshop 20÷24 April 2015. Terms of Reference". It should be noted that a number of measured planned for operating NPPs and Chornobyl NPP and the scope of measured remained unchanged in the updated National Action Plan. The updated National Action Plan specified the status of safety upgrades and their schedule.

Part I of "The Safety Improvement Measures" of the Updated National Action Plan presents the list of measures of the National Action Plan upon stress-test results (2013) both for operating power units and for Chornobyl NPP with updated information on status of measures and their schedule.

Part II of "The Safety Improvement Measures" of the Updated National Action Plan presents more detailed information on updates, namely: the information on planned implementation scope of a measure; its implementation status (more detailed information is presented for implemented measures) is specified on each planned measure; updated deadline.

The updated National Action Plan upon Stress-Test Results can be found on the SNRIU official website.

The National Report of Ukraine on the updated Action Plan, which included the information on bringing the Ukrainian nuclear and radiation safety standards to compliance with WENRA reference levels as it was proposed during the preliminary working meeting in 2013, interested the representatives of the EC, Austria, Sweden, and Finland.

A series of safety improvement measures at Ukrainian NPPs were defined before the tragic events at the Fukushima-Daiichi NPP and were a part of C(I)SIP and "Safety Improvement Plan of Nuclear Installations at Chornobyl NPP".

All countries participating in the ENSREG meeting expressed commitment to full implementation of the measures specified in their reports under supervision of regulatory bodies.

4.2. Safety Review and Long-Term Operation of Nuclear Facilities

4.2.1. Safety Review and Long-Term Operation of NPP Units

Most Ukrainian NPPs were commissioned in the 1980s and their design-basis life is to expire in the near future. The Government of Ukraine decided to continue operation of NPP units as reflected in the "Energy Strategy of Ukraine until 2030" and "Comprehensive Work Program for Long-Term Operation of Nuclear Power Plant Units". The *Energoatom* Company together with the WWER General Designer Hydropress revised the schedule for beginning of commercial operation and established the dates for completion of the design-basis life (see Table 4.1):

In a period from 2015 to 2020, the design-basis life of eight NPP units in Ukraine (see the schedule) expires. It will be required to take a decision from 2016 on life extension of two power units at the same time:

- completion of design-basis life

- last scheduled outage for implementation of long-term operation measures

- period of preparation for long-term operation

In accordance with the current legislation, a decision on long-term operation of a power unit is made by the SNRIU based upon conclusions of the state nuclear and regulatory

safety review of the periodic safety review report (PSRR) by amending the license for its operation. Long-term operation may be allowed only if the safety level of the NPP unit is not lower than that established by current regulations and rules on nuclear and radiation safety.

The PSRR is based upon a substantial scope of efforts, in particular, related to the following:

- assessment of current technical state of components and structures and their lifetime extension;
- elimination of deviations from nuclear and radiation safety regulations, rules and standards adopted during the last years;
- implementation of safety upgrades planned under C(I)SIP;
- implementation of measures upon results of the Fukushima NPP events and stress tests;
- equipment qualification for harsh environments and seismic events and seismic evaluation of NPP piping, buildings and structures;
- implementation of the ageing management program for NPP components and structures;
- in-depth safety analysis applying deterministic and probabilistic methods;
- enhancement of operational safety through improvement of operational and emergency documentation;
- improvement of the management system to be in compliance with nuclear and radiation safety regulations and rules, IAEA recommendations and best international practice;
- improvement of emergency preparedness system.

In accordance with nuclear and radiation safety regulations, rules and standards, the PSRR is finalized as individual reports based upon assessment of 14 safety factors:

- NPP unit design;
- current condition of systems and components;
- equipment qualification;
- ageing;
- deterministic safety analysis;
- probabilistic safety assessment;
- internal and external hazard analysis.
- safety performance;
- use of experience from other plants and research findings;
- organization and administration;
- operating procedures;
- human factor;
- emergency preparedness and planning;
- environmental impact.

This approach complies with IAEA recommendations and best international practice and allows a comprehensive assessment of the power unit safety to make a sound decision on further operation of the power unit, including long-term operation.

For SUNPP unit 2, ZNPP units 1, 2, 3, and RNPP unit 3 whose design-basis life expires in 2015÷2017, The *Energoatom* Company chose “another option” of long-term operation in compliance with NP 306.2.099-2004 in which a power unit is to be shut down after its design-basis life expires and organizational and technical measures are to be taken to continue and recommence operation.

For SUNPP unit 2, ZNPP units 1, 2, and RNPP unit 3, the SNRIU agreed long-term operation programs and licensing plans in accordance with which safety upgrades, equipment qualification and technical condition assessments are underway.

For ZNPP unit 3, licensing plan was agreed and state nuclear and radiation safety review of long-term operation program was provided.

Safety upgrades, equipment qualification and technical condition assessments are underway at these power units. The respective reports are submitted to the SNRIU for consideration and state nuclear and radiation safety review.

4.2.2. Long-term Operation of SUNPP Unit 2

Within safety review of SUNPP unit 2, all technical decisions on life extension for equipment, piping and building structures of the power unit and results of the following activities were completely agreed by the SNRIU:

- equipment qualification for harsh environment and seismic conditions and seismic impact;
- ensuring seismic resistance of equipment, piping, buildings and structures.

Results of the above activities were considered under making a decision on possible long-term operation of SUNPP unit 2.

On 7 December 2015, during open meeting of the SNRIU Board, the SNRIU considered the issue on "Long-term Operation of SUNPP Unit 2 upon Periodical Safety Review". The meeting was attended by members of the Board and SNRIU staff, *Energoatom* Company management, authorized representatives of the Ministry for Energy and Coal Industry of Ukraine, Ministry of Ecology and Natural Resources of Ukraine, representatives of the SSTC NRS, Verkhovna Rada Committee on Fuel and Energy Complex, Nuclear Policy and Nuclear Safety, EBRD, public organizations, and mass media.

Taking into account positive results of the state nuclear and radiation safety review of the periodical safety review report and comprehensive inspection of SUNPP unit 2, the SNRIU Board considered that safe operation of SUNPP unit 2 until 31 December 2025 is justified.

Considering the above mentioned, on 19 December 2015, the SNRIU issued a license, series EO No.001047, for the operating organization (*Energoatom* Company) to perform activity at lifecycle stage “operation of SUNPP unit 2”.

Серія АА

№ 000002

№ ЕО 001047

ДЕРЖАВНА ІНСПЕКЦІЯ ЯДЕРНОГО РЕГУЛЮВАННЯ УКРАЇНИ

Видана: експлуатуючій організації - Державному підприємству «Національна атомна енергогенеруюча компанія «Енергоатом» Україна, 01032, м. Київ, вул. Назарівська, 3

Ідентифікаційний код юридичної особи 24584661

На право провадження діяльності на етапі життєвого циклу «експлуатація ядерної установки енергоблока № 2 Южно-Української АЕС»

Місце провадження діяльності 55000, Миколаївська область, м. Южноукраїнськ, межі майданчика ВП «Южно-Українська АЕС» згідно з Генеральним планом від 07 травня 2001 року

Технологічний комплекс у складі енергоблока № 2, об'єктів та будівель, що технологічно з ними пов'язані, відповідно до Генерального плану промайданчика «Южно-Українська АЕС» від 07 травня 2001 року

Перелік документів, на підставі яких прийнято рішення про видачу ліцензії - згідно з розділом 1

Перелік посадових осіб, до службових обов'язків яких належить здійснення організаційно-розпорядчих функцій, пов'язаних з забезпеченням ядерної та радіаційної безпеки, фізичного захисту ядерних установок, радіоактивних відходів, інших джерел іонізуючого випромінювання - згідно з розділом 2

Умови провадження діяльності - згідно з розділом 3

Найменування підрозділу або органу, що повинен здійснювати нагляд за дотриманням умов та правил провадження виду діяльності, що ліцензується

Державна інспекція з ядерної безпеки на Південно-Українській АЕС

Державної інспекції ядерного регулювання України

Дата видачі 09 грудня 2015 року

Строк дії ліцензії до до видачі ліцензії на здійснення діяльності на етапі життєвого циклу «зняття з експлуатації ядерної установки»

Голова С. Бомко

М.П.

Сторінка 1 з 9

4.2.3. Preparation of ZNPP Unit 1 for Long-Term Operation

On 17 December 2015, during open meeting, the SNRIU Board considered the issue "On Status of Long-Term Operation Efforts for ZNPP unit 1".

Taking into account that long-term operation efforts for ZNPP unit 1 were not completed to the full extent, the SNRIU Board decided to amend the license (series EO

l000196) to perform activity at lifecycle stage “operation of SUNPP unit 1” regarding operation of ZNPP unit 1 in shut down state with complete fuel unloading from the reactor core to the spent fuel pool for the period of administrative and technical measures to justify its possible long-term operation, and determined conditions under which reopening the issue on long-term operation of ZNPP unit 1 at power levels is possible.

4.2.4. Preparation of other NPP units 1 for Long-Term Operation

The efforts on consideration and agreement of technical decisions on life extension for equipment, piping and building structures at other NPPs continued during 2015.

As of 01 January 2016, the SNRIU agreed:

- summary reports on equipment qualification for harsh environment conditions of ZNPP unit 2;
- results of seismic hazard research at ZNPP site (using deterministic and probabilistic methods);
- initial data for efforts to confirm seismic resistance of equipment, piping, buildings and structures at ZNPP unit 2.

In 2015, based on the periodic safety review:

- regulatory decisions on SUNPP unit 2, ZNPP units 1 and 2, RNPP unit 3 were made;
- reports on safety factor assessment for SUNPP unit 2, ZNPP units 1, 2 and 3, RNPP unit 3, 4 were considered.

In addition, as of the end of 2015, the SNRIU performed the state nuclear and radiation safety review of the following:

- reports including results of assessing all 14 safety factors and Chapter “Comprehensive Safety Analysis”, PSRR for SUNPP unit 2. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 14 safety factors and Chapter “Comprehensive Safety Analysis”;
- reports including results of assessing all 14 safety factors and Chapter “Comprehensive Safety Analysis”, PSRR for ZNPP unit 1. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 11 safety factors;

- reports including results of assessing all 14 safety factors and Chapter "Comprehensive Safety Analysis", PSRR for ZNPP unit 2. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 9 safety factors;
- reports including results of assessing 6 safety factors out of 14, PSRR of ZNPP unit 3;
- reports including results of assessing 7 safety factors out of 14, PSRR of RNPP unit 3. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 7 safety factors;
- reports including results of assessing all 14 safety factors and Chapter "Comprehensive Safety Analysis", PSRR for RNPP unit 4. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 9 safety factors;
- reports including results of assessing all 14 safety factors and Chapter "Comprehensive Safety Analysis", PSRR for KhNPP unit 2. When comments of the state nuclear and radiation safety review were considered by the operating organization, the SNRIU agreed the reports with the results of assessing 8 safety factors

Safety review of Ukrainian NPP units and activity of the operating organization on long-term operation is under regulatory control of the SNRIU.

4.3. NPP Operational Events in Ukraine (2000-2015)

One of key tools for ensuring safety of NPP operation and its further improvement is consideration of operating experience, which includes accounting and analysis of NPP operational events, corrective measures to eliminate detected causes and prevent recurrence of events.

NPP event is one of the most important indicators of operational safety level.

During 2015, 15 events occurred at 15 power units with water-cooled water-moderated reactors (WWER) under commercial operation. Events were not registered at Chornobyl NPP units that are at the decommissioning stage.

Figure 4.3.1 presents distribution of operational events at operating Ukrainian NPPs (without considering Chornobyl NPP) during 2000-2015.

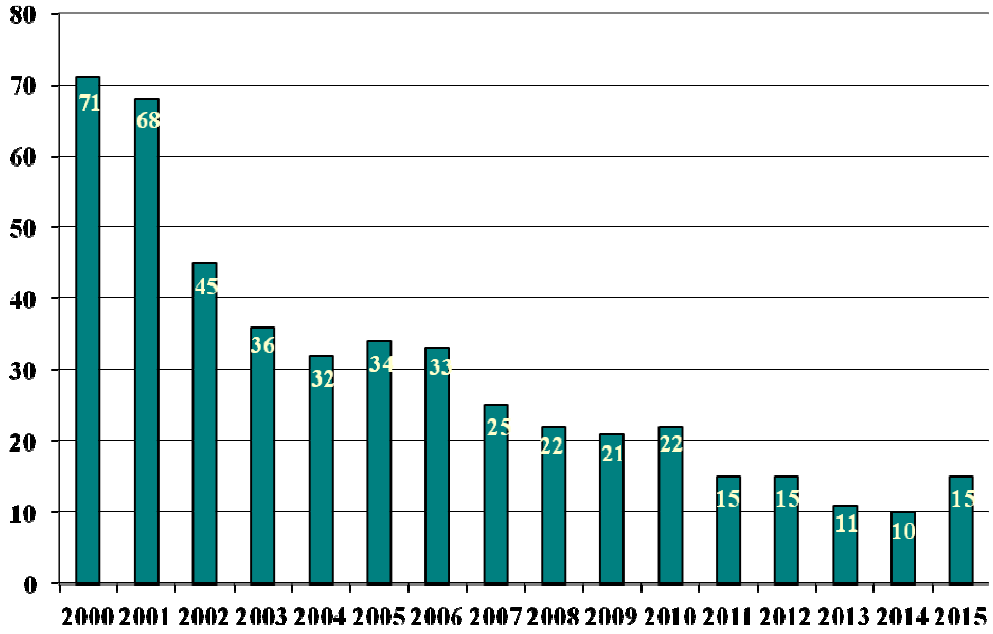


Figure 4.3.1. Number of operational events at Ukrainian NPPs in 2000-2015.

Figure 4.3.2 presents the distribution of events by NPP sites in 2000-2015.

The number of operational events in 2015 increased twice at ZNPP and KhNPP (and is the highest one at these sites for the last 5 years), at SUNPP increased thrice compared to the previous year. At RNPP in 2015, events did not occur.

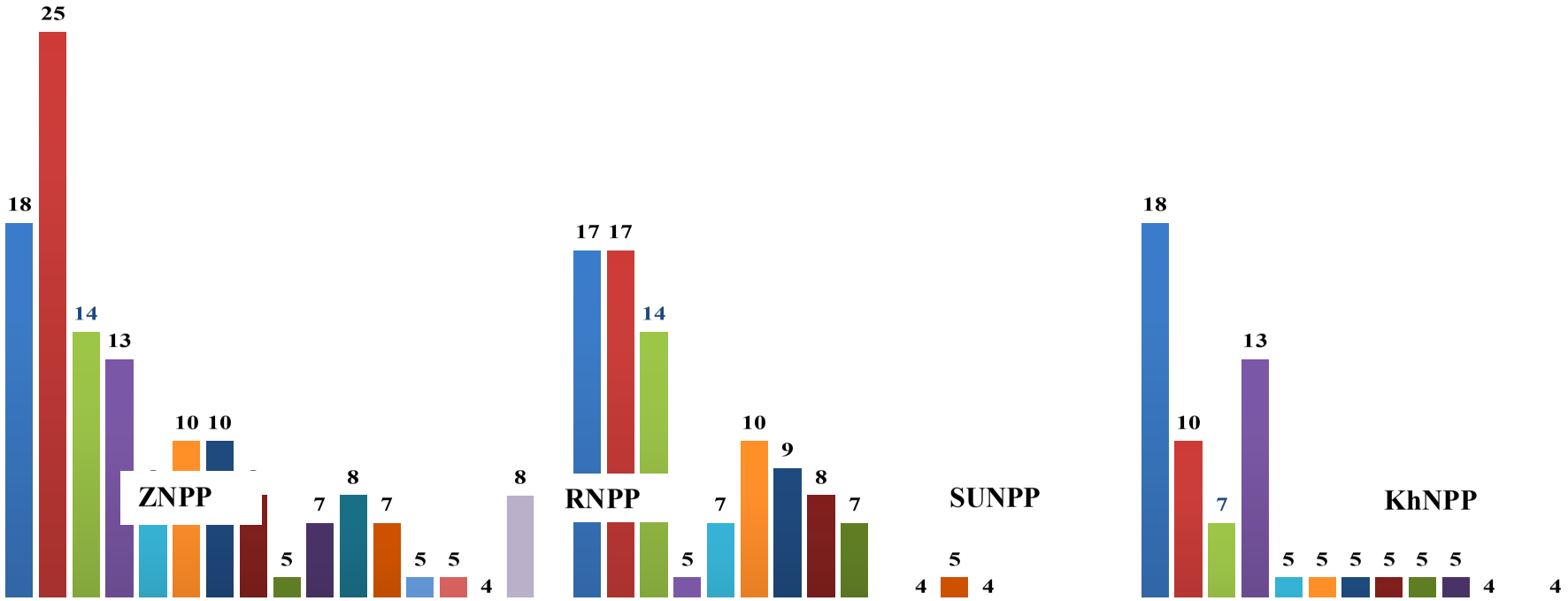


Figure 4.3.2. Distribution of events by NPP sites in 2000-2015.

According to the INES, the worldwide instrument developed to inform the public on significance of nuclear and radiological events for safety, Ukraine had no events higher than "below scale/level 0" (insignificant for safety) in 2015. Figure 4.3.3. presents the distribution of events at operating Ukrainian NPPs in 2000-2015 classified according to the INES.

Events resulting in personnel overexposure or release of radioactive materials to the environment, incompliance with safe operation boundaries and conditions did not occur in 2015. In addition, events related to inoperability of systems important to safety and events resulting in fall and/or damage of fuel assemblies and fuel rods did not occur.

Depending on features and consequences, NPP operational events in 2015 included the following:

- NPP unit unloading by 25 % and more – 7 events (47%);
- reactor shutdown with scram, preventive protection, power limiter – 2 events (13 % of general event number in 2015);
- power unit disconnection from the grid by emergency automatics – 3 events (20 %);
- failures of equipment and piping important to NPP safety – 3 events (20 %).

During an NPP operational event, there is deviation from normal operation (abnormal event) that may be caused by equipment failure, external hazard, human error or procedural drawbacks.

Figure 4.3.4 presents the distribution according to systems that failed or were affected during abnormal events in 2015.

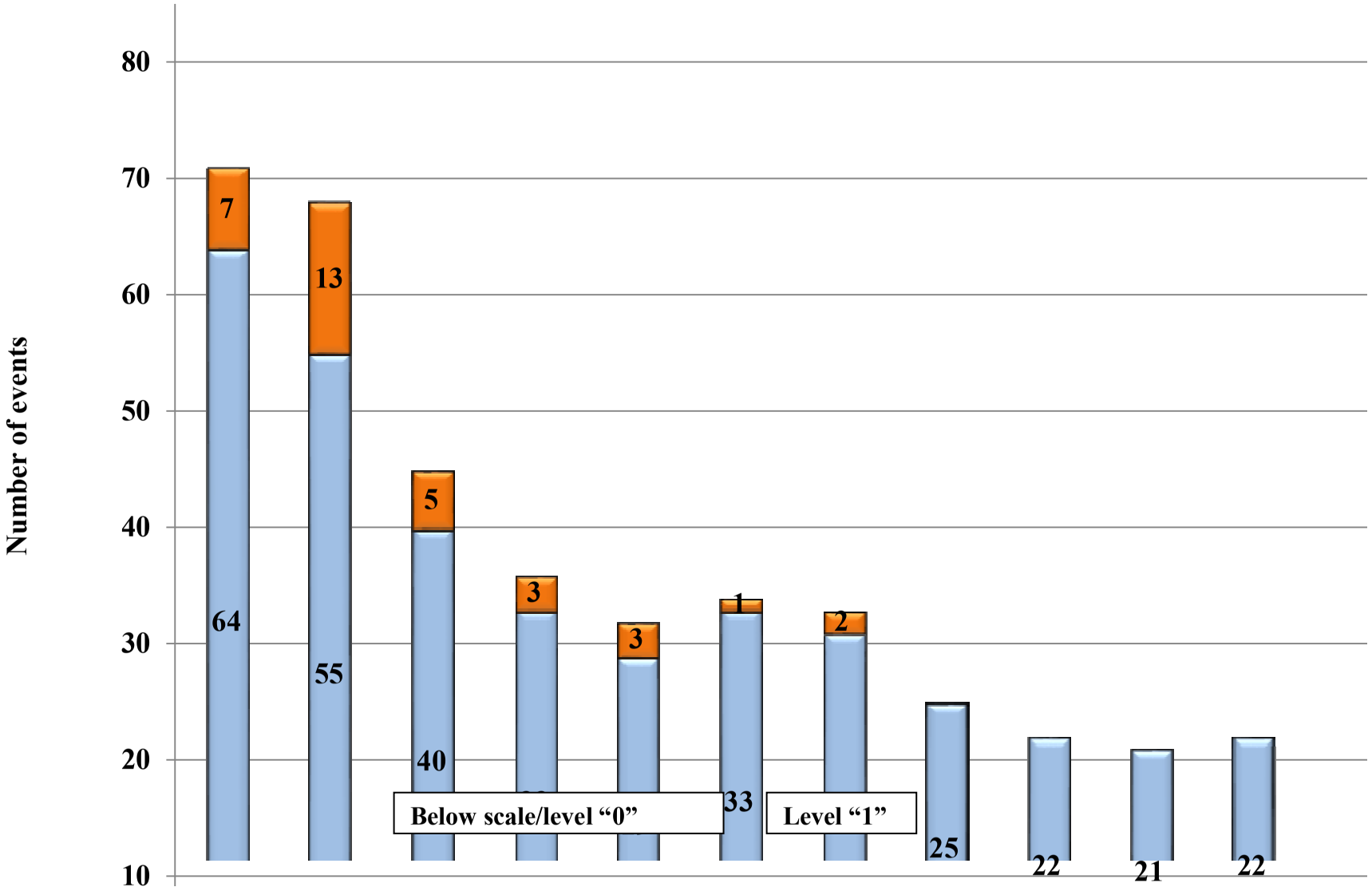


Figure 4.3.3. Distribution of event number at operating Ukrainian NPPs by the INES in 2000-2015.

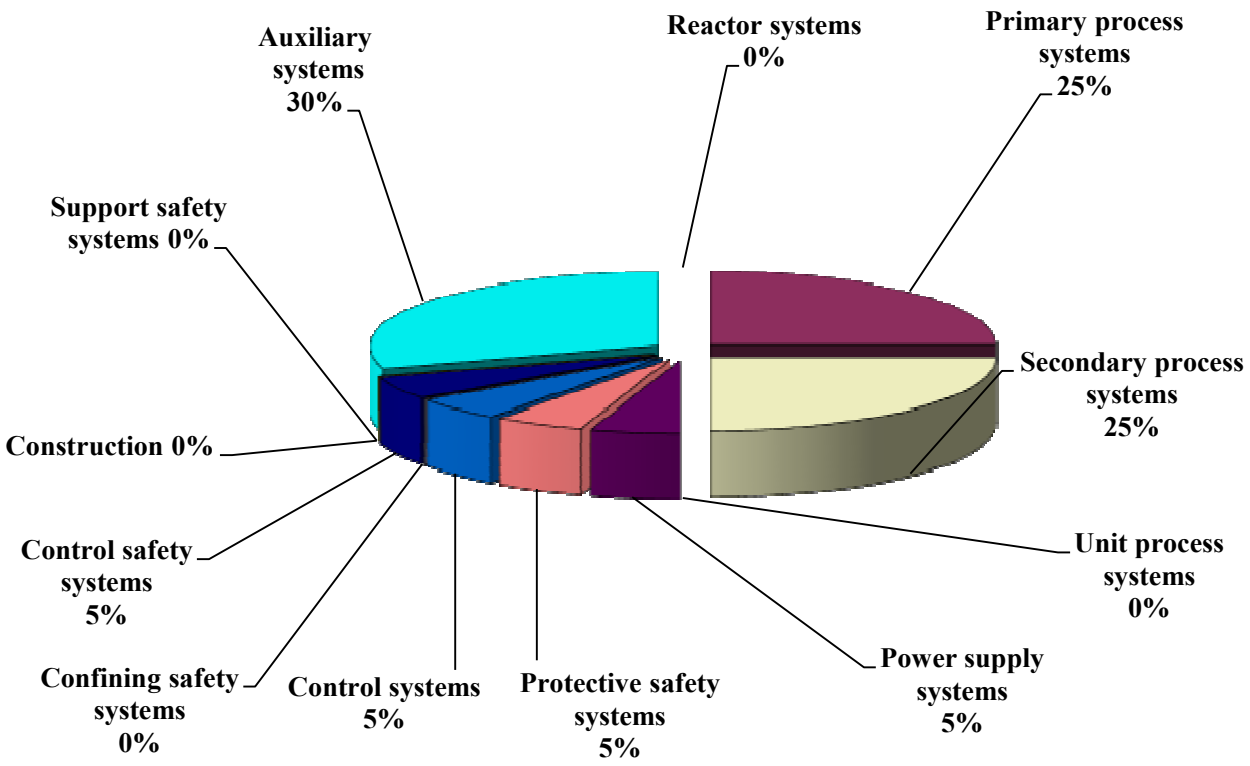


Figure. 4.3.4. Distribution according to systems that failed or were affected during abnormal events

In 2015, the most failures (30%) refer to auxiliary systems ensuring operability of the main systems' equipment. In addition, significant part (25% each) includes failures of secondary process systems, turbine building, and failures of primary process, reactor building.

Investigation of 15 NPP operational events occurred in Ukraine this year registered 20 abnormal events whose 25 root causes were determined. Figure 4.3.5 presents the contribution of each root cause group to general number of events in 2000-2015.

Causes related to equipment failures (52 %) contribute the most. A part of root causes related to documentation quality increased significantly (by 3.2) compared to the last year. Two causes in 2015 were not identified under event investigation (8%) and would be determined during scheduled outage. Although causes related to personnel and the management system has decreased (from 28 % in 2014 to 24 % in 2015) this index is still high enough.

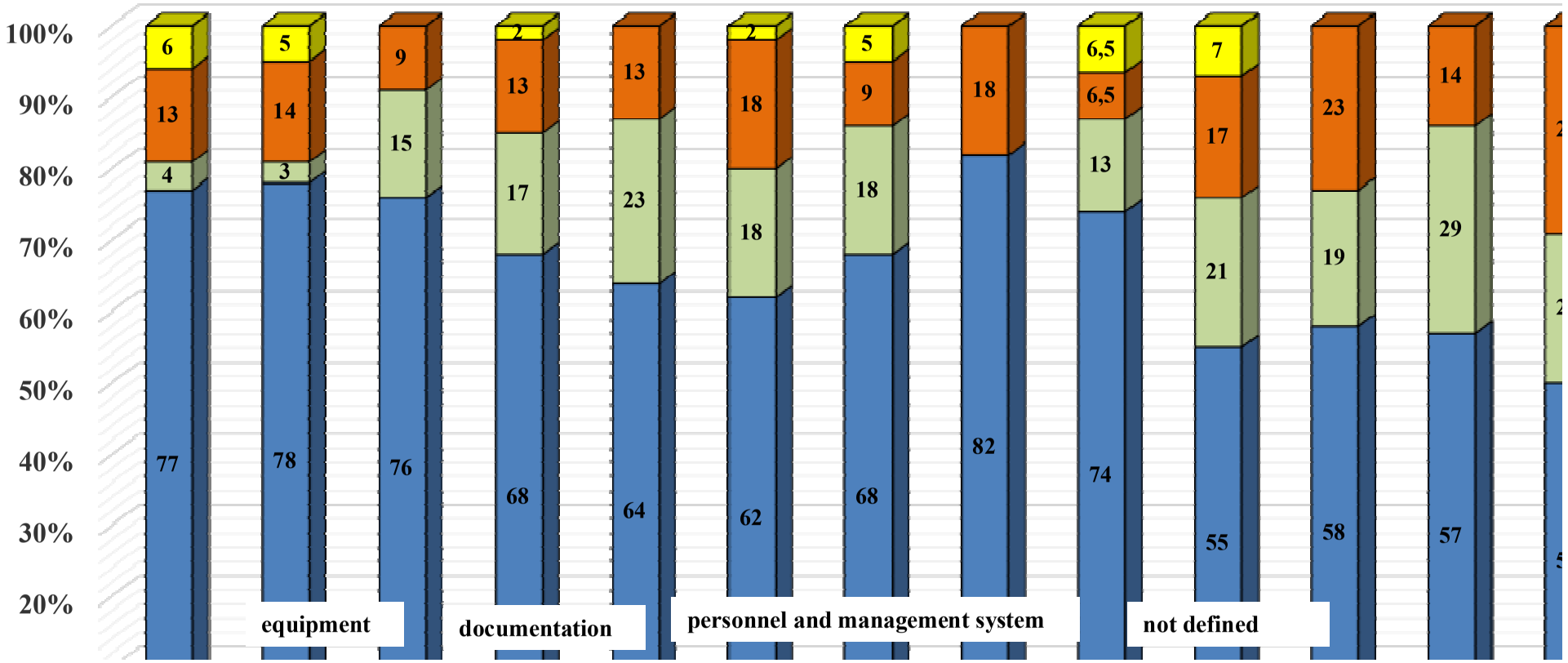


Figure 4.3.5. Distribution of root causes of abnormal events in 2000-2015.

4.4. Releases, Discharges into the Environment and Monitoring of Personnel Exposure Doses

4.4.1. NPP Radiation Impact

Impact of NPP radiological factors is assessed based on information on airborne releases and water discharges into the environment, internal and external doses of NPP personnel and radiological state of environmental objects in the NPP location area.

Radiation safety involves compliance with permissible limits of radiation impact on personnel, the public and the environment established in safety regulations, rules and standards. Radiation protection is a series of radiation health & safety, design & engineering and technical & and organizational measures aimed at ensuring radiation safety. Thus, radiation safety is a goal whose achievement is obligatory in NPP operation and radiation is means to achieve this goal.

NPP radiation protection includes a series of protective barriers on the path of radionuclides toward the environment. The values of airborne releases and water discharges from NPP characterize the state of protective barriers.

Effectiveness of NPP radiation protection is assessed by the following parameters of radiation safety:

- airborne release per 1000 MW of installed capacity;
- water discharge of radionuclides per 1000 MW of installed capacity;
- indexes of radioactive releases and discharges to the environment.

4.4.2. Radioactive Airborne Releases to Atmosphere

According to dynamics analysis, the total indexes of airborne radioactive releases from NPPs operated in 2015 to the environment remain minimally low being no more than one percent of permissible limits during last years.

RNPP and KhNPP mastered the guidance for a facility for monitoring of airborne tritium releases to the environments through NPP ventilation stacks and accepted it into commercial operation. The contribution of this radioisotope to the total release indicator was ~ 67% at RNPP and ~ 38% at KhNPP.

Fig. 4.4.1 graphically represents total index dynamics of airborne radioactive releases into the environment at NPPs operated during last 5 years.

Release indexes, %.

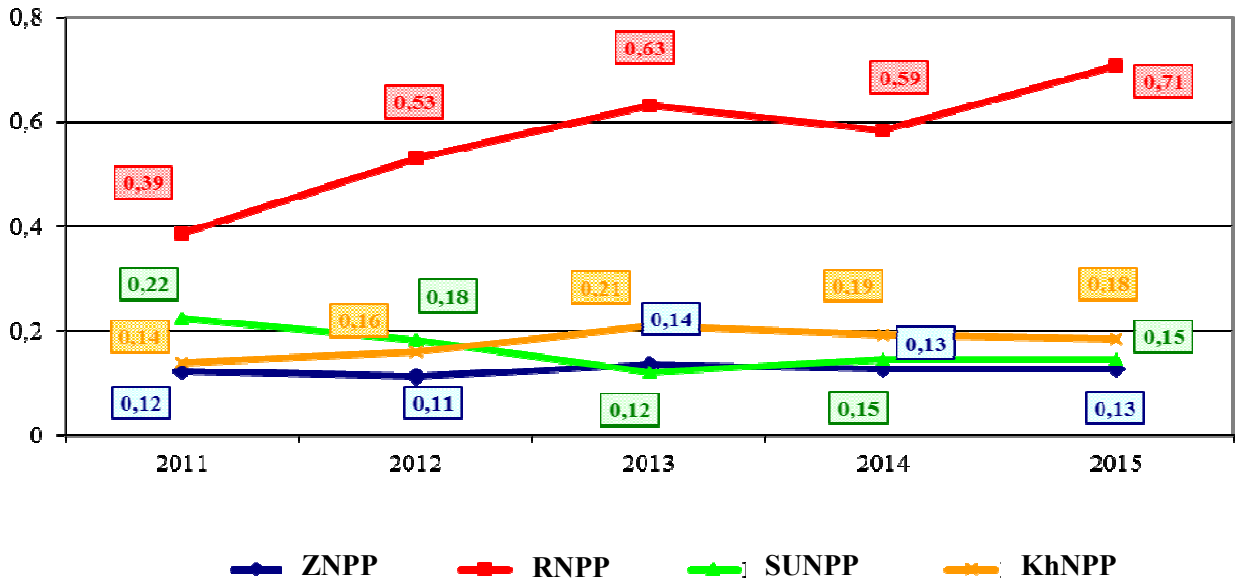


Fig. 4.4.1 Total index dynamics of airborne radioactive releases into the environment at NPPs operated during 2011 -2015

4.4.3. Radioactive Discharges to External Water Bodies

Radioactive discharges of radionuclides from operating nuclear power plants to external water bodies (cooling ponds) are mainly formed by residual waters from chemical demineralization tanks and blowdown essential spray ponds.

Table 4.4.1. presents the reference levels and boundaries of radioactive discharges to open water bodies that were valid at operating NPPs this year.

Table 4.4.1. Reference levels/boundaries for water discharges of reference radionuclides to open water bodies of operating NPPs (MBq/year)

Radionuclide	ZNPP	RNPP	SUNPP	KhNPP
^{137}Cs	364 / 91 000	2 640 / 83 000	1 188 / 16 000	170 / 41 000
^{60}Co	4 400 / 1 100 000	252 / 52 000	252 / 31 000	220 / 55 000
^{3}H	104 E+6/1900 E+6	26E+4 / 2400 E+6	31E+6 /120 E+6	8.0E+6/ 2000E+6

Figure 4.4.2. graphically represents total index dynamics of radionuclide discharges reliably recorded at NPPs during the last years.

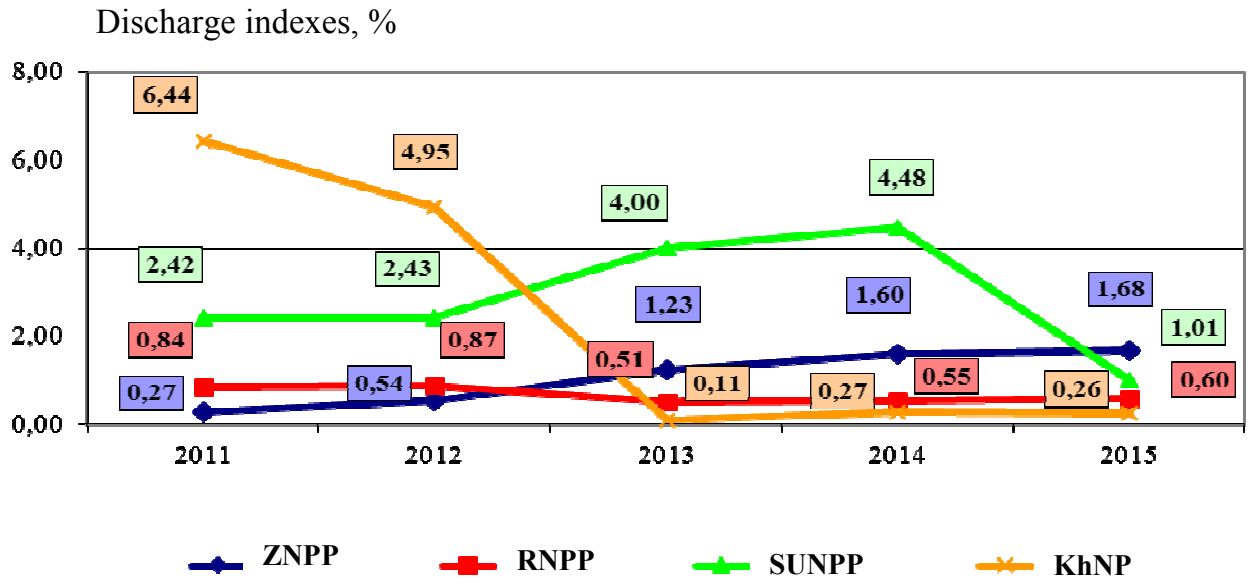


Figure 4.4.2 Total index dynamics of radionuclide discharges reliably recorded at operating NPPs during 2011-2015.

Table 4.4.2. presents indexes of separate radionuclides and total indexes of water discharges at operating NPPs into external water bodies in 2015.

Table 4.4.2. Indexes for water discharges of reference radionuclides to external water bodies in 2015 (%)

NPP	^{3}H	^{137}Cs	^{134}Cs	^{60}Co	^{90}Sr	^{54}Mn	*Total index*
ZNPP	1.495	0.059	0.089	0.006	0.027	0.002	***1.680***
RNPP	0.305	0.193	0.048	0.016	0.028	0.002	***0.595***
SUNPP	0.403	0.099	0.059	0.038	0.401	0.005	***1.007***
KhNPP	0.203	0.034	0.012	0.001	0.005	0.000	***0.255***

Radioactive water discharges to open ponds were not exceeded at any *Energoatom* NPP for 2015. The maximum index of radionuclide water discharge among operating NPPs was at ZNPP (1.68%).

4.4.4. Monitoring of personnel external doses

Individual dosimetry control is a part of radiation monitoring performed according to health and safety assessment of working conditions for personnel in the field of ionizing radiation.

Individual external doses of ZNPP, RNPP and SUNPP personnel were measured with the RADOS dose measurement system with RE-2000 readers and thermoluminescent dosimeters (with MCP-N gamma and beta detectors and MCP-6,7 neutron detector) and with Harshaw 8814/0110 thermoluminescent dosimeters at KhNPP.

For prompt monitoring of external doses, NPPs used DMC-2000S electron dosimeters (MGPI, France) in 2015.

Table 4.4.3. Administrative process (administrative) levels for individual effective doses of NPP personnel and reference levels for annual collective doses of NPP personnel with individual doses higher than 6 mSv/y (RL_6) and 15 mSv/y (RL_{15})

Plant	Administrative process levels for individual doses of personnel		Reference levels for annual collective doses of personnel, man Sv/year	
	Personnel, mSv/y	Women to 45 years of age, mSv	RL_6	RL_{15}
ZNPP	15.0 (18.5*)	-	4.50	1.80
RNPP	15.0 (19.0*)	1.90 (for two months)	3.60	0.83
SUNPP	15.0	1.40 (for two months)	3.30	0.48
KhNPP	14.0 (18.0*)	1.40 (for two months)	1.60	0.32

** - for personnel involved in hazardous radiological work*

For more informative comparison of collective exposure doses for NPP personnel during several years, and to minimize the impact of peak doses during scheduled outage on annual fluctuations of this index, Figure 4.4.3. presents the dynamics of collective exposure doses for one NPP unit as average values of this index for three years with trend line. The data cover the last ten years.

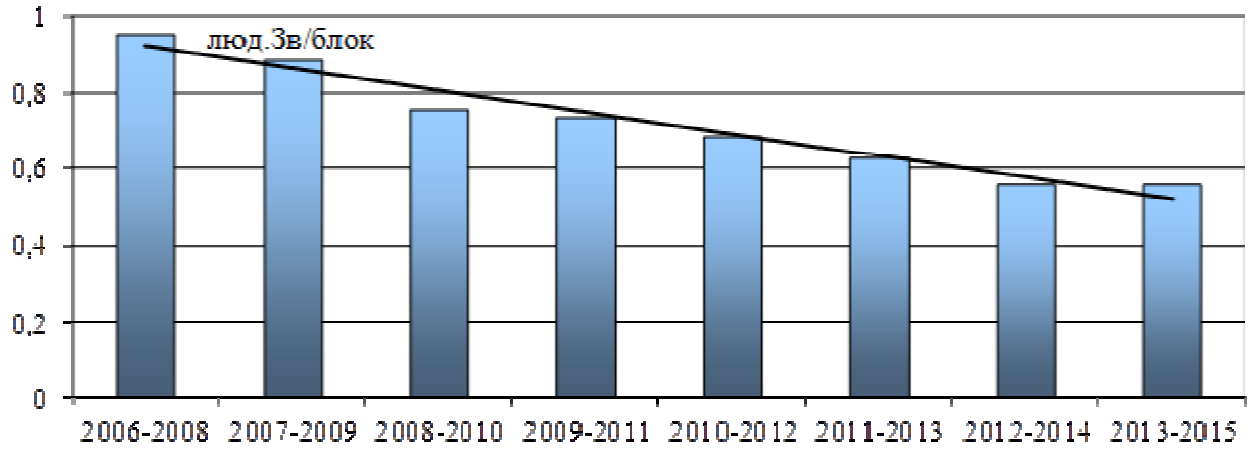


Figure 4.4.3. Dynamics of collective exposure doses for one NPP unit (*Energoatom* Company) as average values of this index for three years with trend line in 2006 – 2015

Diagram trend line shows general stable trend to decrease the index of average annual collective exposure doses for one NPP unit during the last ten years.

Average individual exposure doses for personnel at operating NPPs in 2015 were: ZNPP – 0.635 mSv/person per year, Rivne NPP – 0.512 mSv/person, SUNPP – 0.970 mSv/person, KhNPP – 0.343 mSv/person.

In 2015, the maximum average annual individual exposure dose for *Energoatom* personnel as in previous years was registered at SUNPP: 0.970 mSv/person per year representing 4.9% of the general annual limit for individual effective exposure dose for personnel, category A DL20 (20 mSv/year).

At ZNPP in 2015, the levels of collective and average individual exposure doses for personnel increased by 29.4 % compared to the previous year and represented correspondingly 3051.41 man mSv (2014 – 2154.29 man mSv) and 0.635 mSv/person per year (2014 – 0.448 mSv/person). Increase of collective exposure dose level for ZNPP personnel in 2015 is almost

caused by major repairs of unit 2 and 5, as well as repair of sealed surface of the main reactor connector. These activities were performed at ZNPP for the first time. In addition, a significant contribution to the total collective exposure dose for ZNPP personnel in 2015 was made by activities to remove leaks of the primary equipment at unit 1, spent fuel pool at unit 4 and other radiation hazardous activities during the year.

At RNPP, the level of personnel collective dose increased in 2015 (by 320.69 man-mSv) compared to the last year and was 2033.33 man-mSv, the level in 2014 was 1712.64 man-mSv. Average annual individual dose for RNPP personnel in the reporting year is 0.512 mSv/person per year and 0.459 mSv in 2014. Increase of RNPP personnel dose level results from four scheduled repairs of the NPP while in 2014 three repairs were performed, i.e. that increased scope of radiation hazardous activities were conducted.

The level of collective dose for SUNPP personnel increased in 2015 by 39.3 % compared to 2014 and was 3257.02 man-mSv (2014 - 1978.26 man-mSv). Average annual individual effective dose for SUNPP personnel also increased to 0.970 mSv compared to the previous year (0.642 mSv – 2014). Such increase of collective dose for SUNPP personnel in 2015 was caused by implementing a large scope of reconstruction activities aimed at long-term operation of unit 2 and resulted in involving significant number of SU NPP personnel and personnel of contracting organizations to conduct these activities.

In 2015, the level of annual collective doses for KhNPP personnel decreased by 35.7 % in 2015 compared to the last year and was equal to 935.09 man-mSv (1454.58 man-mSv – 2014). At the same time, average individual dose for KhNPP personnel in the reporting year was 0.343 mSv/person per year (2014 – 0.519 mSv/year).

During the reporting year, administrative and process levels of personnel individual doses, as well as reference levels of annual collective doses for personnel were not exceeded at any of the operating NPPs.

4.4.5. Monitoring of Personnel Internal Doses

Internal exposure was monitored by direct measurement of radionuclide activity in human body (critical organ) using human radiation spectrometers based on scintillation and semiconductor detectors with subsequent conversion of the results into expected effective dose according to a model proposed by ICRP-30.

Permissible levels of individual annual inhalation of radionuclides (ALI_A^{inhal}) established by NRBU-97 for category A personnel are 400 kBq/y for ^{131}I, 200 kBq/y for ^{60}Co, 100 kBq/y for ^{137}Cs and 200 kBq/y for ^{134}Cs.

Content of ^{137}Cs and ^{60}Co radionuclides in human body and lungs and of 131I in thyroid gland was monitored at all NPPs.

Table 4.4.4. shows distribution of individual internal doses and collective internal dose of operating NPP personnel in 2015.

Table 4.4.4. Number of persons who passed biophysical examination by SVL installation (taking into account personnel of outside organizations), distribution of annual individual doses and collective internal doses for personnel of NPPs and outside organizations in 2015

NPP	Number of monitored persons, persons/year	Number of persons with dose received in 2015 (mSv), persons					Collective internal dose, man-mSv
		< 1	1 - 2	2 - 6	6 - 20	> 20	

ZNPP	7319 (2130)*	7319	0	0	0	0	1.20
RNPP	4987 (509)	4987	0	0	0	0	-
SUNPP	3624 (1168)	3624	0	0	0	0	-
KhNPP	3837(1222)	3837	0	0	0	0	0.16
Energoatom	**19767 (5029)**	**19767**	**0**	**0**	**0**	**0**	**1.36**

( ) - personnel of other organizations*

Annual collective internal dose for these personnel at ZNPP in the reporting period was 1.20 man-mSv that was higher than in 2014 (1.08 man-mSv per year).

At RNPP, 789 cases of cesium-137 content and 95 cases of cobalt-60 content in critical organs above the MBA were registered for NPP personnel and personnel of outside organizations. Internal doses for these personnel were not calculated, since radionuclide content did not exceed the derivative monitoring level.

The annual collective internal dose for SUNPP personnel in 2015 was not calculated also, since the registered levels of cesium, cobalt-60 and iodine-131 content in monitored human organs did not exceed the MBA level.

At KhNPP in 2015, content of cobalt-60 in lungs above the MBA level was registered for ten persons from operating and repair personnel. Regarding eight of them, radionuclide intake was registered in previous years, as for the remaining two, cobalt in organism was detected for the first time. The annual collective internal dose for two persons of KhNPP personnel was 0.16 man-mSv (1.45 man-mSv in 2014).

4.4.6. Content of radioactive substances in the environment

Research regarding content of radioactive substances in environment objects within NPP location areas was conducted at all NPPs: water of surface water bodies, air, ground coating of adjacent settlements.

Analysis of cesium and strontium in water of NPP surface water bodies compared to "zero background" shows that these concentrations are values of the same order and may vary due to natural conditions: season, floods, drought, etc.

In 2015, tritium was monitored in water of ZNPP cooling ponds and adjacent water area of Kahovskyi reservoir, at RNPP, SUNPP and KhNPP in the Styr, Pivdennyi Bug and Goryn rivers.

The maximum values of tritium volume activity in ZNPP cooling pond was 98.6 kBq/m^3 representing the average level during the last years. At SUNPP, the maximum tritium values were registered in the Pivdennyi Bug river in front of the NPP 16.3 kBq/m^3, at the back of the NPP (control section) 20.0 kBq/m^3, in ZNPP cooling pond the maximum tritium concentrations were registered at the level of 133.0 kBq/m^3; in KhNPP cooling pond at the level of 91.0 kBq/m^3, in the Goryn river (in front of the NPP) 32.0 kBq/m^3, at the back of the NPP 54.5 kBq/m^3, and in the Styr river (Rivne NPP) in front of the NPP 7.1 kBq/m^3, at the back of the NPP 25.3 kBq/m^3.

The registered levels almost comply with the data in publications of the National Research Center for Radiation Medicine of the NAS of Ukraine whose experts monitor tritium in the country during the last years.

4.4.7. Content of Radioactive Materials in the Air and Surface Soil Layer

At all *Energoatom* NPPs, the air contamination by radioactive aerosols was monitored by the aspiration technique using filtering installations mounted at radiation monitoring points. Aerosol sampling was performed by air pumping through filter fabric.

Table 4.4.5. Density of surface ground layer contamination by cesium-137 at radiation monitoring points at a distance from operating NPPs in 2015, Bq/m^2

NPP	*"Zero background"*	Control area	Control area 10 km	10-20 km	> 20 km
ZNPP	*1180*	190	170	110	100
RNPP	*444 – 5070*	1050	3790	4770	2710
SUNPP	*1376*	291	235	277	324
KhNPP	*1180*	187	358	278	455

As the table shows, the density levels of soil contamination are within "zero background" values. The highest levels of soil contamination were registered in NPP location area that may be explained by uneven nature of the radioactive fallout caused by the Chernobyl accident.

Radiation parameters characterizing operation of NPPs in 2015 did not exceed the standard values and radiation protection of personnel and the public was provided at appropriate level.

5. IMPLEMENTATION OF NEW NUCLEAR FACILITY DESIGNS

Ukraine currently implements construction projects of several new nuclear facilities:

- Khmelnytsky NPP Units 3 and 4;
- Nuclear Fuel Fabrication Plant;
- Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator;
- Centralized Spent Fuel Storage Facility (see para. 6.2.);
- Dry-type Interim Storage Facility for Spent Fuel at Chornobyl NPP (see para. 6.2.).

5.1. Construction of Khmelnytsky NPP Unit 3 and 4

Taking into account that Ukraine almost two years has been confronting Russian aggression, the efforts on the construction of Khmelnitsky NPP units 3 and 4 according to Russian design have been suspended.

The construction of Khmelnytsky NPP units 3 and 4 was suspended after the feasibility study for construction of these units had been developed and approved in accordance with the established procedure by Cabinet Resolution No. 498-r dated 4 July 2012 and the Verkhovna Rada of Ukraine had adopted Law No. 5217-VI dated 06 September 2012 "On Siting, Design and Construction of Units 3 and 4 of Khmelnytsky Nuclear Power Plant".

This is related to the fact that the mentioned documents were based on the Russian design of the reactor for KhNPP units 3 and 4.

Taking into account the political relations between Ukraine and the Russian Federation, the Verkhovna Rada of Ukraine adopted the Laws of Ukraine (the drafts were approved by the SNRIU) on 16 September 2015:

- "On Declaring Invalid the Law of Ukraine "On Siting, Design and Construction of Units 3 and 4 of Khmelnytsky Nuclear Power Plant";
- "On Cancellation of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation to Cooperate on Construction of Khmelnytsky NPP Units 3 and 4".

After approval of the "Conceptual Decision on Construction of Khmelnytsky NPP Units 3 and 4" on 17 October 2014, *Energoatom* Company performed efforts in 2015 on the construction of Khmelnytsky NPP units 3 and 4 using WWER-1000/V-320 design of AT Skoda JS a.s. (Czech Republic):

- feasibility study revision;
- preparation of the draft Law of Ukraine on Amending the Law of Ukraine No. 5217-VI "On Siting, Design and Construction of Units 3 and 4 of Khmelnytsky Nuclear Power Plant";
- development of technical requirements for the reactor.

According to results of the above measures, *Energoatom* Company developed the document "Technical Requirements for WWER-1000 for Khmelnytsky NPP Units 3 and 4", whose state review was performed in 2015 by the SNRIU. At the same time, the stated document is under review to check completeness and correctness regarding comments of the state review of nuclear and radiation safety.

5.2. Construction of Nuclear Fuel Fabrication Plant

In compliance with legislation, construction of a nuclear fuel fabrication plant (and any other nuclear installation) can be started only under a license issued by the SNRIU for construction and commissioning. In turn, two main conditions for issuing this license is agreement of the preliminary safety analysis report (PSAR) by the SNRIU and approval of the design for this nuclear installation by the Cabinet of Ministers of Ukraine.

PSAR of the Plant was approved in accordance with SNRIU Board Resolution No. 18 of 4 December 2013, and in spite of the positive expert review report on the design documentation "Construction of Nuclear Fuel Fabrication Plant", No. 00-1085-13/PB, submitted by Ukrderzhbudekspertyza on 12 December 2013, the design of this nuclear installation was not approved in 2014-2015.

Considering the above mentioned and expired maximum deadline for consideration of applications of 24 November 2015, the SNRIU did not issue the license for construction and commissioning of the nuclear fuel fabrication plant since the design of this nuclear installation has not been approved and thus, there were no bases to issue such a license.

5.3. Construction of Neutron Source Based on Subcritical Assembly Driven by Linear Electron Accelerator

The Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator (Neutron Source) is being constructed on premises of the National Scientific Center "Kharkiv Institute of Physics and Technology" (KIPT) in accordance with the agreement reached at the Washington Security Summit and outlined in the Joint Statement of the Presidents of Ukraine and USA in April 2010 and Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America on nuclear safety cooperation signed on 26 September 2011. The Neutron Source is under construction with support of the U.S. Argonne National Laboratory.

The Neutron Source is intended for scientific study and applied research in the fields of nuclear physics, radiation material science, biology, chemistry and production of medical radioisotopes. The Neutron Source was described in detail in the "Report on Nuclear and Radiation Safety in Ukraine for 2012".

This nuclear installation is created under SNRIU License EO No. 001018 for construction and commissioning issued on 10 October 2013.

According to the conditions of the above license, NSC KIPT as the operator, performed during 2013-2016 construction and mantling, development and agreement with the SNRIU of technical specifications for equipment important to safety and operating documentation of the Neutron Source.

In addition, the operator should obtain three individual permits within this license for:

- the first import of nuclear fuel for the Neutron Source to the territory of NSC KIPT industrial site;
- initial criticality of the Neutron Source;
- trial and commercial operation of the Neutron Source.

6. NUCLEAR FUEL MANAGEMENT

6.1. Diversification of Nuclear Fuel Supply

In order to diversify the supply of nuclear fuel and avoid dependence on the monopoly supplier, Energoatom has taken measures since 2000 on the development, delivery and qualification of an alternative supplier of nuclear fuel, compatible with Russian-design fuel. These measures are taken within the Implementing Agreement between the Government of Ukraine and the Government of the United States of America on "Nuclear Fuel Qualification Project for Ukraine" signed on 5 June 2000.

In preparation for the implementation of the Qualification Project, in 1999, the Core Design Center was established on the premises of KIPT, to which Westinghouse transferred technologies for design of nuclear fuel and reactor cores and guidance for safety analysis. Experts of the center successfully passed training and internship in the USA.

In the first phase of the Qualification Project in 2005–2009, trial operation of six pilot fuel assemblies manufactured by Westinghouse (FA-W) was conducted at SUNPP unit 3 during four fuel campaigns. In addition, the computer system for the in-core monitoring system was assembled and put into operation.

Since March 2010, in the framework of the second phase of the Qualification Project, trial operation of the reload batch consisting of 42 FA-W was started.

On 30 March 2008, a contract for supply of nuclear fuel for annual reloading of three WWER-1000 units in 2011 ÷ 2015 was signed between Energoatom and Westinghouse Electric Sweden AB (Västerås, Sweden).

In 2011 ÷ 2012, under the contract and with potential extension of the FA-W trial operation, four batches of nuclear fuel were supplied; two of them were loaded into the reactor cores of SUNPP units 2 and 3 in 2011.

In 2012, during scheduled outages, certain complications occurred during reloading of mixed cores at SUNPP units 2 and 3, which were caused by design features of fuel assemblies from both suppliers (TVEL and Westinghouse) that formed the core, namely:

- FA-W with damaged spacer grids were revealed;
- reactor cores could not be loaded as planned.

In this connection, further extension of Westinghouse fuel operation under the contract was suspended. Beginning from 2013, FA-W operation continued only in the SUNPP-3 core. According to the work program for FA-W trial operation, all fuel assemblies in the core were subjected to visual examination and integrity check using regular instrumentation of the power unit during each scheduled outage. Part of FA-W was inspected in more detail with use of the inspection and maintenance test bench supplied by Westinghouse.

At the end of 2014, four-year operating cycle expired for a number of FA-W, i.e., the full cycle envisaged by design documentation. Inspection of these fuel assemblies, including integrity check, revealed no issues.

Therefore, it can be noted that no loss of integrity was revealed during operation of Westinghouse reload batch during 2010÷2014, in spite of the damage of spacer grids during handling operations.

After the events in 2012, in order to recommence FA-W trial operation, Energoatom and Westinghouse, upon agreement with the SNRIU, identified a series of measures, including required upgrades and modification of fuel assembly design.

In 2013÷2014, Westinghouse upgraded the fuel assembly design and conducted comprehensive testing of the upgraded assembly (FA-WR).

Licensing of the upgraded assemblies was started in parallel. For this purpose, Energoatom and Westinghouse developed a full package of justification documents, which was strictly required by Ukrainian NRS regulations, and submitted it to the SNRIU for review. The first stage of this processes completed with an authorization issued by the SNRIU for loading of batch consisting of 42 FA-WR into the SUNPP-3 core in 2015.

The first phase of this process resulted in receiving SNRIU permit for loading of a reload batch of 42 FA-WR into the core by the operator at SU NPP unit 3 in 2015 according to the established procedure.

Thus, trial operation of 42 FA-WR (the first year of operation) and 36 FA-W (the fourth year of operation) was conducted during 2015 at SUNPP unit 3.

It is necessary to note that the capability of Westinghouse Electric Sweden AB to ensure required quality of production to be supplied to Ukrainian NPPs was confirmed by the Energoatom commission that provided in August 2014 the audit of quality control system of this company and acceptance of the FA-WR batch for SUNPP unit 3. A representative of SSTC NRS, technical support organization of the regulatory body, was delegated to the commission board according to the SNRIU order.

During the reporting period, Energoatom also developed and agreed with the SNRIU a set of documents justifying possible extension of trial operation of this fuel for 2016-2017 at Zaporizhzhya NPP units 1, 3, 4, 5 and South Ukraine NPP unit 2. Final decision will be made only conditioned that FA-WR inspection results are positive after the first year of operation (during scheduled outage in 2016) at South Ukraine NPP unit 3.

6.2. Spent Nuclear Fuel Management Facilities

Spent nuclear fuel (SNF) generated during electricity production in nuclear reactors is an important component of the NPP process cycle.

The period for which nuclear fuel is used in the reactors is determined by allowable burnup of fissile isotopes. After planned burnup is reached, nuclear fuel is unloaded from the reactor and is considered spent fuel since it cannot be used directly to produce electricity.

After unloading from the core, SNF is placed into spent fuel pools (SFP). SNF is cooled down in these pools for a period needed to decrease residual heat resulting from radioactive decay of fission products to allowable values. When SNF is stored in SNP for a limited time, spent fuel assemblies (SFAs) are to be removed from the NPP unit and sent for storage (disposal) or processing. This is done because the capacity of NPP SFPs is limited and they must always have free volume for nuclear fuel unloading from the core or periodic inspections of the WWER reactor pressure vessel and internals.

At the same time, factors that are determined by specific features of SNF are to be taken into account in its management: high radioactivity and presence of valuable elements in SNF (uranium, plutonium, germanium, erbium, palladium, zirconium etc.), which can be used prospectively, including that in other nuclear cycles (nuclear fuel for fast neutron reactors, MOX fuel for light-water reactors). Considering the above mentioned, SNF is not considered radwaste.

The state of nuclear energy all over the world shows that, given the current development of technologies, one cannot make ultimate conclusions on economic feasibility of SNF reprocessing or disposal, i.e., on the final stage in the nuclear fuel cycle (NFC). In this regard, Ukraine, like most countries with developed nuclear energy, accepted the so-called deferred decision, providing for long-term SNF storage. The postponed decision allows deciding on the final NFC stage later to benefit from the development of global technological and national economic feasibility.

Ukraine currently operates two interim spent fuel storage facilities: wet-type spent fuel storage facility – ISF-1 at the Chornobyl NPP – and dry-type spent fuel storage facility – Zaporizhzhya ISF.

In addition, two other storage facilities are under construction in Ukraine: dry-type interim spent fuel storage facility – ISF-2 at Chornobyl NPP – and centralized spent fuel storage facility of national NPPs with WWER – centralized ISF.

6.2.1. Management of WWER Spent Nuclear Fuel

The ZNPP was the first plant that had to deal with a lack of space for spent fuel in NPP SFP. To solve this issue, ZNPP started implementation of Zaporizhzhya ISF project in 1996.

Zaporizhzhya ISF design is based on the licensed and repeatedly tested spent fuel storage technology of Duke Engineering & Services (USA). SNF is stored as follows: 24 fuel assemblies with low decay heat (<1 kW) after five-year cooling in SFP are placed into a special canister, which is filled with helium (inert gas with high thermal conductivity) and sealed, then the canister is placed into a ventilated concrete storage cask (VSC). The storage facility is designed for 380 VSC, which may contain 9000 spent fuel assemblies.

The first stage of Zaporizhzhya ISF for 100 VSC was commissioned in 2001, and the second stage for 280 VSC - at the end of 2011.

Zaporizhzhya ISF

As of 01 January 2016, **131** VSC are placed at Zaporizhzhya ISF site.

During 2015, the SNRIU reviewed and approved six technical decisions “On the Content of Multiple Sealed Canisters with Spent Nuclear Fuel”.

Besides, in October 2015, the SNRIU started review of the periodical safety review Report of Zaporizhzhya ISF.

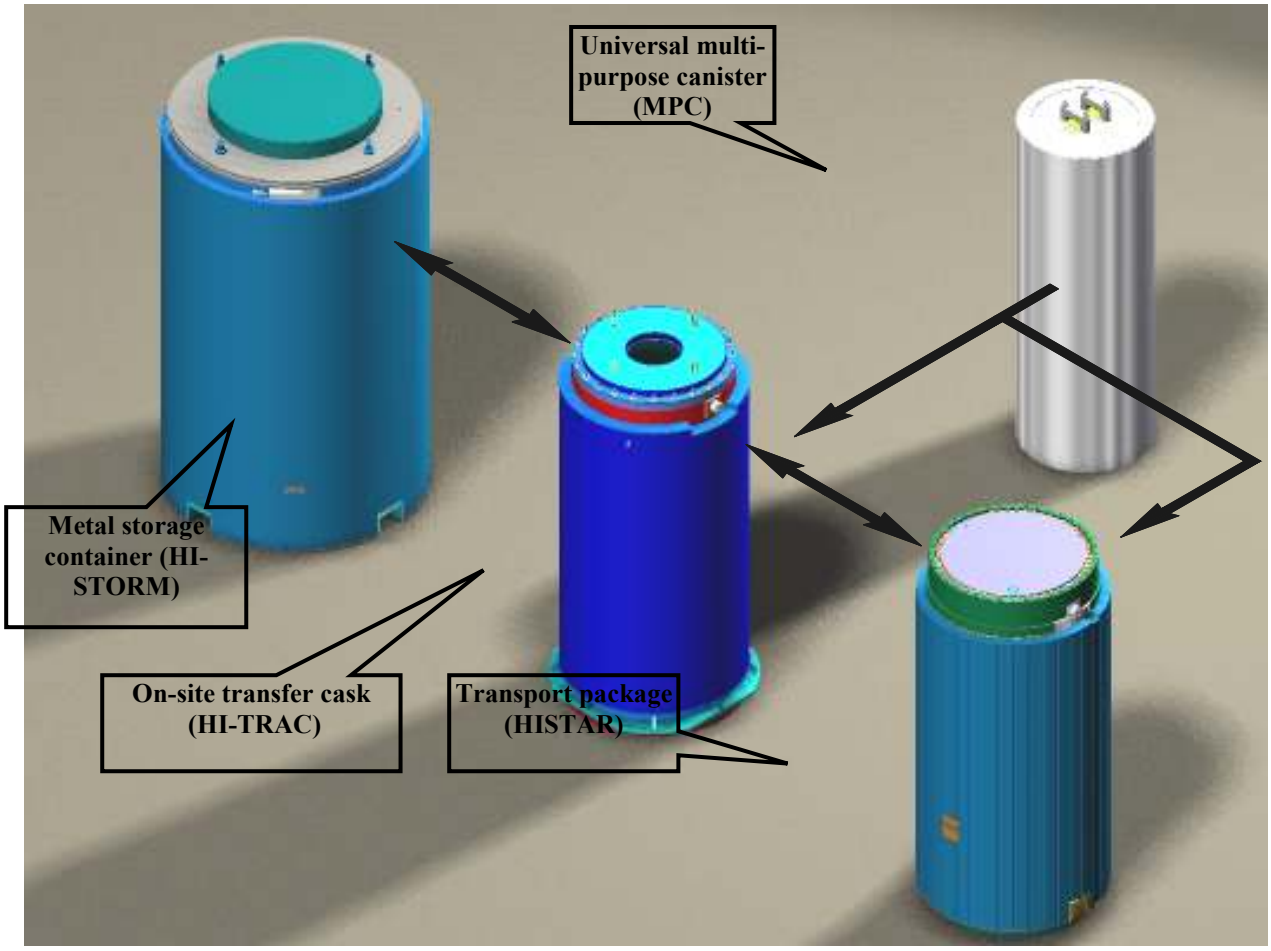
SNF from the Rivne, Khmelnytsky and South Ukraine NPPs is currently transported to the Russian Federation. WWER-1000 spent fuel was sent for storage and WWER-440 spent fuel (RNPP-1, 2) for reprocessing.

To implement the “Action Plan for 2006-2010 for Implementation of the Energy Strategy of Ukraine until 2030” (approved by Cabinet Resolution No. 427 of 27 July 2006), Energoatom concluded a contract with U.S. Holtec International for construction of a

centralized storage facility in Ukraine to accept spent fuel from the Rivne, Khmelnytsky and South Ukraine NPPs employing the dry storage technology proven at the Zaporizhzhya NPP.

In compliance with legislative requirements, Energoatom developed the "Feasibility Study for Investments into Construction of the Centralized Spent Fuel Storage Facility (centralized ISF) of the National WWER Nuclear Power Plants". The Feasibility Study was approved by Cabinet Resolution No. 131-r of 4 February 2009 after comprehensive regulatory review.

The Feasibility Study proved that long-term spent fuel storage in Ukraine was economically sound as compared to fuel transfer to the Russian Federation and justified the construction of one centralized spent fuel storage facility as compared to any other spent fuel storage options.



Centralized ISF main equipment

It is planned to store 12.500 WWER-1000 spent fuel assemblies and WWER-440 4000 spent fuel assemblies for 100 years in the centralized ISF.

On 9 February 2012, the Verkhovna Rada of Ukraine made a decision on centralized ISF siting in the Exclusion Zone and its design and construction by adopting Law of Ukraine No. 4383VI "On Management of Spent Nuclear Fuel in Siting, Design and Construction of Centralized Spent Fuel Storage Facility of National WWER Nuclear Power Plants".

On 30 April 2013, the SNRIU agreed the Energoatom document "Statement of Work on Upgrading the Technology of Spent Nuclear Fuel Unloading from WWER-1000 (M V-320) for Transfer to centralized ISF".

On 23 April 2014, Cabinet Resolution No. 399-r authorized Energoatom to develop a land utilization project and to allocate lands with a total area of 45.2 ha between the former villages of Stara Krasnitsa, Buryakivka, Chystohalivka and Stechanka of the Kyiv region in the

Exclusion Zone affected by the Chornobyl area to transfer them subsequently to Energoatom for permanent use with change of their purpose for the construction of centralized ISF and access railway.

On 22 July 2015, the SNRIU agreed the amended "Licensing Plan for Construction of the Centralized Spent Fuel Storage Facility" (PN-D.0.46.527-15) developed instead of PN-D.0.46.527-11.

On 23 July 2015, the SNRIU agreed the Operator's proposals on the content of the explanatory note "Construction Project for the Centralized Spent Fuel Storage Facility for Ukrainian NPPs with WWER" and submitted recommendations for centralized ISF design.

On 12 October 2015, a management committee was formed according to Energoatom Ordinance No. 926 for implementation of Holtec International technology for SNF management at Rivne, Khmelnytsky, South Ukraine NPPs that includes one representative from the SNRIU and SSTC NRS.

On 24 December 2015, the SNRIU sent to the State Enterprise "Specialized State Expert Organization - Central Service for Ukrainian State Construction Review" UKRDERZHBUDEXPERTYZA a Conclusion of the State NRS Review on the design of "Access Railway from Current Branch Railway Line Vilcha-Yaniv to the Construction Site of the Centralized Spent Fuel Storage Facility (centralized ISF)".

Since 28 December 2015, the SNRIU started review of technical specifications for the systems and equipment important to safety at the centralized ISF submitted by Energoatom according to the "Licensing Plan for Construction of the Centralized Spent Fuel Storage Facility".

In addition, SNRIU experts participated during 2015 in meetings of the management committee for implementation of Holtec International technology for SNF management at Rivne, Khmelnytsky, and South Ukraine NPPs that was formed according to Energoatom Ordinance No. 926 of 12 December 2015.

6.2.2. Management of RBMK Spent Nuclear Fuel

The RBMK design envisaged the following sequence of spent fuel management:

- after operation in the reactor, fuel was to be reloaded into SFPs to be cooled down for at least 1.5 years to reduce radioactivity and decay heat;
- after cooling in SFP, RBMK fuel should be sent to a wet-type spent fuel storage facility.

As of 01 January 2016, 21.284 spent fuel assemblies are stored on the Chornobyl NPP site. Among them:

- 21,231.5 spent fuel assemblies stored in ISF-1 SFP;
- 32 damaged fuel assemblies stored in unit 1 SFP;
- 20.5 damaged fuel assemblies stored in unit 2 SFP.

ChNPP unit 3 has no spent fuel, and further use of its SFP for spent fuel is not envisaged. In this connection, on 7 December 2012, the SNRIU agreed the ChNPP decision "On Recognition of Power Unit 3 as Radioactive Waste Management Facility". Therefore, ChNPP unit 3 has been regarded as a radwaste management facility since 8 December 2012.

There is no fresh nuclear fuel on the ChNPP site.

ISF-1 is operated under SNRIU License EO No. 000859 for operation of the nuclear installation – spent fuel storage facility of 25 June 2008.

ChNPP ISF-1

The Chornobyl NPP operator currently makes efforts to implement:

- Action Plan to Improve ISF-1 Safety, agreed by the SNRIU on 24 June 2008;
- Action Plan to Improve Safety of ChNPP Nuclear Installations approved by the SNRIU on 12 December 2011;
- Action Plan for Stabilization, Transfer and Storage of Special Canisters with Damaged Spent Nuclear Fuel agreed by the SNRIU on 25 March 2014 (in accordance with this Action Plan, it is planned to transfer and store damaged fuel assemblies from unit 1 and 2 SFPs to ISF-1 SFP in 2015-2016).

ISF-1 SFP room

In the framework of the stated above in 2015, the SNRIU reviewed and agreed the following documents:

- "Technical Decision for Modification of Storage Diagram for Damaged Spent Nuclear Fuel in Spent Fuel Storage Facility (ISF-1)";
- "Technical Decision for Modification of Mounting Diagram of Stocks for Damaged Spent Nuclear Fuel Management in 2 Assembly Cooling Pool-2 at ChNPP Unit 2";
- "Technical Decision on Modification of Diagram for Spent Fuel Storage in ISF-1 in Leak of Trench or One of Spent Fuel Pool Sections".

Resulting from these measures implementation, the operator performed ISF-1 safety review. The review results were presented in ISF-1 Safety Analysis Report Version 3.02, the conclusion of its state NRS review was approved by the Resolution of SNRIU Board No. 5 of 02 June 2015.

At the same time, the ISF-1 lifetime determined upon safety review in 2011 expires at the end of 2025. Therefore, a new dry-type interim storage facility (ISF-2) is under construction to ensure long-term safe storage of all spent fuel on the ChNPP site.

ISF-2 is being constructed under SNRIU License EO No. 001002 for construction and commissioning of the nuclear installation (interim spent fuel storage facility (ISF-2)) of 20 February 2013.

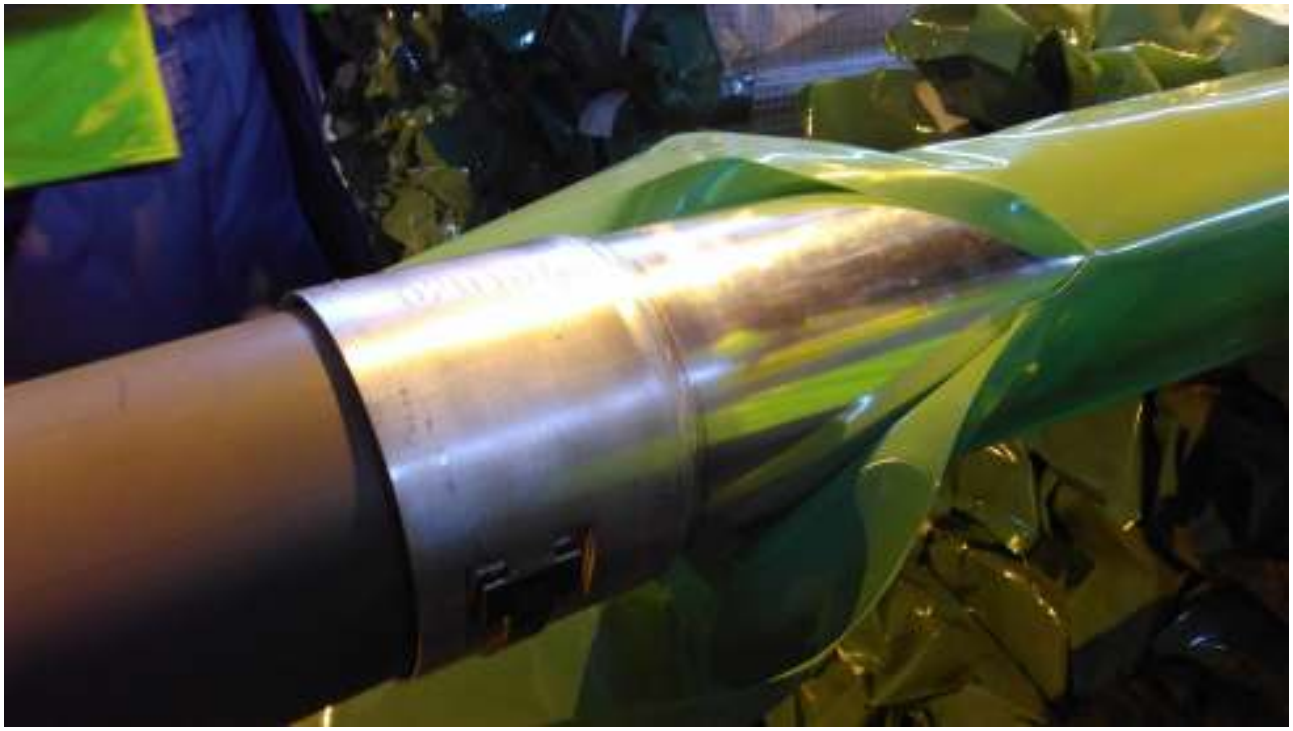
ISF-2 construction site

SNF management algorithm envisaged in ISF-2 design was presented in detail in the Report on Nuclear and Radiation Safety State in Ukraine in 2014.

During 2015, Chornobyl NPP continued development and agreement of packages of technical specifications (TS) and design documentation for the systems and equipment important to safety according to the established procedure. According to ISF-2 design, the following should be developed:

- 41 packages of TSs for equipment important to safety, 41 of which were preliminarily agreed by the SNRIU as of 01 January 2016 (14 were agreed in 2015);
- 7 TSs for the systems important to safety, all of which were preliminarily agreed by the SNRIU as of 01 January;
- 36 programs of acceptance testing of equipment important to safety, 22 of which were agreed by the SNRIU as of 01 January 2016 (20 of them were agreed in 2015); participation of SNRIU representatives in 12 acceptance tests was envisaged.

The first five double-walled shielded canisters at ISF-2 site



Fuel cartridges for spent fuel assemblies in double-walled shielded canisters

Besides, in 2015 the SNRIU experts developed and agreed according to the established procedure an Agreement on Amendment No. 1 to Agreement on Grant (ChNPP nuclear safety project) between the European Bank for Reconstruction and Development (as the Administrator of Grant funds of the Nuclear Safety Account), the Cabinet of Ministers of Ukraine and the State Nuclear Regulatory Committee of Ukraine (as a Receiver) of 8 July 2009" approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1072-r of 13 October, 2015.

ISF-commissioning is planned in the 4th quarter of 2016.

6.3. Transport of Nuclear Fuel and Radioactive Materials

An important sphere of nuclear energy use is transport of radioactive materials to be used in nuclear energy, industry, medicine during radwaste management.

Radioactive materials are transported through public roads, thus, it is necessary to ensure conditions during transport that exclude impact of hazardous factors typical for radioactive materials on personnel, the public and the environment. In order to achieve this objective, administrative and technical measures should be taken such as licensing of radioactive material transport, issuing permits for international transport of radioactive materials, inspections, approval of package design and special conditions for radioactive material transport.

Radioactive material transfer is licensed according to the Law of Ukraine "On Authorizing Activity in Nuclear Energy Use". In 2015, the SNRIU issued, amended and revised 17 licenses. 47 enterprises have licenses for radioactive material transport.

The SNRIU issues permits for international transport in accordance with the procedure approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1196 of 3 October 2007 in order to monitor transport of radionuclide sources and fresh and spent fuel through the borders during their import, export and transit. 17 permits were issued and amended in 2015.

An important segment in the structure of radioactive material transport is transfer of fresh and spent nuclear fuel of Ukrainian NPPs and fuel transit traffic between the Russian Federation and Eastern European countries such as Slovakia, Hungary and Bulgaria in accordance with intergovernmental agreements on cooperation in the field of nuclear material transport.

Railway wagon for nuclear fuel transport

The agreements specify basic legislative and administrative principles of cooperation in nuclear material transport: competent authorities involved in the implementation of agreements, international documents applicable to nuclear material transport, procedure for shipment tracking, physical security and protection, reloading points, guard changing points, responsibility for loss of shipment, civil responsibility for nuclear damage, elimination of accident consequences, the procedure of notification on transport.

The legislation of Ukraine also specifies the cases when transport of nuclear material and radioactive waste may not be implemented: in case of potential threats related to military actions, armed conflicts, civil war, insurrection, political or civil unrest, strikes, acts of terrorism; force majeure including natural events of exceptional, inevitable, unpredictable character; during the events of national importance in Ukraine (national holidays, international cultural and sport events, etc.).

In 2015, the SNRIU issued 28 licenses for transport of fresh and spent nuclear fuel of Ukrainian NPPs and transit traffic to foreign NPPs.

Safety during radioactive material transport is ensured through the use of transportation packages the design of which meets nuclear and radiation safety rules.

The international and national rules envisage approval of package design by competent authorities of producing countries, and multilateral approval of package design by competent authorities of transit and destination countries in case of international transport.

Package design compliance with the rules is approved by testing or calculations. Testing programs for different types of packages are specified in the IAEA rules and national regulations (Nuclear and Radiation Safety Rules in Radioactive Material Transport (PBPRM-2006)), and approved by the SNRIU in each individual case. As a rule, SNRIU representatives perform testing oversight. Testing results shall be fixed in minutes to be submitted with other technical documentation by Applicants to the SNRIU for package design approval.

Testing of transport packages

During radioactive material transport that does not comply with nuclear and radiation safety standards, rules and regulations, according to Article 58 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the SNRIU shall approve special conditions for transport under which general safety level during transport is at least equivalent to a level that would be ensured if all applicable requirements of the rules are met.

The SNRIU issued 25 certificates for special conditions and 11 certificates for package design, at that, 7 certificates were issued in 2015.

In 2015, a range of administrative and technical measures specified by the legislation for safety regulation ensured high level of reliability and fail safety during radioactive material transport.

7. SAFE MANAGEMENT OF RADIATION SOURCES

7.1 International Standards, Approaches and Practice of Safety Regulation of Radiation Sources, Conceptual Changes and Prospects

Ukraine is one of the first countries in the world that considered the provisions of the Code of Conduct on the Safety and Security of Radioactive Sources (IAEA, 2003), which formed a basis of the state policy of radiation source safety and security.

This Code and the Guidelines on Export and Import of Radioactive Sources attached are an important tool to provide international safety and security mode of radionuclide sources.

The principles of this Code are to achieve and maintain high safety of sources during their lifecycle; prevent unauthorized access to radioactive sources, minimize radiological consequences of any accident or acts of crime related to radioactive sources; and increase safety level.

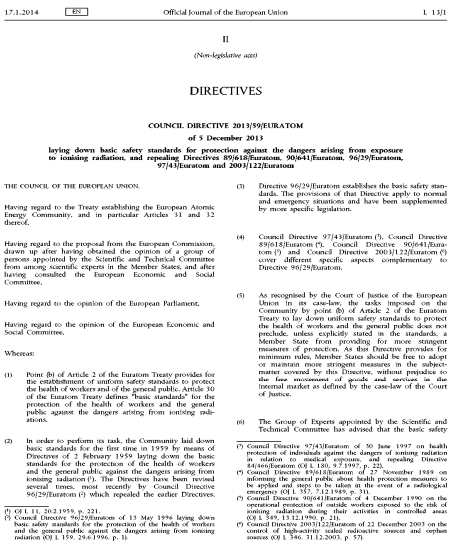
Taking into account the fact that radiation sources in Ukraine are in different sectors of economy (industry, medicine, scientific research, education, etc.), it is critical that their use be safe and consistent with the national and international requirements. The objective of this Code is achieved by establishing an appropriate regulatory control system of radioactive sources.

The State Nuclear Regulatory Inspectorate of Ukraine is responsible for coordination of measures aimed at development, functioning and progress of this system in Ukraine.

In 2015, SNRIU representatives took active part in IAEA development of harmonized *Guidelines to the Code on Management of Spent Radiation Sources.* It is necessary to note that the provisions of the draft Guides consider Ukrainian experience and practice in the regulation of safe management of spent radiation sources in expiration of their lifecycle, and legislative requirements in this sphere. The main ways of spent radiation source management are return to the Supplier, reuse and recycling, temporary storage in facilities and long-term storage followed by disposal at specialized radwaste treatment plants, etc.

One of SNRIU priority tasks in 2015 was to implement Council Directive 2013/59/Euratom, which establishes basic safety standards for protection against radiation and repeals Directives 89/816/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43Euratom and 2003/122Euratom.

This Directive is aimed at establishing the uniform basic safety standards to protect health of the public and people subjected to professional and medical exposure; improving the efficiency of radiation safety and radiation protection in using radiation sources in different spheres of economy and vital activity security; it shall be applied in case of planned, current and emergency exposure.



17.1.2014 EN Official Journal of the European Union L 13/1

II

(Non-legislative acts)

DIRECTIVES

COUNCIL DIRECTIVE 2013/59/EURATOM

of 5 December 2013

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Atomic Energy Community, and in particular Articles 31 and 32 thereof,

Having regard to the proposal from the European Commission, drawn up after having obtained the opinion of a group of persons appointed by the Scientific and Technical Committee from among scientific experts in the Member States, and after having consulted the European Economic and Social Committee,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the European Economic and Social Committee,

Whereas:

(1) Point (b) of Article 2 of the Euratom Treaty provides for the establishment of uniform safety standards to protect the health of workers and of the general public. Article 30 of the Euratom Treaty defines "basic standards" for the protection of the health of workers and the general public against the dangers arising from ionising radiations.

(2) In order to perform its task, the Community laid down basic standards for the first time in 1959 by means of Directives of 2 February 1959 laying down the basic standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (1). The Directives have been revised several times, most recently by Council Directive 96/29/Euratom (2) which repealed the earlier Directives.

(3) Directive 96/29/Euratom establishes the basic safety standards. The provisions of that Directive apply to normal and emergency situations and have been supplemented by more specific legislation.

(4) Council Directive 97/43/Euratom (3), Council Directive 89/618/Euratom (4), Council Directive 90/641/Euratom (5) and Council Directive 2003/122/Euratom (6) cover different specific aspects complementary to Directive 96/29/Euratom.

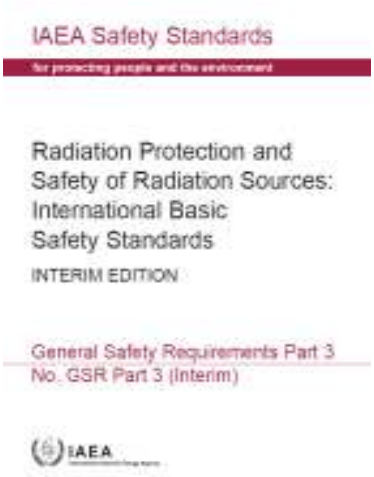
(5) As recognised by the Court of Justice of the European Union in its case-law, the tasks imposed on the Community by point (b) of Article 2 of the Euratom Treaty to lay down uniform safety standards to protect the health of workers and the general public does not preclude, unless explicitly stated in the standards, a Member State from providing for more stringent measures of protection. As that Directive provides for minimum rules, Member States should be free to adopt or maintain more stringent measures in the subject-matter covered by this Directive, without prejudice to the free movement of goods and services in the internal market as defined by the case-law of the Court of Justice.

(6) The Group of Experts appointed by the Scientific and Technical Committee has advised that the basic safety

(1) OJ L 11, 20.2.1959, p. 221.
(2) Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159, 29.6.1996, p. 1).
(3) Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure, and repealing Directive 84/466/Euratom (OJ L 180, 9.7.1997, p. 22).
(4) Council Directive 89/618/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency (OJ L 357, 7.12.1989, p. 31).
(5) Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas (OJ L 349, 13.12.1990, p. 21).
(6) Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (OJ L 346, 31.12.2003, p. 57).

Chapter VII: Council Directives 2013/59/Euratom of 05 December 2013 are devoted to radiation safety regulation in medicine using radiation sources, particularly, the requirements for licensing of medical institutions, justification of medical exposure, monitoring of radiation parameters of equipment with radioactive sources, establishment and application of reference diagnostic levels for diagnostic procedures, and other safety requirements.

According to the international standards (GSR Part 3 International Basic Safety Standards, IAEA; Radiation Protection and Safety in Medical Uses of Ionizing Radiation, IAEA SAFETY STANDARDS DS399 of 22 September 2014), the functions of the nuclear regulatory body in the field of the use of radiation sources in medicine are to:



identify the type of authorizing procedure (notification, registration, licensing) applied for a medical institution;

establish requirements for the scope of radiation safety functions performed by personnel of a medical institution who perform activities using radiation sources (independently of authorizing procedure used – licensing or registration);

perform NRS review of projects of placement of radiation sources used in medicine or their reconstruction;

It is important that in compliance with the international standards:

conditions for release from licensing such as *safety and protection envisaged in radiation source structure, absence of accidents with such radiation sources, simple operating procedures, etc.* are not used for release from licensing of radiation sources used in medicine for three reasons (patient's safety depends on human factor, equipment design does not provide radiation safety and security, personnel training is important);

license for medical practice (in using radiation sources for diagnostics or therapy) is not issued by the Ministry of Health Protection without an authorizing document of the nuclear regulatory body.

Thus, coordination and interaction with the health protection authority and state regulatory authority are necessary for radiation protection and comprehensive safety in a medical institution**.**

The SNRIU applies considerable efforts to preserve and develop the system of state regulation (licensing, registration, oversight) for safe use of radiation sources in compliance with EU legislation and IAEA standards.

7.2 State Safety Regulation of Radiation Sources in Ukraine

The state regulation of nuclear energy use (Article 27 of the Law of Ukraine "On the Use of Nuclear Energy and Radiation Safety") is extended to the use of radiation sources in industry, agriculture, medicine, education and research considering differentiated approach to safety requirements depending on potential nuclear and radiation hazard of a particular type of activities related to specific facilities (sources).

The principle of individual approach is also used in the authorizing activity: the system procedure, levels and criteria of radiation source release from regulatory control, state registration and licensing were established.

That is, since 2000 the SNRIU uses during its activity the optimization principle of state regulation (not just deregulation, but also finding an optimum state regulation level considering the potential hazard of facilities and types of activity related to them).

4 167 entities in Ukraine use radiation sources, only **59% (2481)** of them are subjected to licensing; the others are released from licensing according to the procedure established by the legislation **(41%).**

According to the criteria established by the Cabinet of Ministers of Ukraine (Resolution No. 1174 of 16 November 2011), the following is released from licensing: educational and medical institutions (x-ray rooms, stomatology, fluoroscopy, mammography etc.); enterprises using radioactive sources for calibration (metrological centers, enterprises with smoke detectors, aviation enterprises, etc.); scientific and industrial enterprises using electron microscopes and X-ray analysis devices; customs authorities using radiation sources to check luggage etc.

At the same time, the state regulation (oversight and authorizing activity) is performed by institutions dealing with high potential hazard: oncologic centers; scientific institutions with linear accelerators; enterprises using intensive radiation sources (e.g., flaw detectors at NPP, in construction and science) etc.

The activity dealing with the use of radiation sources is licensed exceptionally to ensure nuclear and radiation safety; it is not a permit for economic activity, and provided that the enterprises, organizations and institutions ensure the required level of nuclear and radiation safety in the licensing process, safe conditions are formed for business development in different sectors of the economy.

In 2015, the SNRIU proposed the following in form of a respective draft law in order to optimize the state regulation and decrease regulatory pressure on radiation source users with low level of potential hazard:

release from licensing the transport of radioactive materials by rail, water and air transport; reloading (loading, unloading and shipment) of packages and their transit storage in sea and river ports, airports, railway stations provided that carriers and organizations

performing such operations have a license for transport of hazardous shipment in order to avoid duplication in licensing;

exclude receiving (purchase) and transfer (sale) of such sources including also their supply from the list of activities related to the use of radiation sources subjected to licensing.

24 582 radiation sources are used in Ukraine, **9 654** of them are radionuclide sources and **14 928** are radiation generators.

Flaw detector **Protection with uranium (biological protection)** **Transport cask**

In 2015, **519** radiation sources were deregistered, **265** of them were spent radionuclide sources transferred for storage to specialized radwaste treatment plants, **14** radiation sources were returned to the suppliers abroad, **254** generators were put out of operation.

In 2015, **187** radionuclide sources to be used in medicine and industry were transported to the territory of Ukraine. As compared to 2013 and 2014, the number of radiation sources imported was decreased only by 15-20%.

Radioisotope process monitoring devices (moisture and density meters, etc.)

The main producers and suppliers of radionuclide radiations sources to the territory of Ukraine are enterprises in Poland, Belarus, Germany, Netherlands, the USA, Czech Republic, Finland, in particular, the following: the National Center for Nuclear Research (successor to the Institute of Atomic Energy POLATOM) joint Belarusian-Russian CJSC *Isotopic Technologies*, Eckert&Zeigler Nuclitec GmbH, Berthold Technologies GmbH&Co.KG, Mallinckrodt Medical BV, Environics Oy, etc.

Radionuclide sources in Ukraine are supplied by Ukrainian State Production Enterprise Isotop, Ltd. "Foreign Trade Company *Impuls"*, Ltd. Tutkov Borehole Service, Ltd. STAR TECHNOLOGY, and the intergovernmental organization *Ukrainian Science and Technology Center*.

The number of radionuclide sources imported in 2015 and their application area are stated in Table 7.1

Table 7.1

No.	Radionuclide	Application area	Number of radiation sources	
			Units	% (of imported)

1	Am-241	Radioisotope monitoring devices	92	49.7
2	Ir-192	Gamma-therapy, Gamma-radiography	34	18.34
3	Cs-137	Radioisotope process monitoring devices	24	13.0
4	Co-60	Gamma-therapy, Radioisotope process monitoring devices, exposure installations, radiography	20	10.8
5	Cf-252	Radioisotope monitoring devices	5	2.7
6	Others		10	5.4

The main users of radionuclide radiation sources in 2015 are the State Border Service of Ukraine - 41.62%; industrial enterprises (in nuclear energy sector, mining and processing, metallurgy, ship-repair and shipbuilding, oil and gas, paper, pulp and cardboard branches, etc.) - 43.78%; medical oncological institutions- 14.60 %.

14 spent radiation sources were exported from the territory of Ukraine in 2015, 12 of them to be used in medicine were returned to the producer to the Netherlands and two radiation sources to be used in industry were returned to the producer to Poland.

2 083 radiation sources with lifetime over 35 years are used in Ukraine, including: 25 sourced produced in the fifties of the previous century and 170 sources produced in the sixties. Over 100 entities did not make a decision on further management of spent radionuclide sources.

The information on import of unsealed radiation sources to Ukraine in 2015 for medical exposure is given in Table 7.2:

Table 7.2

	2015	**For comparison**	
		2014	**2013**
I-131	3 687,774 Gbq	1 192,138 Gbq	2 049,08 Gbq
I-125	23 815,179 MBq	966,75668 MBq	16 452,246 MBq
P-32	13 290,07 MBq	8 391,97 MBq	7 816,879 MBq
Sr-89	2 430,3 MBq	4 500 MBq	1 050 MBq
Sm-153	104 292,0 MBq	198 MBq	24 036 MBq

The information on production of radiation generators in Ukraine in 2015 is presented in Table 7.3:

Table 7.3

Producer enterprise	**Type of manufactured generator**	**Produced (units)**	**including**	
			for Ukrainian needs	**exported abroad**
CJSC Kyiv Production Enterprise *Medaparatura*	X-ray diagnostic complex with digital image processing RDK-VSM	8	5	3
	X-ray with digital image processing FTsOZ	22	16	6
LTS. X-ray Equipment Plant *Kvant*	X-ray diagnostic complex KRD-50 INDIagraf	11	11	-
	X-ray diagnostic complex INDIascop	2	2	-

Producer enterprise	Type of manufactured generator	Produced (units)	including	
			for Ukrainian needs	exported abroad
	X-ray diagnostic complex INDIascan	7	7	-
Radmir firm	X-ray mammographic digital complexes MADIS	8	4	4
	X-ray mammographic digital complexes SIMA	5	-	5
Ltd. Scientific and Production Enterprise *KRAS*	X-ray digital device Aspect	1	1	-
	X-ray device 12F9 Ukraina	10	10	-
	X-ray device KRAS 30/50	4	4	-
Ltd. Teleoptik	X-ray diagnostic digital complex KRDTs	4	4	-
Ltd. Elvatekh	Spectrometer of the X-ray radiation energy SER-01 and SER-02	108	5	103
Ltd. Institute of Analytical Monitoring Methodologies	X-ray fluorescent elemental analyzers of alloys Expert 3L	6	5	1
	X-ray fluorescent elemental analyzers of alloys Expert Mobile	1	1	-
TOTAL		197	75	122

The number of radiation generators produced abroad and imported to Ukraine in 2015 is 46 units to be used in medicine.

Placement of radiation sources and their owners in administrative - territorial units of Ukraine is demonstrated in Table 7.4:

Table 7.4

Administrative - territorial unit (region)	Total number of owners	Radionuclide radiation sources	Generators
Vinnytsia	123	66	465
Zhytomyr	103	70	374
Kyiv	129	1 909	556
Cherkasy	113	50	327
Chernihiv	75	44	308
The city of Kyiv	286	421	1 419
Dnipropetrovs'k	329	1 221	1 130
Kirovohrad	80	70	320
Donets'k	447	692	1287
Zaporizhzhya	174	573	618
Luhan'sk	200	337	621
Kharkiv	316	1 005	1 350

Administrative - territorial unit (region)	Total number of owners	Radionuclide radiation sources	Generators
Poltava	141	373	516
Sumy	151	137	466
Rivne	95	266	323
Volyn’	78	46	266
Khmelnytsky	132	157	398
Ternopil	87	8	251
Ivano-Frankivs’k	101	54	374
Lviv	163	219	747
Zakarpattya	69	88	298
Chernivtsi	56	23	311
Odesa	212	1 019	684
Mykolaiv	82	540	341
Kherson	87	12	279
The Autonomous Republic of Crimea	310	139	804
The city of Sevastopol	28	138	66
Total in Ukraine	**4 167**	**9 654**	**14 928**

8. ACTIVITY IN THE EXCLUSION ZONE

8.1. Chornobyl NPP Decommissioning

Chornobyl NPP is being decommissioned and the respective projects are implemented within this activity according to SNRIU License EO 000040 of 22 March 2002.

According to Chornobyl NPP Decommissioning Program and conditions of the license, decommissioning is implemented in the following stages: termination of operation, final closure and preservation, safe storage, and dismantling.

In March 2015, the SNRIU completed the review of ChNPP application and a package of documents and issued individual license OD 000040/8 for activity at the stage of final closure and preservation at Chornobyl NPP units 1, 2 and 3.

This license resulted in termination of operation and beginning of Chornobyl NPP decommissioning stage.

A package of the following main documents was analyzed during the licensing process for the stage of final closure and preservation: project of final closure and preservation of units 1, 2 and 3, Chornobyl NPP safety analysis report at the stage of final closure and preservation, stage implementation program, radiation protection program and radwaste management program, operating procedures of units 1, 2 and 3 at the stage of final closure and preservation, as well as other documentation.

The documents submitted describe the activity to be performed at ChNPP including spent nuclear fuel and radwaste management, operation of ChNPP industrial site and infrastructure on it, etc.

The implementation of final closure and preservation project is envisaged within six commissioning stages (CS):

- CS-1 – reconstruction of fire water system at Chornobyl NPP;
- CS-2 – dismounting and upgrade of ChNPP process channels and CPS channels;
- CS-3 and CS-5 –of reactor preservation and confinement of unit preservation areas of Chornobyl NPP units 1, 2, and 3;
- CS-4 and CS-6 – reconstruction of central hall covers and dismounting of hoisting devices at Chornobyl NPP units 1, 2 and 3.

Completion of the final closure and preservation stage is envisaged in 2028.

Radwaste management facilities at Chornobyl NPP

Radioactive waste accumulated during Chornobyl NPP operation, accident elimination in 1986, those generated during decommissioning of units 1, 2 and 3 and the Shelter transformation into an environmentally safe system are stored in radwaste storage facilities at Chornobyl NPP site such as solid radwaste storage facility, liquid radwaste storage facility, and solid and liquid radwaste storage facility[1], and are transferred for disposal to facilities at Buryakivka radwaste disposal site.

[1] ChNPP liquid radwaste storage system consists of interrelated special piping for liquid radwaste pumping in the following storage facilities:

- liquid radwaste storage facility (LRSF) designed for 26 000 m^3 including 5 intake tanks with volume of 5000 m^3 and two intake tanks with volume of 500 m^3 made of corrosion resistant steel;
- liquid and solid radwaste storage facility (LSRSF) that operates only for liquid radwaste storage is designed for 12 000 m^3 and includes 12 intake tanks with volume of 1 000 m^3 made of corrosion resistant steel;
- radioactive oil storage facility consisting of two tanks with volume of 72 m^3 each.

During 2015, 18.35 m^3 of liquid radwaste was generated at Chornobyl NPP and sent for storage, including 15 m^3 of vat residue and 3.35 m^3 of perlite pulp. In total, the following was accumulated at the end of 2015 in liquid radwaste storage facilities: 13 523.40 m^3 of vat residue; 4 082.36 m^3 of spent ion-exchange resin; 2 293.38 m^3 of perlite pulp; 145.314 m^3 of radioactive contaminated oil-fuel mixture.

Low – and intermediate-level solid radwaste generated during decommissioning and the Shelter transformation into the environmentally safe system are transferred for disposal to facilities at Buryakivka radwaste disposal site. 4923.80 m^3 (7669.06 t) of low-level radwaste and 87.60 m^3 (121.20 t) of intermediate level solid waste were transported to Buryakivka radwaste disposal site in 2015.

High-level radwaste is collected into special casks (KTZV-0.2) and placed in temporary solid radwaste storage facility in a building of former fresh fuel storage facility. During 2015, 0.01 m^3 (0.007 t) of solid high-level radwaste and 0.33 m^3 (2.07 t) of low-level and intermediate level long-lived radwaste was generated and transferred for storage.

A number of radioactive waste management facilities was constructed and is being currently put into operation at Chornobyl NPP site in the framework of international technical assistance projects. The commissioning of these facilities will provide processing of accumulated and generated radwaste to bring them to a condition suitable for safe disposal.

Liquid radwaste treatment plant (LRTP) is designed to process liquid radwaste accumulated in tanks of LRSF, LSRSF and SRSF that will be generated resulting from decommissioning.

On 11 December 2014, the SNRIU issued individual license OD 000040/7 for LRTP operation.

However, the plant operation may be started in presence of a Certificate for Facility Completion according to the Procedure for Completed Facility Commissioning approved by the Resolution of the Cabinet of Ministers of Ukraine No. 461 of 13 April 2011.

This Certificate is absent in Chornobyl NPP and fire and lighting protection systems should be reconstructed in accordance with new regulations in order to obtain it. This requires additional time and funding from the State Budget of Ukraine.

For such reasons, processing of liquid radwaste at LRTP in 2015 has not been performed, and support of equipment and systems in an operable state has been provided.

During the reporting period, the SNRIU considered and approved the following documents on LRTP:

- Decision on Subsequent Processing of ChNPP Liquid Radwaste Considering the Results of Activities at the Stage of LRTP Commissioning;
- Radiation Monitoring Procedure during Operation of ChNPP Liquid Radwaste Treatment Plant.

Industrial complex for solid radwaste management (ICSRM) at ChNPP site includes a number of radwaste management facilities[2]. ICSRM facilities were completed, their commissioning is underway.

[2]**Temporary storage facility for low-level and intermediate level long-lived high-level radwaste** is designed for interim storage (during 30 years) of long-lived and high-level radwaste that will be generated during sorting at SRTP, and activities aimed at preparation to construction of the Shelter New Safe Confinement. This storage facility was constructed by means of reconstruction and re-equipment of a room, which was located on the upper level of ChNPP LSRSF that has not been operated until present;

SRRF is solid radwaste retrieval facility designed to retrieve solid radwaste from current solid radwaste storage facility at ChNPP and transfer radwaste for processing to SRTP;

Three stages of **SRRF** and **LRTP** commissioning are envisaged to test and maintain functioning of all systems including equipment for radwaste characterization and sorting:

Stage 1 – testing of radwaste in sealed packages with characteristics known in advance (completed),

Stage 2 – testing of unsealed radwaste with known characteristics (completed),

Stage 3 – testing of radwaste retrieved from solid radwaste storage facility sections.

In 2015, ChNPP performed preparation to ICSRM commissioning and developed a "Decision on Stage 3 of Hot Testing and Initial Stage of ICSRM Commercial Operation agreed with the SNRIU at the beginning of 2016.

Radwaste will be received and placed for storage in sections of temporary storage facility for low-level and intermediate-level long-lived and high-level radwaste after completion of SRTP commissioning.

The SNRIU also considered and approved in 2015 Technical Decision "On Construction of Decontamination Section in Building BNS-1,2" to meet the needs for decontamination of a significant amount of dismantled structures and equipment, which is released in the framework of ChNPP decommissioning.

ChNPP started operation of the said decontamination section.

8.2. Construction of the Shelter New Safe Confinement (NSC)

The task related to the Shelter transformation into an environmentally safe system was solved through a subsequent development and implementation of individual plans, projects and programs.

One of the main projects related to the Shelter is construction of the New Safe Confinement (NSC).

NSC project implementation is envisaged in the framework of two commissioning stages (NSC CS):

- NSC CS-1– protective building with process life support systems and required infrastructure;
- NCS CS-2 – an infrastructure for dismounting of non-stable structures of the Shelter.

NSC design lifetime makes up 100 years.

NSC CS-1 is currently implemented by the contractor for design, construction and commissioning of which is French Company Novarka.

According to the predicted design schedule, NSC CS-1 will be completed in November 2017.

NSC arch structures are mounted at a specially equipped site to the West from the Shelter at the distance of about 200 meters to decrease the Shelter negative effect on personnel during the work.

After mounting completion, NSC arch will be transferred and established into a design position over the Shelter[3].

SRTP is solid radwaste treatment plant designed for sorting of solid radwaste of all categories and processing (fragmentation, incineration, compaction, concreting) of low-and intermediate-level short-lived solid radwaste retrieved from solid radwaste storage facility and waste generated resulting from ChNPP decommissioning and the Shelter transformation into an environmentally safe system. SRTP also envisages packaging of long-lived high-level radwaste that will be generated during sorting, and transport of these packages for storage to temporary storage facility.

[3] Important stages of NSC CS-1 construction during 2012-2014:

For the Eastern part of the arch:

-the first lifting of the arch at the height of about 53 m was in November 2012.

- completion of the second lifting of the arch to the level of 85 meters was in June 2013;
- the third jacking to the level of 109 meters was performed in several stages and completed in October 2013;

ChNPP and Novarka performed practical work envisaged in the design decisions approved by the SNRIU.

The Structures of the Western and Eastern parts of the arch were mounted at the site for NSC arch mounting and in the local area of the Shelter, particularly, end walls, ventilation center and air ducts of the ventilation system; the activity on covering the inner and outer walls of the arch was continued; the components of NSC main crane system were installed; the process building and other auxiliary buildings were constructed: buildings of electrical and technical devices, firefighting pump station; NSC external and internal space was equipped (electricity, water, sewage), etc.

An important stage of NSC design implantation was joining together of the Western and the Eastern part of the arch that was successfully completed on 24 July 2015.

Safety assessment of the following main documentation was performed within the reporting year by the SNRIU within the regulatory support of NSC CS-1 construction:

- the state NRS review was performed and four work projects were agreed related to reinforcement and confinement of ChNPP Stage II building structures performing functions of NSC fencing system;

- from 31 March to 02 April 2014, the Eastern part of the arch was transferred to the waiting area; the structure with the weight of 12.6 thousand ton was transferred by 112 meters within 72 hours;

For the Western part of the arch:

- the first lifting was completed in May 2014;
- the second lifting was completed in August 2014;
- the third lifting of the arch with total weight of over 12 560 ton to the height of 109 meters was completed on 12 November 2014;
- the first stage of back skidding of the arch was completed on 26 November 2014: the Eastern part of the arch was transferred by 25 meters to the Western part; the distance between the end parts of the metal structures of two halves of the arch was 1.35 m.

- a review was performed and three technical decisions were agreed on management of radioactive materials and radwaste generated during NSC fencing structure reinforcement and confinement;
- a review was performed and document "NSC Main Crane System. Specification for Purchase" was agreed as a preliminary technical specification for the main crane system; compliance with the requirements of this system should be approved by acceptance testing results;
- review was performed and amendments to NSC CS -1 design related to the optimization of the power supply system and NCS electrical equipment;
- technical assessment was conducted and regulatory decisions were developed in the packages of operational documentation on safety justification of NCS fire water system, the ventilation system and the system for installation of sealing anchors, and standard shielding at the upper levels of the NCS, etc.

Joining together of the Eastern and Western parts of NSC arch

As regards NSC CS -2, that is, the infrastructure for dismounting unstable structures of the Shelter, its designing is envisaged in two Stages:

Stage 1 – studying of an option of "integrated dismounting/management" and option of "dismounting with postponed management" related to dismounted structures and radwaste and justification of option selection (completed);

Stage 2 – development of NSC CS-2 working design for the selected option of dismantling.

At the beginning of 2015, the SNRIU agreed ChNPP technical decision "On Selection of an Option for Early Dismantling to Develop NSC CS-2 Working Design *Infrastructure for Dismantling of the Shelter Unstable Structures*",

According to this decision, the implementation of an option for integrated dismantling/management is envisaged within NSC CS-2 as the most advisable one in view of economy and technology.

Such option is also acceptable in view of safety since management of dismantled structures and radwaste that will be generated during the activities is more optimized in this option.

However, NSC CS-2 working design was not developed because of lack of funding and uncertainties in financing.

8.3. Radwaste Management Facilities in the Exclusion Zone

The Exclusion Zone of unconditional compulsory evacuation is the territory of Ukraine contaminated by radionuclides resulting from Chornobyl accident, from which the population was evacuated during the first years after the accident.

The State Specialized Enterprise *Centralized Radwaste Management Enterprise* (SSE CRME), which is assigned by the Operator at the stages of operation and closure of radwaste disposal facilities, performs the main activity related to radwaste management on the territory of the Exclusion Zone (except ChNPP site), as well as individual types of activity aimed at radwaste processing and transport.

SSE CRME performs the following on the territory of the Exclusion Zone:

- operation of two parallel modules of engineered near surface solid radwaste disposal facility (ENSDF) at the Vektor site for radwaste package disposal from LRTP and SRTP;
- operation of near-surface radwaste disposal facilities - Buryakivka radwaste disposal site;
- maintenance and safety enhancement of Pidlisnyy and ChNPP Stage III radwaste disposal site established during the first years of accident elimination at ChNPP;
- maintenance, survey monitoring and elimination of trenches and storage pits in radwaste interim confinement points (RICP);
- operation of decontamination point of overalls and individual protection means and decontamination point for special vehicles and equipment.

The State specialized enterprise for Exclusion Zone capital construction management assigned by the Operator at the stage of siting, design, and construction of radwaste storage-disposal facilities of the Vektor complex performs designing, construction and repair of radwaste management facilities on the territory of the Exclusion Zone (except ChNPP site).

Chornobyl Specialized Plant performs radiation and dosimetric monitoring and environmental control in the Exclusion Zone.

The Vektor complex

The site of the Vektor complex is placed on the territory of the Exclusion Zone at the distance of 11 km in the South-West direction from the Chornobyl NPP.

The Vektor complex is a complex of enterprises for radwaste decontamination, transport, processing and disposal. The construction of this complex was started in March 1998 in two stages.

The Vektor complex Stage 1 is designed for disposal of radwaste generated resulting from Chornobyl accident. The commissioning stage 1 includes a facility for radwaste disposal in reinforced concrete containers (SRW-1) and module disposal facility for non-packed large-sized radioactive waste in bulk (SRW-2) with total capacity of 19.2 thousand m^3 and required infrastructure facilities.

Unfortunately, completion of SRW-1 and SRW-2 radwaste disposal facilities and other Vektor complex facilities was stopped in 2010 and has not been renewed until present. The buildings and equipment are degraded through constant delays of completion, some infrastructure facilities constructed at the beginning of 2000 are to be already subjected to repair, the design cost increases, reliability of safe radwaste storage in new facilities requires additional measures aimed at inspection and assessment.

The Vektor site – the main facilities of Stage 1 and ENSDF

The engineered near surface disposal facility designed for disposal of ChNPP conditioned radwaste was constructed and commissioned at the Vektor site. The design capacity of the disposal facility is 50 210 m^3 for radwaste packages. ENSDF consists of two parallel sections; each has 11 reinforced concrete compartments (modules). The facility is equipped by central drainage gallery, two portable frame structures with bridge cranes for filling of modules, the radiation and environmental monitoring system. In the framework of the disposal facility operation, the functioning of the central drainage gallery under the disposal facility and monitoring of the state of building structures in disposal facility modules is provided, up-to-date methodologies of safety assessment are studied and implemented for ENSDF safety review in order to extend the number of radwaste suppliers and actualize radwaste acceptance criteria to this disposal facility.

The SNRIU submitted to SSE CRME the regulatory decisions on approval of acceptance of radwaste packages produced in other radwaste treatment plants (except Chornobyl NPP) for disposal to ENSDF. In 2015, 74 packages of conditioned radwaste with total mass of 123588 kg was accepted from Kharkiv SISP for disposal to ENSDF. In total, 66.78 m3 of radwaste with activity of 1.7E+11 Bq were disposed in ENSDF.

Radwaste disposal in ENSDF Section A-1

According to the feasibility study of the Vektor complex Stage 2 approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1605-r of 23 December 2009, **the Vektor complex Stage 2**, envisages construction of a complex of radwaste management facilities:

– centralized near surface disposal facilities for radwaste generated during operation of current Ukrainian NPPs and accumulated at the sites of the specialized radwaste treatment plants of the Ukrainian State Association *Radon*;

– treatment plants of Chornobyl radwaste and the one from the sites of the specialized radwaste treatment plants of the Ukrainian State Association *Radon*;

– long-term storage facilities for high-level long-lived radwaste including long-term storage facilities for vitrified waste that will be returned from the Russian Federation after treatment of spent nuclear fuel from Ukrainian NPPs;

– centralized long-term storage facility for spent radiation sources.

During 2015, construction of the centralized long-term storage facility for spent radiation sources and mantling of the systems and equipment in this storage facility related to technological process of management of spent radiation sources including their acceptance, treatment and long-term storage as well as radiation monitoring and ventilation systems was completed. The project implementation is supported by the Department of Energy and Climate Change of the Great Britain.

SSE CRME was appointed as the operator at the stages of operation and closure.

SSE CRME performed testing of the systems important to safety of the centralized long-term storage facility for spent radiation sources (CLTSF) including comprehensive tests (cold startup) of CLTSF according to appropriate programs agreed with the SNRIU.

The SNRIU accepted SSE CRME licensing documents for consideration regarding CLTSF operation together with the documents justifying safety of comprehensive (hot) tests of CLTSF using spent radiation sources at the beginning of operation.

CLTSF is a facility that does not have any analogs in the world at present and is the main component for improvement of the whole management system of spent radiation sources in Ukraine. CLTSF should provide centralized placement of the whole amount of spent radiation sources (about 500000 spent radiation sources of different type and structures) accumulated currently at the sites of specialized radwaste treatment plants of the Ukrainian State Association *Radon* and used in medicine and industry.

CLTSF

CLTSF storage site for spent radiation sources

Existing radwaste management facilities on the territory of the Exclusion Zone

Facilities for disposal and confinement of a large amount of emergency radwaste were constructed on the territory of the Exclusion Zone in 1986-1987 in taking urgent measures for Chornobyl accident elimination. These radwaste disposal facilities include facilities at

Buryakivka and Pidlisnyy radwaste disposal site, ChNPP Stage III radwaste disposal site and radwaste interim confinement points (RICP).

Buryakivka radwaste disposal site is operated since 1987. Buryakivka radwaste disposal site consists of 30 near-surface radwaste disposal facilities (trenches). The main engineering barrier providing radionuclide confinement is a specially constructed clay screen with thickness of one meter. In total, about 687 thousand m^3 of Chornobyl radwaste with total activity of $2.54x10^{15}$ Bq were placed since the beginning of operation in storage facilities (trenches) of Buryakivka radwaste disposal site.

Buryakivka radwaste disposal site is one of the main components of the management system of large amount of emergency radwaste generated resulting from Chornobyl accident that was constructed when urgent measures were taken to eliminate accident consequences. Operation of the storage facilities at this radwaste disposal site provides until present disposal of a large amount of low-level radwaste generated during the activities at ChNPP site and on contaminated territories in the Exclusion Zone. The capacity of Buryakivka radwaste disposal site is almost exhausted. Considering safety review of Buryakivka radwaste disposal site supported by the European Commission, a decision is under consideration for its reconstruction and extending its capacity for disposal of low-level radwaste.

Pidlisnyy and ChNPP Stage III radwaste disposal site were constructed during the first years of Chornobyl accident elimination. The most hazardous high-level long-lived emergency radwaste was stored in these facilities. Radwaste should be further retrieved from these facilities and disposed in geological disposal facility. Safety of these facilities should be envisaged before construction of the geological disposal facility in Ukraine. Activities were performed at the Pidlisnyy radwaste disposal site during the previous years according to the approved temporary shutdown project. These activities were aimed at protection against degradation and maintenance of required confining functions of engineering barriers in these storage facilities, construction of additional barriers and improvement of the monitoring systems. Project "Disposal Facility Closure at ChNPP Stage III Radwaste Disposal Site" was approved. The project envisages construction of additional engineering barriers (new multi-layer upper protective shield over the existing modules with radwaste), modernized drainage system and monitoring system, facility infrastructure improvement (driveways, physical protection system, etc.) for stabilization and safety improvement of this facility.

Nine **RICP**s were placed on the Exclusion Zone territory: Stantsiya Yaniv, Naftobaza, Pischane Plato, Rudiy Lis, Stara Budbaza, Nova Budbaza, Prypyat, Kopachi, Chystohalivka with total area of about ten hectares having trenches and storage pits with radwaste on their territory. Estimated number of trenches and storage pits on the territories of RICP is about 1000 pieces. RICP territory survey, maintenance of trenches and storage pits in a safe state is being regularly performed. The objective of this survey is to find and specify the layout of trenches and storage pits with radwaste, and identify the composition and activity of radwaste placed. First, the decisions to eliminate RICP storage pits and trenches were taken for territories with seasonal flooding where the activities were performed in the framework of ChNPP decommissioning projects and at the Shelter. Storage pits and trenches of Nova Budbaza and Naftobaza RICP were retrieved and disposed according to the technical decisions approved by the SNRIU. In total, 4800 m^3 of radwaste from RICP storage pits and trenches were retrieved and disposed at Buryakivka radwaste disposal facility site during 2015.

In 2015, the Central Analytical Laboratory (CAL) of the Measuring Center of Radiation and Environmental Monitoring and Dosimetric Control *Ecocenter* of Chornobyl Specialized

Plant was established, which was funded by the European Community in the framework of cooperation in the sphere of nuclear safety.

The implementation of this project was aimed at improving the radioactive waste management infrastructure in the Exclusion Zone, in particular: characterization of radwaste samples according to physical, chemical and radiation indicators; checking compliance with specification for conditioned radwaste packages; development of methodologies for monitoring and standardization.

The SNRIU arranged consideration of "Measurement Methodology for Full Radwaste Characterization in the CAL and Survey of Radioactively Contaminated Territories by the Mobile Laboratory" submitted by Chornobyl Specialized Plant.

9. EMERGENCY PREPAREDNESS AND RESPONSE

9.1. Emergency Preparedness and Response

Emergency preparedness and response is one of the fundamental safety principles and a constituent of the defense-in-depth concept in order to:

- develop response measures at local, regional, national and international level to any nuclear or radiation emergency;
- minimize radiation risks in case of anticipated events;
- take measures to mitigate consequences for human life, health and the environment in any incidents even those of very low probability.

These measures include timely establishing criteria for protective actions and personnel informing under emergency.

The IAEA considers that the objective of the emergency preparedness and response to incidents and emergencies is to support and improve the national and international mechanisms and potential for early notification and timely response to incidents and emergencies *independently on whether they result from man-made accident, disaster, negligence or criminal activity*.

Considering the experience of training and response to actual emergencies, in particular the Fukushima accident, the IAEA involving the majority of its member states reviewed safety requirements "Preparedness and Response for a Nuclear or Radiological Emergency" (Safety Series GS-R-2). New publication of the document of GRS Series Part 7 containing general criteria for protective measures was approved by the IAEA Board of Governors and published in 2015.

In this regard, the SNRIU in cooperation with other state bodies, licensees, scientific and public organizations reviews the national regulatory requirements for emergency preparedness and response to bring them into compliance with IAEA safety standards, provisions of Council Directive EU/Euratom 2013/59 establishing fundamental safety standards for protection against radiation sources.

The SNRIU monitors trends and participates in implementing modern European approaches on planning and preparedness to take protective measures at the early stage of a nuclear accident (HERCA-WENRA approach). The HERCA-WENRA approach is aimed at enhancing international coordination of response to nuclear accidents by establishing planning zones for preventive, emergency and long-term actions of radiation protection. First, it concerns protective measures in NPP near area at the early stages of a nuclear accident and making prompt decisions for preventive measures in the area of emergency impact based on predictive assessments, even at a time when there is very little information on the situation, but there is a severe accident threat.

The HERCA-WENRA approach shall be implemented at the national level in each European country including Ukraine, which became a member of the WENRA Association in 2015.

In order to harmonize with the HERCA-WENRA approaches, it is planned to review the national legislation and regulatory framework that is a basis for emergency planning and radiation protection measures for the public. Recommendations on general and procedural issues will be considered in the review of the national response plan for radiation accidents and other regulatory documents in force in Ukraine in the system of emergency preparedness and response.

The SNRIU as a national competent authority and single national point of communication within the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency provided jointly with the State Emergency Service, participation in the IAEA exercises of ConvEx format to test mechanisms in the event of transnational radiological emergency, check the communication with the IAEA Incident and Emergency Center, test mechanisms for request and assistance, etc.

On-line information exchange between the SNRIU, the IAEA and competent authorities of the countries in compliance with the intergovernmental agreement is implemented through secure web site within the unified system for information exchange in incidents and emergencies (USIE).

The analysis of possibilities and preparatory measures on registration of national potential in IAEA network on response and assistance was performed (RANET) was performed jointly with the State Emergency Service in 2015.

By SNRIU Ordinance No.163 of 06 February 2015, functional subsystem of the unified civil protection system (hereinafter – FS UCPS) "Safety of Nuclear Facilities" was transferred to the high alert mode in compliance with FS UCPS mode.

Subsystem activity at facility level is ensured by State Inspections on Nuclear Safety, at regional level it is ensured by the State Regional Inspections on Nuclear and Radiation Safety.

At the national level, the key subsystem component is SNRIU Information and Emergency Center (IEC), which under its activation involves the most experienced experts of SNRIU subdivisions and subordinated organizations.

Twenty-four hours duty, operational communication with NPPs of Ukraine, analysis and registration of the information of NPP events and its inclusion to computerized database is provided in the SNRIU IEC. Information summaries on the state of NPP units in Ukraine and messages on NPP operational events shall be prepared for distribution and be available at SNRIU web site www.snrcu.gov.ua.

The FS UCPS ensured the following in the high alert mode:

- observe and control nuclear and radiation safety and security of potentially hazardous facilities of licensees and adjacent territories;
- improve oversight of implementing measures to prevent accidents during production, use of radiation sources, transport of radioactive materials and at radioactive waste management facilities, uranium facilities, to ensure preparedness of enterprises, institutions and organizations for eliminating consequences of such accidents;
- additional checking of the licensee's emergency plans, in particular, information update, checking communication systems and procedure of participant interaction, etc.

In 2015, the SNRIU IEC was fully activated during joint plant emergency training, namely:

on 22-23 April at SUNPP, simulated emergency "Loss of Power Supply at SUNPP with Failure of all Diesel-Generators at Unit 1 with Subsequent Severe Core Damage";

on 2–3 November at ZNPP, simulated emergency "General Emergency at ZNPP Resulted from Extraordinary Geological Situation in ZNPP Location Area and Caused Failure of Main and Backup Energy Saving Systems, as well as Unit 1 Depressurization".

A system to support decision-making (RODOS) as a tool for comprehensive analysis of possible consequences of various emergency scenarios and operational verification for prediction calculation of the operating organization was used by IEC experts in trial operation

during joint plant emergency training to assess, predict progression and management of emergencies outside nuclear sites.

Based on training analysis, appropriate corrective measures to improve response to emergencies at NPPs were developed and implemented.

To monitor radiation situation in the observation area of the Ukrainian NPPs, as well as to predict and support decision making on protective measures for the public outside nuclear sites, the SNRIU uses the data of the automatic radiation monitoring systems (ARMS) obtained in the IEC in on-line mode from all operating NPPs after connection to the SUNPP ARMS Data Transfer System since September 2015.

On 26 January 2015, a “round table” on emergency preparedness and response in the field of nuclear energy was held by the SNRIU jointly with the All-Ukrainian Environmental NGO "MAMA-86" under the auspices of the European social network Nuclear Transparency Watch supported by the Swedish International Cooperation and Development Agency.

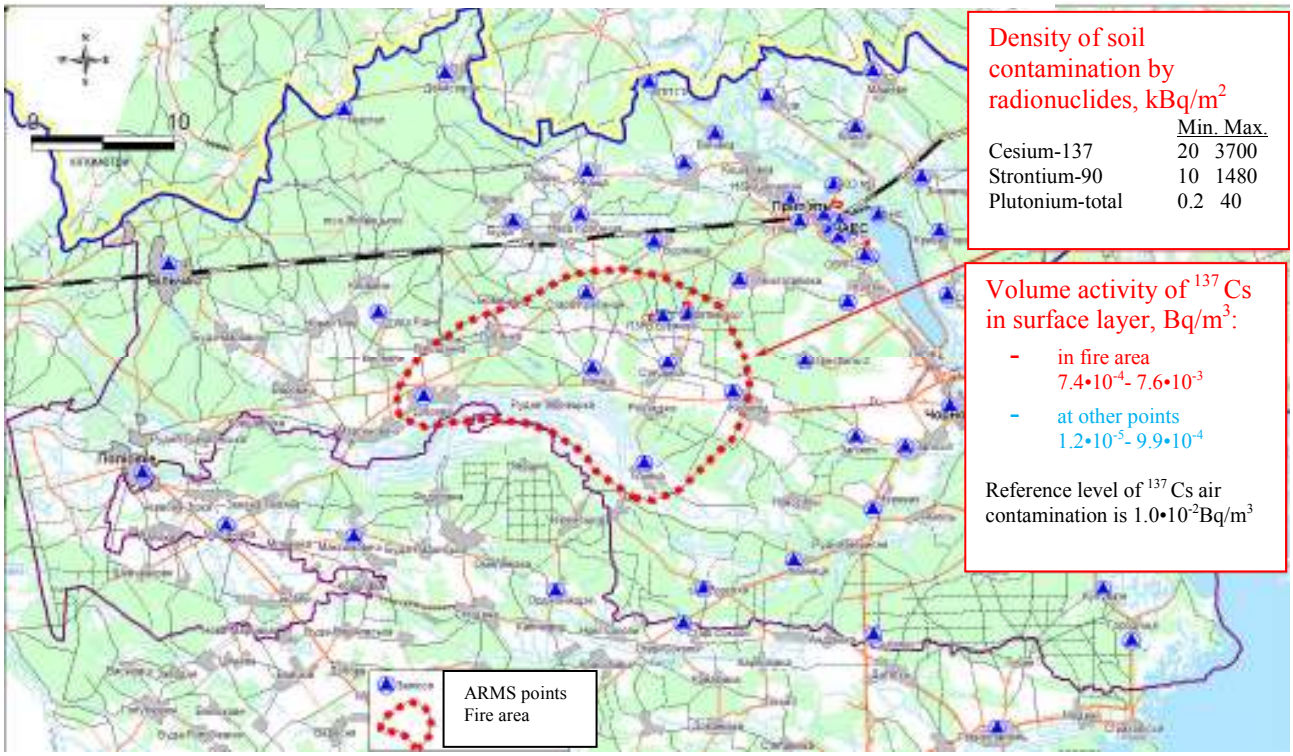
9.2. Fire Suppression in the Exclusion Zone

Fires in the exclusion zone in spring and summer 2015 caused public concern and media attention due to possible spread of radionuclide contamination with combustion products outside the Exclusion Zone.

The SNRIU in cooperation with the Hydrometeorological Center of Ukraine, Central Geophysical Laboratory, Chornobyl NPP, Measuring Center of Radiation and Environmental Monitoring and Dosimetric Control *Ecocenter* of Chernobyl Specialized Plant and SSTC mobile laboratory analyzed the data on radiation state monitoring, assessed radiation impact, provided information by request of the IAEA, some member states in compliance with the intergovernmental agreements and disclosure of on-line information on the official website www.snrc.gov.ua.

Continuous monitoring of radiation background in the Exclusion Area is provided by the automatic radiation monitoring system (ARMS) of *Ecocenter* at 39 points. Data are obtained in the control center each hour and in emergency each 2 minutes within twenty-four hours.

Sketch-map of ARMS points in the Exclusion Zone



Location of fire area as of 30 April 2015.

Due to forest fires on **28-30 April 2015**, control over radiation situation in the Zone was strengthened. The data on background radiation and radionuclide content in the air near fire according to nine ARMS stationary points and mobile response groups equipped with dosimeters and aspiration devices were analyzed online.

Increase of radionuclide content in the near-surface air to the values not exceeding the reference levels established for this area was observed during fires according to measurements.

Analysis of air sample in Stara Krasnytsya **on 28 April 2015** showed the volume activity of ^{137}Cs in the air 7.6×10^{-3} Bq/m^3 that was approximate to the reference level of ^{137}Cs air contamination (reference level for ^{137}Cs volume activity in the air was established at the level of 1.0×10^{-2} Bq/m^3 for the 10 km zone around Chernobyl NPP).

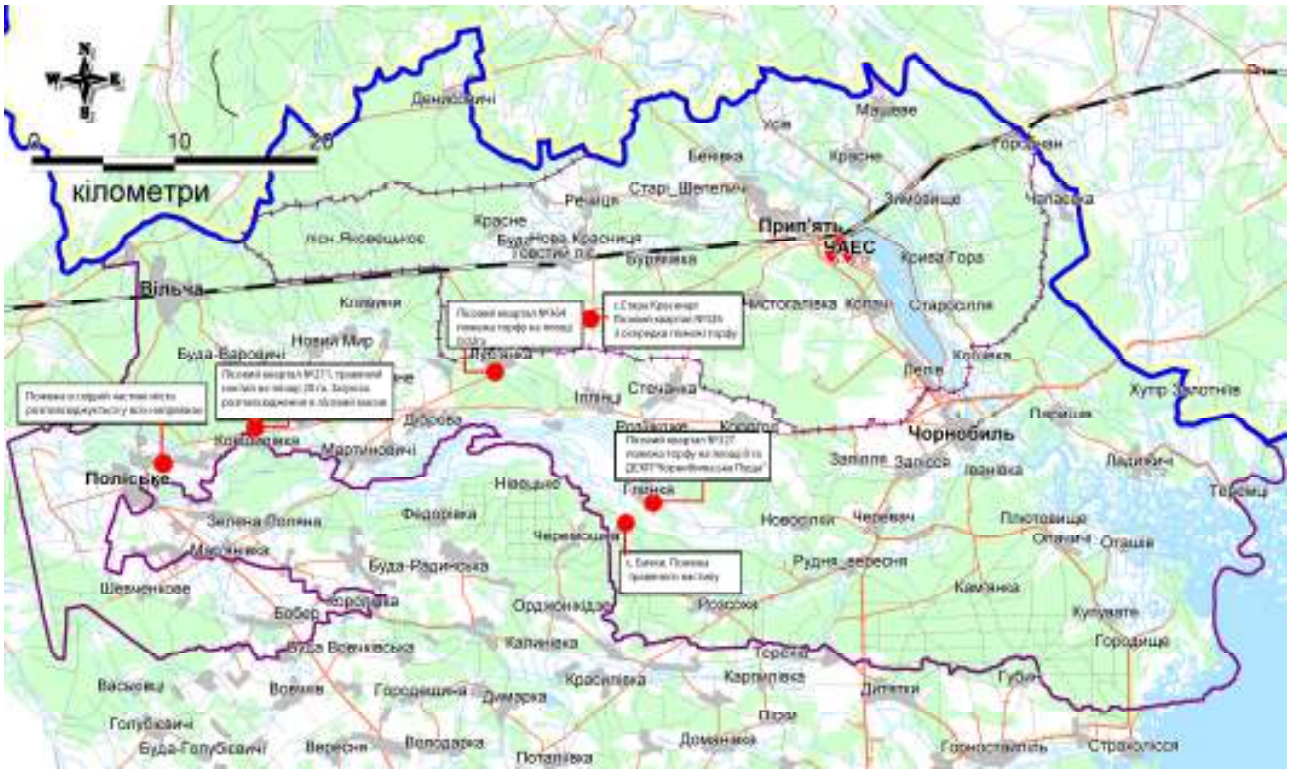
On 3 April 2015, the experts from the SSTC NRS Radiation Protection Department, SNRIU performed radiation survey of Kyiv using mobile radiological laboratory "RanidSONNI" by the following route: Vasylya Stusa Street – Peremoga Avenue – Shevchenko Boulevard – Khreshchatyk Street – Volodymyr Descent – Poshtova Square – Naberezhno-Rybalska Street – Heroiiv Stalingradu Avenue – Obolonskiy Avenue – Bohatyrska Street – Lugova Street – Pravdy Avenue – Velyka Kiltseva Road.

No radiation anomalies were found in Kyiv streets during continuous monitoring by stationary and portable equipment of "RanidSONNI" laboratory. Gama-radiation doses are within 0.04 - 0.10 μSv/h that complies with natural background conditions. The levels of radionuclide content in the air are significantly below the permissible levels established by the Radiation Safety Standards of Ukraine.

Reference: the mobile laboratory is Mercedes-Benz based laboratory equipped with stationary radiometric complex with highly effective gamma radiation detectors, portable spectrometer with a detector of high-purity germanium, portable radiometer with gamma radiation and neutron detectors. Radiation monitoring equipment of the laboratory has state metrological certificates. The car is equipped with GPS, video monitoring, sampling devices.

Operating experience of the mobile laboratory: activities to improve security against the threats of nuclear and radiation terrorism during preparing to and holding the final part of the European Football Championship EURO 2012 in Ukraine; surveys of facilities and territories of the Kirovograd region by request of local authorities; scheduled inspection of the Kyiv State Interregional Specialized Plant by the SNRIU; scheduled survey of medical institutions where radiation and nuclear technologies are applied: Feofania Clinical Hospital of the State Administration and Municipal Institution of the Kyiv Regional Council, Kyiv Regional Oncology Center.

On 29 June 2015, several fire sites of different type occurred in the south-western part of the Exclusion Zone. The distance from fires to Chernobyl was about 20 km, to ChNPP was 23 km, to Buryakivka radwaste disposal site and Vektor site was 10 km, to and to the southern boundary of the Exclusion Zone 5-10 was km.



Location of fire sites as of 30 June 2015

On 30 June 2015, a mobile group of the Measuring Center of Radiation and Environmental Monitoring and Dosimetric Control *Ecocenter* performed radiological survey of fire areas by the following route: Korogod – Dibrova – Kovshylivka – Poliske – Lubianka – Stara Krasnytsia. No significant increase in the gamma exposure dose rate and beta-particle flux density has been found.

However, an air sample taken in the fire area near the evacuated urban village of Polis'ke contained 2.5×10^{-3} Bq/m^3 of ^{137}Cs, which is one order of magnitude higher than the reference level established in the health and safety standard "Basic Reference Levels, Exemption Levels and Action Levels for Radioactive Contamination of Objects in the Exclusion and Resettlement Zone" for the former populated centers, where specific categories of personnel are staying. In ash sample (remaining forest cover), radionuclide content was: ^{137}Cs – 3.4 kBq/kg, ^{90}Sr – 2.7 kBq/kg that is below the criteria for referring ash to solid radioactive waste.

Thus, the data from current radiation monitoring systems in the Exclusion Zone and adjacent territories showed that changes in key indexes of air radiation state, except fire sites did not exceed the reference levels established for certain areas and in Kiev they were within natural background fluctuations.

Realtime Online Decision Support System (RODOS) for nuclear emergency management implemented in Ukraine under assistance of the EC was used in test mode to assess dispersion and to develop models for atmosphere transfer of combustion products.

10. NUCLEAR SECURITY ISSUES

10.1. Design-Basis Threat

Problems of ensuring security of radioactive materials have recently attracted much attention from the community and a wide range of experts. This is caused not only by increase of nuclear terroristic threats, but also recognition of these threats on the highest political level of the state. This was mainly fostered by the Washington Summit 2010, Nuclear Security Summit Seoul 2012 and Hague Summit 2014. The main issues of these events were prevention of nuclear terrorism, measures on neutralization of internal and external threats related to malicious use of radioactive materials.

Taking this into account, priority tasks of the state nuclear policy related to security are aimed at Ukraine meeting international obligations to reach main purposes of physical protection: minimize risks of nuclear terrorism, theft of nuclear material, radioactive waste and other radiation sources, and strengthening of the non-proliferation regime.

In 2015, new revision of the **Design-Basis Threat for Nuclear Facilities, Nuclear Material, Radioactive Waste and Other Radiation Sources in Ukraine** was approved by the President's Decree No. 520/14t/2015 dated 27 August 2015. Provisions of this document have criteria to:

- improve the regulatory framework for physical protection and illicit trafficking of radioactive waste;
- perform state review of documents related to physical protection systems of nuclear facilities, nuclear materials, radioactive waste, other radiation sources and designs of engineering and technical means of physical protection systems that are under reconstruction or technically upgraded;
- perform state checking the ability of physical protection systems of nuclear facilities, nuclear materials, radioactive waste, other radiation sources to withstand design-basis threat.

According to the mentioned Decree, facility design-basis threats have been developed at all Ukrainian NPPs; the documents of the Interdepartmental Commission on Protection of the Most Important NPP Facilities have been revised.

Taking into account current threats to national security of Ukraine and functioning of the state physical protection system in the high alert mode, NPP security staff kept enhanced guard. New Facility Interaction Plans have been developed and implemented at all NPPs for all cases of a sabotage at a nuclear power plant. Besides, the Procedure for Facility Interaction Plan Participants Staying at NPP Site in Case of Emergency has been also developed and implemented. During 2015, a set of emergency trainings were held at all NPPs. The training objective was to exercise actions of the Facility Interaction Plan participants in case of a sabotage in different situations, and to eliminate consequences revealed in earlier trainings. Vulnerability assessment of Ukrainian NPPs has been completed. It was followed by reports on assessing vulnerability of nuclear facilities and nuclear materials and recommendations of putting the physical protection system in compliance with requirements of the current legislation.

Within implementation of the program "Global Threat Reduction Initiative and Improving the Security of Radiation Sources" in 2015, surveys were held in Ukraine and the decision was made on the modernization of engineering and technical means of the physical protection system of the following medical institutions: Vinnytsia Regional Cancer Center, Zhytomyr Regional Cancer Center, Kyiv Regional Cancer Center, Chernihiv Regional Cancer

Center. Besides, the decision on the modernization of physical protection system of UkrDo Radon state interregional plants has been made.

10.2. Zaporizhzhya NPP Security

Reinforced security duty has been implemented at Zaporizhzhya NPP since 2014 to ensure stable and reliable functioning of the nuclear power plant, prevent unauthorized access to NPP facilities, and counter possible sabotage and terroristic acts.

According to the current legislation of Ukraine, NPP physical protection subdivisions and military departments of the National Guard of Ukraine shall ensure uninterrupted operation of Zaporizhzhya NPP physical protection systems, unconditional compliance with the mode requirements at its facilities, enhanced protection of nuclear facilities and nuclear materials, preventive measures for emergencies.

Considering the current revision of the design-basis threat, Zaporizhzhya NPP together with other Ukrainian NPPs is put in compliance with regard to issues of its protection, equipping the fighters of the National Guard of Ukraine, their interaction with other departments, including air defense staff of the Ministry of Defense of Ukraine. The measures have been developed on prevention of insider actions, special measures on elimination of potential threats from the outside of NPP perimeter. Due to ZNPP design, additional measures on monitoring of the water area around the facility were taken, physical protection department and NPP air defense subdivision armored groups were enhanced.

In 2015, emergency training “Facility-2015” on checking preparedness of forces and means of the participants of ZNPP Facility Interaction Plan in Case of a Sabotage was held.

The following exercises were performed:

– interaction of anti-terrorist groups on revealing, prevention and termination of possible terroristic acts and sabotage at facilities with large amount of people staying there;

– practical skills of ZNPP anti-terrorist staff, advance and coordinating group of the Anti-Terrorist Center of the Security Service of Ukraine in Zaporizhzhya region during taking anti-terrorist measures at the facility related to rally point, data analysis and draft decisions on termination of possible terrorist actions and sabotage.

Tactics and interaction procedure of anti-terrorist subdivisions, local authorities, ZNPP management during anti-terrorist operations on revealing and mitigation of terrorist acts have been improved.

Due to certain publications in western mass media on the reliability of ZNPP nuclear security, including Zaporizhzhya ISF, scheduled International Insurance Inspection of World Insurance Pool System was performed on ZNPP site in May 2015. The inspection was held by technical inspectors of Ukrainian and foreign nuclear insurance pools within the agreement on general liability insurance of NAEK Energoatom for nuclear damage. The issue related to safe storage of spent nuclear fuel at Zaporizhzhya NPP was included into NPP report and program for NPP inspection by the experts of the International Insurance Inspection.

According to results of Zaporizhzhya ISF inspection, the inspectors confirmed that such a method for spent nuclear fuel storage complies with all international standards and best practices.

11. INTERNATIONAL COOPERATION IN NUCLEAR AND RADIATION SAFETY

WENRA

Currently, international non-governmental organizations and associations acquire special significance in the international cooperation on nuclear and radiation safety. WENRA (Western European Nuclear Regulators Association) goes ahead among the leading European non-governmental organizations.

WENRA was established in 1999 on a voluntary basis by the regulatory bodies of EU Member States and Switzerland as an association of senior management of the Western European regulatory authorities having at least one nuclear facility under construction, operation or decommissioning.

The priority feature of WENRA activity is to develop common standards of nuclear and radiation safety in EU member states and establish assessment criteria of the regulatory sphere in the countries planning to join EU. Since 2009, Ukraine is an associate member of WENRA.

In 2003, the list of WENRA member states was extended due to membership of new countries in the European Union.

Today, WENRA Association includes: Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Lithuania, Netherlands, Romania, Slovenia, Slovakia, Spain, Sweden, Switzerland, the United Kingdom and Ukraine. Austria, Armenia, Norway, Poland, Belarus, Denmark, Ireland, Canada, Luxemburg and Russia are included to WENRA Association as observer countries.

The main WENRA tasks are to:

- develop and improve methods of independent safety assessment of nuclear facilities;
- develop general approaches related to nuclear safety and its regulation as well as support to harmonization of requirements in practices.

To implement the above tasks, two WENRA work groups were established in 2002; one of them is the work group on radioactive waste management and decommissioning (WGWD).

The objective of this work group is to develop the so-called safety reference levels (SRLs) and subsequent analysis of national legislation and development of National Action Plans to harmonize regulations of WENRA member states with the SRLs. The main documents for the development of SRLs are IAEA safety standards and experience in activities in the field of radwaste management and decommissioning. WGWD develops reports and safety reference levels related to:

- radioactive waste storage;
- decommissioning;
- radioactive waste disposal;
- radioactive waste processing.

Ukraine recognizes the importance of international cooperation between regulatory authorities for harmonization of regulatory requirements on NPP safety, safety in management of spent nuclear fuel and radioactive waste and NPP decommissioning, exchange of experience and development of common approaches to nuclear and radiation safety regulation. In 2015, Ukraine took an active part in WENRA plenary sessions and work groups. In particular, after the official application of SNRIU Chairman during regular plenary session, WENRA Secretariat considered the application for Ukraine to acquire full membership in the Association, which was later announced during the Association plenary session in March 2015 in Geneva (Switzerland). On 26 March 2015, Ukraine and WENRA member states signed

relevant guide document of the Association, namely "Terms of Reference of the Western European Nuclear Regulatory Association". Ukraine became a full member of WENRA Association.

The new status of Ukraine within the Association confirms foreign policy course of the state with the European integration as one of the main priorities. Active participation of Ukraine in new initiatives of the Association according to current challenges and further steps in the harmonization of national requirements for nuclear and radiation safety with WENRA reference levels will contribute to improved cooperation of the SNRIU with WENRA member states regulators, which will respectively give an opportunity to get closer to nuclear and radiation safety standards of the EU and continue developing common approaches to the major issues related to improving the safety of nuclear power plants under operation.

To fulfil Ukraine's obligations as a full member of the Association and in order to arrange efficient WENRA-SNRIU interaction, Order No. 115 dated 17 June 2015 approved SNRIU Board on harmonization of national regulations and rules of nuclear and radiation safety of Ukraine with WENRA reference levels.

Currently, the SNRIU completed self-assessment of Ukrainian regulations on decommissioning to check their compliance with WENRA safety reference levels and submitted them for WGWD consideration. The report with safety reference levels related to radwaste processing is under development.

Swedish-Norwegian-Ukrainian Initiative on Nuclear Safety and Security Cooperation

During the Nuclear Security Summit held in the Hague on 24-25 March 2014 in the Hague, Erna Solberg, the Prime Minister of Norway, and the Government of Sweden made statements regarding cooperation with Ukraine and noted that Norway and Sweden propose to initiate cooperation with Ukraine in issues related to improving nuclear safety and security of nuclear power plants in the country. Such statements were made in connection with the temporary occupation of Crimea, Donets'k and Luhans'k regions by the Russian Federation.

On 18 November 2014, Ole Harbitz, Director General of the Norwegian Radiation Protection Authority, Fredrik Hassel, Deputy Director General of the Swedish Radiation Safety Authority, and Serhii Bozhko, SNRIU Chairman, signed the Common Statement on Cooperation in the Sphere of Nuclear Safety and Security between Ukraine, Norway and Sweden.

According to the Statement, the Parties have pledged to report on cooperation results and achieved progress during the Washington Security Summit (USA, 2016).

Creation of this trilateral Initiative became a framework for a number of joint projects related to nuclear security of Ukrainian NPPs. It is important to state that nuclear safety and security are of a strategical importance for national safety in general under emergency conditions during armed conflict.

In 2015, eight projects have been implemented within the Initiative arranged according to the results of the Hague Nuclear Security Summit of March 2014. The meeting objective was to discuss results of the following projects:

1. Technical support of the SNRIU in the development of requirements for licensing of new and modified fuel.
2. Improvement of SNRIU capabilities in periodical safety assessment using state-of-the-art computer codes.
3. Modernization of applied software of the State Register of Radiation Sources (Register).
4. Damaged fuel management.

5. Instruments for probabilistic safety analysis.
6. Modernization of systems important to safety of RNPP, as a part of C(I)SIP implementation.
7. Modernization of Khmelnitsky NPP physical protection system.
8. 13th Ukrainian Nuclear Security Conference.

Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management

Ukraine is a party of an important international IAEA tool, such as the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.

On 11-22 May 2015, the **Fifth Meeting on Obligations under the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management** (Joint Convention) was held in the IAEA headquarters in Vienna. The meeting objective was to present the Fifth National Report on Compliance with Obligations under the Joint Convention. Ukraine presented comprehensive information on the current state of spent fuel and radioactive waste management infrastructure in Ukraine, legal aspects, progress reached during three years, policies and future plans in this sphere.

According to the established rules and procedures, review of national reports of countries is confidential, so that the authorized representatives of the Parties had the opportunity to consider openly and impartially safety challenges in the management of spent nuclear fuel and radioactive waste, assess progress in reaching the Convention objectives, express recommendations on needed measures to overcome challenges and threats. Presentation of national reports was performed in seven working groups of countries. Ukraine was included into the fifth group of countries together with Lithuania, Hungary, Luxemburg, Morocco, Croatia, Vietnam, Tajikistan, Russia and Gabon.

Ukrainian presentation was made by Tetiana Kilochytska, SNRIU Deputy Chairperson. The presentation paid much attention to the functioning of spent fuel and radioactive waste management infrastructure, legal aspects, progress reached during three years, policies and future plans in this area. Ukrainian presentation is placed on SNRIU web site.

Ukrainian delegation gave weighted, competent and extensive answers to the questions of meeting participants, which contributed to making a positive conclusion on the National Report of Ukraine.

The final report on review results of the National Report of Ukraine stated that Ukraine demonstrated significant progress from the Fourth Meeting of the Parties with regard to creating the infrastructure for safe management of spent nuclear fuel and radioactive waste and presented recommendations on a number of safety improvement measures during the next three years, namely:

- development of plans related to ChNPP Exclusion Zone future;
- development of conceptual plans related to Exclusion Zone use and status;
- under further development of conceptual plans for the Exclusion Zone one shall consider opinions of other countries (namely, countries suffered from Chornobyl accident), in particular Belarus;
- continued safety review of specialized plants for radioactive waste management of UkrDO Radon and implementation of improvement measures, if necessary.

The following challenges were defined for Ukraine:

- completion of ChNPP New Safe Confinement;

- construction of priority facilities for radioactive waste and spent nuclear fuel management in the Exclusion Zone, including design and construction of the centralized ISF, design and construction of long-term storage facility for vitrified high-level waste from WWER-440 spent fuel processing to be returned from Russia.

Therefore, Ukraine confirmed fulfillment of its obligations under the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.

Annex 1. SPECIAL REGULATORY ASPECTS IN INDIVIDUAL TERRITORIES OF UKRAINE

In 2015, Ukraine fully met the requirements of non-proliferation, as set out in the Agreement on the Application of Safeguards in Connection with the Treaty on the Nonproliferation of Nuclear Weapons and the Additional Protocol to the Agreement. Reports on nuclear materials, other information on nuclear activities in Ukraine were timely sent to the IAEA, three additional accesses and 39 IAEA inspections were arranged and conducted at the Ukrainian enterprises, including six unannounced. Due to the official report of Ukraine to the IAEA on lost control over nuclear material and forced limitation of access for IAEA inspectors to certain locations of nuclear material in the temporarily occupied territory of Crimea, Donets'k and Luhans'k regions, the above agreements did not cover these areas in 2015.

Individual Territories of Donets'k and Luhans'k Regions

On 14 April 2014, Decree of the President of Ukraine "On the Decision of the National Security and Defense Council of Ukraine of 13 April 2014 "On Urgent Measures to Overcome the Terrorist Threat and to Preserve the Territorial Integrity of Ukraine"" No. 405/2014 came into force.

Since June 2014 and during 2015, almost continuous combat operations were ongoing in some areas of Donets'k and Luhans'k regions occupied by illegal armed groups. Large territories within the area of the South-Eastern Inspection responsibility were found under control of terrorists. The largest number of industrial coal, metallurgical, chemical and mining enterprises in Ukraine, which belong to the industries of high risk and use sealed radionuclide radiation sources are located in these territories.

Seventy three economic entities (including eight institutions with category 1 high-level radiation sources, activity over 1000 Ci), using over 1200 units of sealed radionuclide radiation sources lost state regulatory control of nuclear and radiation safety in Ukraine. Almost all enterprises of Donbass coal industry (including *Donets'k Coal Energy Company* and *Luganskvugillia*) and a half of all iron and steel companies of South-Eastern Ukraine were found under control of terrorists. In addition, two storage facilities remained in the territory of Donets'k (Special Center *Vugleisotop* and PJSC *Donets'kstal' – Metallurgical Plant*) where about 500 sealed radionuclide radiation sources are stored.

Cabinet Ordinance No. 1085-r of 07 November 2014 approved the list of populated centers where state authorities temporarily do not exercise their powers. This list included 24 reginal centers and 136 populated centers of Donets'k and Luhans'k regions including regional centers Donets'k and Luhans'k. Another 114 settlements are located on the confrontation line. Thus, control of nuclear and radiation safety in these settlements is almost impossible.

At the same time, a number of nuclear entities using radiation sources, in 2015 performed activities in compliance with the requirements of laws, regulations, rules and standards on nuclear and radiation safety of Ukraine. Appropriate reporting documents (annual reports on radiation safety, quarterly reports on amount of radioactive waste) were timely submitted to the South-Eastern State Inspection. The measures were taken on nuclear material accounting and control. During 2015, seven licensees applied to the South-Eastern State Inspection to amend the licenses due to change of legal entity location to the territory under control of Ukraine. They include an enterprise, which tests radiation sources and checks their tightness in the territory of Ukraine.

The South-Eastern State Inspection received official notification on radiation incidents from licensees in the territories beyond Ukrainian control. In particular, JSC *Yenakiyevo Steel Plant* reported the discovery of an abandoned container with radiation sources in its territory, which was in illegal trafficking and was previously used in small private enterprise *BIK* in Sverdlovsk district of Luhans'k region.

In addition, three licensees in nuclear energy officially informed the South-Eastern State Inspection on the impossibility to ensure physical protection of radiation sources due to acquisition by seizure of facilities using radiation sources by armed military units of the so called Donets'k People's Republic and Luhans'k People's Republic (Luhans'k Customs, LLC *Cargill Combine*, PJSC *Ilyich Iron and Steel Works of Mariupol*).

Unfortunately, there is no official information in the SNRIU on radiation safety at two large Donbass coal mining enterprises (*Donets'k Coal Energy Company* and *Luhans'kvugillia*) bringing together 14 coal mines located in the territory beyond the control of Ukraine. Total number of radiation sources used by these companies is 114 (maximum rated activity of single source reaches 2.35×10^{11} Bq). There is no information also on the state of temporary

shutdown radioactive waste storage facility located on the territory of Donets'k state factory of chemical products, which experienced strong explosion at the end of 2014.

The territory of Donets'k state factory of chemical products

Based on the analysis of the situation, it can be concluded that the main potential threat in the area of the Anti-Terrorist Operation is illicit trafficking of radiation sources and radioactive waste from the territory beyond Ukrainian control that could result in public exposure and radioactive contamination of the environment due to unsealing of radiation sources or their use as a "dirty" bomb.

In this regard, the SNRIU took measures to strengthen control over radiation sources and radioactive waste from the territories beyond Ukrainian control to reduce the threat of their illicit trafficking and assess risks of loss of regulatory control over them.

For interaction under emergency with radiation hazard for the public, mutual information feedback on similar cases among the South-Eastern State Inspection and regional state administrations of Donets'k, Luhans'k and Zaporizhzhya regions was provided. The lists of nuclear entities with high risk in these regions were also provided. In order to specify the plans of response to radiation accidents in Donets'k, Luhans'k and Zaporizhzhya regions, the information on enterprises and organizations whose activity may result in radiation accidents was submitted to the Main Department of the State Emergency Service of Ukraine in Zaporizhzhya region and the Department of Civil Protection, Mobilization and Defense Activity of the Donets'k Regional State Administration. To timely notify and submit the information on emergencies with radiation hazard for the public, licensees using radionuclide radiation sources were proposed to urgently review the emergency plans regarding update of the contact information for emergency communication.

Autonomous Republic of Crimea

Due to the occupation of the Autonomous Republic of Crimea in 2014 by the Russian Federation, Ukraine lost regulatory control over such nuclear facilities as research reactor IR-100 of the Sevastopol National University of Nuclear Energy and Industry and two subcritical assemblies with low-enriched and natural uranium. In addition, in Crimea there are several companies and medical institutions using devices and containers with radiation protection of depleted uranium and high-level radiation sources (7 institutions, mainly oncological centers).

Taking into account Resolution of the UN General Assembly of 27 March 2014 "The Territorial Integrity of Ukraine", the IAEA informed Ukraine on continuation of applying its safeguards in accordance with its Charter and the international law. Therefore, the IAEA applies the safeguards to nuclear materials and facilities in the territory of Crimea in accordance with the Safeguards Agreement between Ukraine and the Agency and its Additional Protocol.

However, in 2015 the licensees located in Crimea did not submit any report on the results of physical inventory for the current year. Communication between the SNRIU with the Crimean State Inspection for Nuclear and Radiation Safety was actually lost, and since September 2014, it was officially subordinated by the Federal Service for Environmental, Technological and Nuclear Supervision of the Russian Federation.

At the beginning of 2015, the State Nuclear Regulatory Inspectorate of Ukraine decided to terminate activity of the Crimean State Inspection on Nuclear and Radiation Safety (Simferopol, K. Marks St., 40) by its reorganization, namely joining as regards:

safety regulation of nuclear facilities, radioactive waste management facilities goes to the Northern State Inspection on Nuclear and Radiation Safety (Kyiv, Verkhovna Rada Blvd., 3);

safety regulation of other radiation sources goes to the Southern State Inspection on Nuclear and Radiation Safety (Odessa, Shevchenko Avenue, 1).

Annex 2. PUBLIC HEARINGS ON LONG-TERM OPERATION OF SUNPP UNIT 2

On 28 October 2015, the State Nuclear Regulatory Inspectorate of Ukraine initiated public discussion of SNRIU draft decision on possible long-term operation of the nuclear facility, namely SUNPP unit 2.

Public hearings held by the SNRIU in Yuzhnoukrainsk on 25 November 2015 with the participation of *Energoatom* Company were the key stage of active dialogue with the public.

The event attracted much attention of the public. Nearly 600 people participated in the event: residents of SUNPP region, representatives of public organizations, journalists of central and regional mass media.

The following documents were provisionally published on official web sites of the regulatory body and the operating organization and distributed to participants of the public hearings on long-term operation of SUNPP unit 2:

- SNRIU draft decision;
- periodical safety review report. Safety factor 14 “Environmental impact of operation”;
- periodical safety review report. Comprehensive safety analysis of SUNPP unit 2;
- conclusions of the state review of nuclear and radiation safety of the Report on periodical safety review of SUNPP unit 2;
- certificate of comprehensive inspection of Energoatom Company preparedness to perform activities at a lifecycle stage “nuclear facility operation” on SUNPP unit 2 long-term operation;
- environmental information presented to the public during public discussion of March-June 2015 of safety justification of SUNPP unit 2 long-term operation arranged by state authorities and local bodies of SUNPP observation area;
- possible transboundary impact from SUNPP regular operation and in case of emergencies within requirements of Espoo Convention.

Serhii Bozhko, SNRIU Chairman, opened public hearings and stressed that interaction with the public is one of regulator's priorities and making the decision on further SUNPP unit 2 operation is open and transparent despite existing global nuclear safety challenges and nuclear non-proliferation safeguards. S. Bozhko stated that the SNRIU is guided by national legislation that is in full compliance with international IAEA and WENRA standards. NPP safety improvement is the decisive criterion.

Yurii Nedashkivsky, Energoatom Company President, and Volodymyr Lisnichenko, SUNPP Director General, presented the operating organization.

All interested parties, supporters and fierce opponents of nuclear energy, had the opportunity to express their opinion. The following presentations were made: Volodymyr Korovkin, Ukrainian Nuclear Community, Tetiana Verbytska, National Ecological Center of Ukraine, Olha Kosharna, Ukrainian Nuclear Forum, Serhii Koliesnikov, Zeleny Svit (Voznesensk), and Mykhailo Yatsenko, Youth Energy Community. Many representatives of other Ukrainian public organizations, local residents, local and regional council members joined the discussion on further fate of SUNPP unit 2. Viktor Parokonnyi, Yuzhnoukrainsk Mayor, also made a speech.

The documents based on public discussion results were published on SNRIU official web site. Public hearing results were analyzed on 7 December 2015 during the open session of SNRIU Board related to making the decision on ensuring SUNPP unit 2 long-term operation.

List of Abbreviations

C(I)SIP – Comprehensive (Integrated) Safety Improvement Program
centralized ISF – Centralized Spent Fuel Storage Facility
ChNPP – Chornobyl Nuclear Power Plant
CRME – Centralized Radioactive Waste Management Enterprise
CS – Commissioning Stage
FS UCPS – Functional Subsystem of the Unified Civil Protection System
IAEA – International Atomic Energy Agency
ICSRM – Industrial Complex for Solid Radioactive Waste Management
IEC – Information and Emergency Center
INES – International Nuclear and Radiological Event Scale
ISF – Interim Spent Fuel Storage Facility
KhNPP – Khmelnytsky Nuclear Power Plant
LRTP – Liquid Radioactive Waste Treatment Plant
NIP – Nuclear Insurance Pool
NPP – Nuclear Power Plant
NRBU – Radiation Safety Standards of Ukraine
NRS – Nuclear and Radiation Safety
NSC – New Safe Confinement
PSA – Probabilistic Safety Analysis
PSRR – Periodical Safety Review Report
Radwaste – Radioactive Waste
RNPP – Rivne NPP
SAR – Safety Analysis Report
SFA – Spent Fuel Assembly
SIP – Shelter Implementation Plan
SNF – Spent Nuclear Fuel
SSE – State Specialized Enterprise
SUNPP – South Ukraine Nuclear Power Plant
VSC – Ventilated Storage Cask
WWER – Water-Cooled Water-Moderated Power Reactor
Zaporizhzhya ISF – Dry-type Spent Fuel Storage Facility
ZNPP – Zaporizhzhya NPP

Appendix C22

EnergoAtom. 2014b. Technical Meeting to Share Experiences and Lessons Learned from the Application of Different Management System Standards in the Nuclear Industry.

Ministry of Energy and Coal Industry of Ukraine

ЕНЕРГОАТОМ
ENERGOATOM

National Nuclear Energy Generating Company

Integrated Management System of SE "NNEGC "ENERGOATOM":

based on international standards ISO 9001-2008 «Quality management systems — Requirements»,

ISO 14001-2004 «Environmental management systems—Requirements with guidance for use» ,

focused on requirements of IAEA Safety Standard GS-R-3

«The Management System for Facilities and Activities»

Technical Meeting to Share Experiences and Lessons Learned from the application of Different Management System Standards in the Nuclear Industry

Yuliia Hasheva,

Vienna, 2014

National Nuclear Energy Generating Company "Energoatom"

ЕНЕРГОАТОМ ENERGOATOM

State Enterprise "National Nuclear Energy Generating Company "Energoatom" was founded in 1996

NNEGC "Energoatom" is an operating organization having primary responsible for safety of four Ukrainian NPPs.

Generating capacities of Ukrainian NPPs

ЕНЕРГОАТОМ ENERGOATOM

Now we have 15 nuclear power units in operation with overall installed capacity of 13 835 MWt, including:

13 - with reactor facility type of WWER-1000

2 - with reactor facility type of WWER-440

Zaporizhzhya NPP

6 nuclear power units with WWER-1000

Rivne NPP

4 nuclear power units, including 2 with WWER-440 and 2 with WWER-1000

South-Ukrainian NPP

3 nuclear power units with WWER-1000

Khmelnitsky NPP

2 nuclear power units with WWER-1000

NNEGC "Energoatom" structure

ЕНЕРГОАТОМ ENERGOATOM

NNEGC "Energoatom" structurally consist of:

- Main office
- NPPs:
  - Zaporizhzhya NPP
  - Rivne NPP
  - South-Ukrainian NPP
  - Khmelnitsky NPP
- Service divisions:
  - «Atomenergomash» (repair and modernization of heat-exchange and heat-mechanic equipment, fabrication of RAW storage casks and metal structures for NPPs needs)
  - «Atomremontservice» (mounting, maintenance and repair, reconstruction and upgrading of equipment of NPPs)
  - «Atomcomplect» (procurement of material production for NPPs)
  - «Emergency and Technical Centre» (emergency preparedness and response, specific engineering works)
  - «Scientific and Technical Centre» (establishing and maintenance of science and technical support system)
  - «Warehouse Division» (storing of material production for NPPs)
  - «Atomprojectengineering» (providing activities on capital construction of nuclear facilities)
  - "Design Division «Atompribor» (development of new types of equipment for NPPs)
  - «Executive Office» (communal and householding activities, material and service support)

NNEGC "Energoatom" objectives:

ЕНЕРГОАТОМ ENERGOATOM

Main objectives are:

- ✓ **Generation of power in safely manner.**
- ✓ **Construction of new and LTO of operating facilities**
- ✓ **Purchasing of fresh fuel, removal of spent fuel**
- ✓ **Establishing of national infrastructure for irradiated fuel handling**
- ✓ **Physical protection of nuclear facilities**
- ✓ **Training and professional development of NPPs` personnel**
- ✓ **Social support of Company`s staff.**

History of creation
Quality Assurance System (QAS)

WAS was developed, documented, analyzed and improving in accordance with requirements of ISO standards series 9000 (issued in 1994), IAEA safety series Series No. 50-C-QA (1996) «Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations», national regulation НП 306.5.02/3.017-99 «Requirements to quality assurance program on all stages of nuclear facilities lifecycle".

Quality assurance departments were founded with following functions:

- **Development of methods and procedures of QAS**
- **Implementation and ensuring of functioning of QAS**
- **Organization and performing of assessments of effectiveness of QAS**
- **Organization and performing of assessments of suppliers.**

Individuals were assigned (at top management level) with relevant authorities and responsibilities for ensuring of implementation and functioning of QAS.

History of creation
Quality Assurance System→Management System

Further QAS has evolved to meet the changing needs of the Company and both revising and new international and national standards and/or regulations (e.g. ISO series 9000 and 14000 issued in 2000).

After the IAEA Safety Requirements GS-R-3 "The Management System for Facilities and Activities" was published in 2006, revision of ISO standards series 9000 were published in 2005/2008 and series 14000 were published in 2004, Company`s QAS was transformed into Management System.

IMS of NNEGC "Energoatom"

Management System certification

CERTIFICATE TÜVNORD

Management system as per
ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Rivne Nuclear Power Plant (RNPP) State Enterprise National Nuclear Energy Generation Company «Energoatom»
34400 Kuznetsovsk, Rivne region
Ukraine

applies a management system in line with the above standard for the following scope

Production of electric and thermal energy

Certificate Registration No. 44 100 061808
Audit Report No. 3511 3208

Valid until 2016-01-24
Initial certification 2007

Certification Body
at TÜV NORD CERT GmbH

Essen, 2013-01-25

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

CERTIFICATE TÜVNORD

Management system as per
ISO 14001 : 2004

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Rivne Nuclear Power Plant (RNPP) State Enterprise National Nuclear Energy Generation Company «Energoatom»
34400 Kuznetsovsk, Rivne region
Ukraine

applies a management system in line with the above standard for the following scope

Production of electric and thermal energy

Certificate Registration No. 44 104 061808
Audit Report No. 3511 3209

Valid until 2016-01-24
Initial certification 2007

Certification Body
at TÜV NORD CERT GmbH

Essen, 2013-01-25

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

Management System of Rivne NPP was primary certified in 2006 by certification body TÜV Nord on conformity of ISO standards 9001:2000 and 14001:2004, and recertified in 2013

IMS of NNEGC "Energoatom"

ЕНЕРГОАТОМ ENERGOATOM

Management System certification

СЕРТИФІКАТ TÜV NORD

На систему менеджменту згідно з
ISO 9001 : 2008

Доказ про застосування згідно зі стандартом надано та відповідно до методики TÜV NORD CERT підтверджується для організації

Відокремлений підрозділ
«Южно-Українська АЕС» ДП НАЕК «Енергоатом»
Проммайданчик
55000, м. Южноукраїнськ
Україна

Сфера діяльності

Виробництво електричної та теплової енергії

Реєстраційний номер сертифіката 44 100 061180 — Чинний до 2015-07-26
Звіт про аудит № 3510 1941 — Первинна сертифікація 2006

TÜV NORD CERT GmbH, орган з сертифікації в системі — Ессен, 2012-07-27

Сертифікація проведена відповідно до затвердженої у TÜV NORD CERT методики аудитування та сертифікації і підлягає періодичним наглядовим аудитам.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen Www.tuev-nord-cert.com

IAF

TGA-ZM-07-06-09

Management System of South-Ukrainian NPP was primary certified in 2006 by certification body TÜV Nord on conformity of ISO standard 9001:2000, and recertified in 2013

IMS of NNEGC "Energoatom"

ЕНЕРГОАТОМ ENERGOATOM

Management System certification

CERTIFICATE TÜVNORD

Management system as per
ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Isolated Substitution
«Repair and Service of Atomic Equipment»
of the State Enterprise National Nuclear Generation Company
«Energoatom»
7, Enthusiastov str.
UKR-07100 Slavutich, Kiev region

applies a management system in line with the above standard for the following scope

Projecting, development, installation, repair, reconstruction, modernization of power devices and equipment; training of the repair personnel

Certificate Registration No. 44 100 120558 Valid until 2015-04-24
Audit Report No. 3509 9203

Certification Body
at TÜV NORD CERT GmbH

Essen, 2012-04-25

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

TGA-ZM-07-08-00

Management System of "Atomremontservice" was primary certified in 2010 by certification body TÜV Nord on conformity of ISO standards 9001:2008, and recertified in 2012

IMS of NNEGC "Energoatom"

Management System→Integrated Management System

IMS integrates following elements of organization into single combined system:

- **Structure**
- **Resources (including knowledge)**
- **Processes**
- **Personnel (including key competencies)**
- **Equipment**
- **Organizational Culture**
- **Documented guides and procedures (including policies)**

Integrated Management System of NNEGC "Energoatom"

IMS based on requirements of ISO standards series 9000 and 14000 taking into account international and national requirements on nuclear and radiation safety.

IMS based on following fundamental principles:

- **Ensuring safety is prior objective as against economical, technical, science and other objectives;**
- **Continual and systematic control of safety requirements compliance has to be essential need;**
- **Planning, management and supervision for activity affecting on safety should be provided in normal, transient and emergency conditions;**
- **Safety culture and security culture have to be developed and maintained;**
- **Top management has a personal responsibility for allocation of resource necessary for safety requirements implementation on a priority basis**
- **Prevention of safety requirements violations by continual analyzing of activity and implementing of corrective and preventive actions.**

Integrated Management System of NNEGC "Energoatom"

One of the principles of IMS construction is the process approach that means consideration of the activity as the set of interrelating and interfacing organizational processes performing by different structural departments of the Company. In the IMS processes are grouped according to the their role in the management system as follows:

- Group of the processes of strategic/administrative management
- Group of the processes of financial and economical management
- Group of the production processes and safety assurance processes
- Group of processes of human resource management
- Group of processes of material resources management
- Group of processes of monitoring and control.

Certification of Integrated Management System of NNEGC "Energoatom"

In 2010 Company starts preparing to its IMS certification. During that preparation following activities were performed:

- Basic IMS procedures were developed/revised (including IMS General Guide, Guide on Ecological System)
- Set of Management policies was developed
- Main processes were developed and described
- Preliminary audits were carried out at Khmelnitsky NPP, Zaporizhzhya NPP, Atomenergomash and Main office
- Corrective actions resulting of preliminary audits were undertaken
- Requirements stated in regulations of Ukrainian Nuclear Regulatory Inspection "General Requirements to Management Systems in Field of Nuclear Energy Utilization" and "Requirements to Management System of the Operator" were integrated into IMS.

Certification of Integrated Management System of NNEGC "Energoatom"

In 2013 NNEGC "Energoatom" Main Office and three separated divisions (Khmelnitsky NPP, Zaporizhzhya NPP, Atomenergomash) were audited by Certification body TÜV Nord for the purpose of confirmation that IMS of NNEGC "Energoatom" is in compliance with requirements of international standards ISO series 9000 and 14000. Relevant certificates were issued on condition that supervisory audits of these entities will be conducted on annual bases.

Main differences between GSR-3 and ISO 9001 (as specified in SRS-69) that were considered during IMS implementation

Aiming.

IAEA GS-R-3 presents the requirements for organizations to establish, implement, assess and continually improve a **management system** that integrates safety, health, environmental, security, quality and economic elements, to foster a strong safety culture and improve safety performance in all the activities of the organization. In IAEA GS-R-3, **safety is of primary importance**, overriding all other demands.

ISO 9001:2008 allows an organization **to demonstrate its ability to meet customer** and applicable statutory and regulatory **requirements**, in addition to its own organizational requirements, **and to enhance customer satisfaction**. It does not include requirements to ensure safety or requirements specific to other management system aspects, such as those particular to environmental management, occupational health and safety management, financial management or risk management.

Main differences between GSR-3 and ISO 9001 (as specified in SRS-69) that were considered during IMS implementation

Satisfaction of customers

IAEA **GS-R-3** requires senior management to consider the expectations and the satisfaction of **interested parties** in the processes of its management system, while **ISO 9001:2008 focuses only on customers**. Thus, the focus in IAEA GS-R-3 is on safety but with due consideration of the requirements and expectations of interested parties as far as they directly or indirectly affect the activities of an organization. IAEA GS-R-3 focuses on a broader range of interested parties than does ISO 9001:2008

Human Resources

ISO 9001:2008 requires the organization to ensure that its **personnel are aware of the relevance and importance of their activities**, and of how these activities contribute to the achievement of the quality objectives. IAEA **GS-R-3 requires** the organization **to ensure that its personnel are competent to perform their assigned work and that they understand the consequences for safety of their activities**. Also in this area, **ISO 9001:2008 focuses on the quality aspects**, **in contrast to the strong focus on safety in IAEA GS-R-3**.

Progress in Integrated Management System of NNEGC "Energoatom"

Now we are actively working on improving our IMS taking into account following aspects:

- **Reviewing the current version of ISO 9001 that will be issued in autumn 2015. Recognizing the new requirements that will be included in ISO 9001, edition of 2015, we implement the electronic workflow approach, knowledge management system (within the corporate knowledge portal), introduce some changes in the process approach etc.**
- **Publication of TECDOC 1740 "Use of a Graded Approach in the Application of the Management System Requirements for Facilities and Activities" in 2014. These new recommendations are analyzed and will be included in our internal standard on graded approach.**
- **Revising the IAEA safety standard GS-R-3, new publication GS-R Part 2 will be issued in 2016. New requirements concerning leadership for safety and safety culture will be analyzed and considered in IMS.**

Thank you
for attention
Kyiv, 2014

Appendix C23

State Nuclear Regulatory Inspectorate of Ukraine. 2016. Current Status of Centralised Spend Fuel Storage Facility Construction.

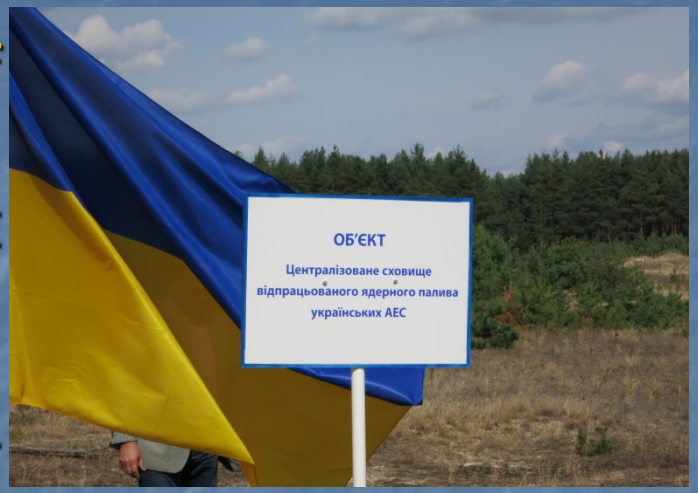
Current Status of Centralised Spent Fuel Storage Facility (CSFSF) Construction

Andrii Shepitchak, Oleksandr Grigorash

NUCLEAR POWER ENGINEERING IN UKRAINE

Centralised Spent Fuel Storage Facility (CSFSF)

- 09.02.2012 - Verhovna Rada of Ukraine enacted the Law «On Spent Nuclear Fuel Management with regard to siting, design and construction of the Centralized Storage Facility for Spent Nuclear Fuel from WWR type reactors of Ukrainian Nuclear Power Plants».
- *Article 1. CSF is a part of the integrated complex for spent nuclear fuel handling of the "Chornobyl NPP" state specialized enterprise.*



CSFSF (cont)

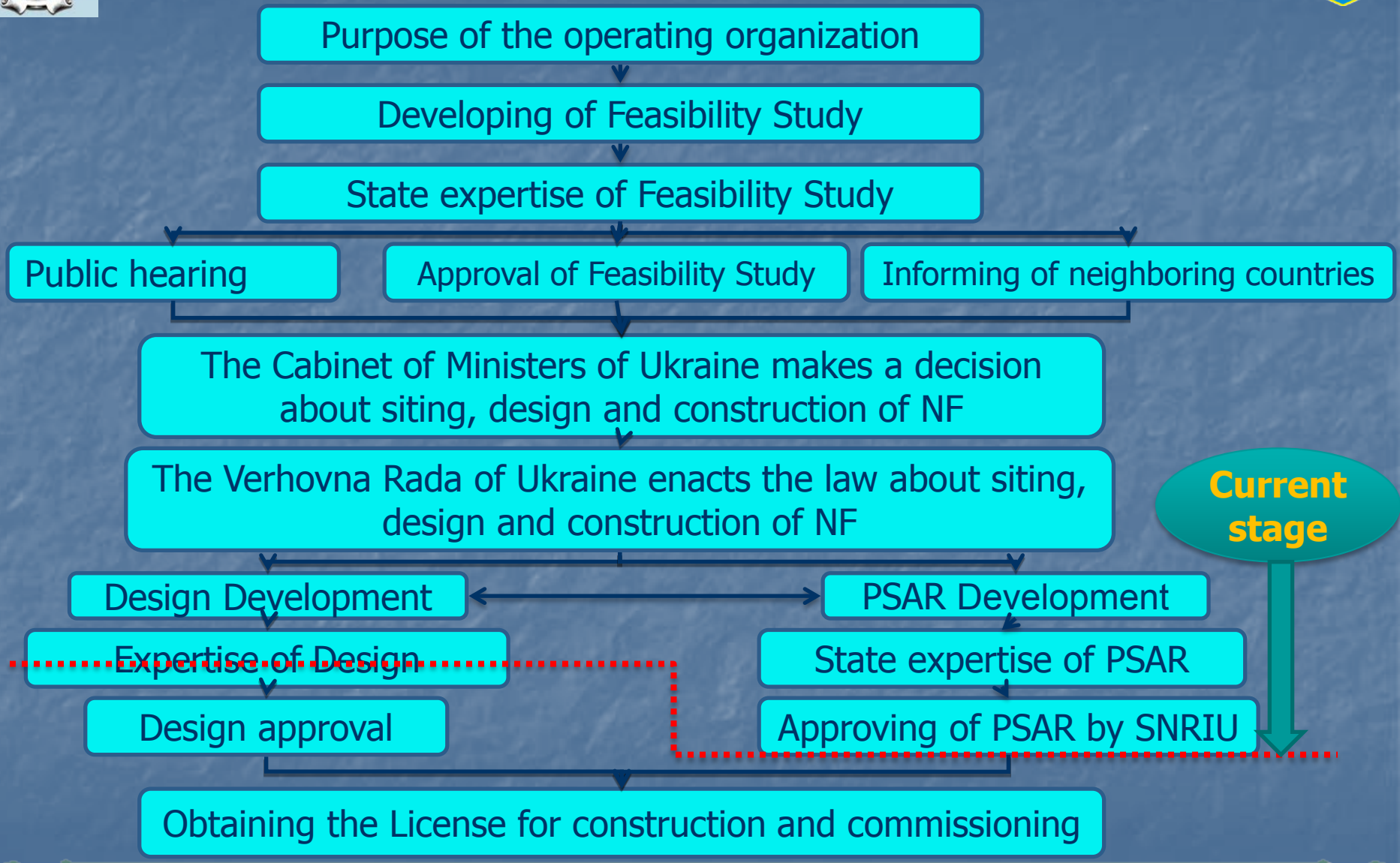
- *Article 2. The "dry" surface storage technology with two-barrier system application for its isolation which is provided with the equipment of specially designed engineering container type systems will be used for SNF storage in the centralized storage facility.*
- *The Contract for construction of the CSFSF was signed with Holtec International in 2005.*
- 04.04.2014 Ministry of Energy and Coal Industry of Ukraine established operating organization of CSFSF - State Enterprise "National Nuclear Energy Generating Company "Energoatom" (hereinafter - NNEGC "Energoatom")

Last events

- **21.09.2016** - SNRIU received an application for a license on "construction and commissioning of a nuclear installation" life cycle stages from NNEGC “Energoatom” and documents which substantiate it.
- **10.05.2016** - land area of 45.2 hectares was removed from the permanent use of the State Agency for Management Exclusion Zone and granted on permanent use to NNEGC "Energoatom“ for the construction and operation of the Facility by the Cabinet of Ministers of Ukraine.
- **21.10.2016** - SNRIU informed NNEGC "Energoatom“ concerning positive preliminary results of application review and initiation of verification of the completeness and accuracy of the information contained in the documents submitted and their evaluation, including the state review of these documents and inspections of the applicant, the date of which will be determined separately;
- **03.11.2016** - SNRIU Board meeting reviewed the results of state review on nuclear and radiation safety of PSAR of CSFSF, after that the Conclusion of State Nuclear and Radiation Safety of PSAR was approved (Board Decision №08 from 11.03.2016).
- ***Current status of technical specifications for equipment important to safety (TS) review:***
- ***- reviewed of 15 TSs and sent previous comments;***
- ***- 2 TSs (on Multipurpose canister) after improving are under reviewing.***

STATE NUCLEAR REGULATORY INSPECTORATE OF UKRAINE

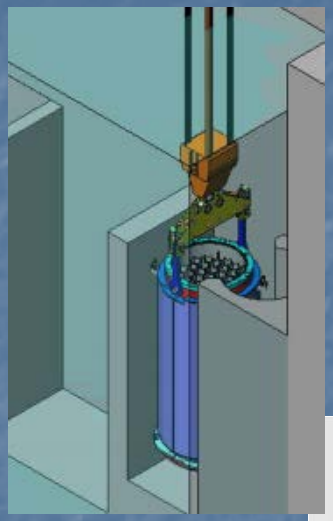
Scheme of creation of Nuclear Facility which has national importance



Main characteristics of CSFSF

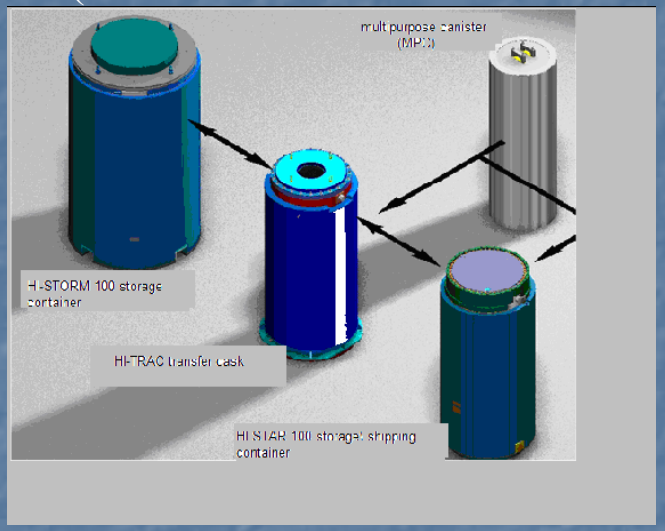
- Square – 11, 7 hectares.
- The total capacity of the centralized storage is 16,529 SFA (12,500 SFAs of WWER-1000 (400 casks) and 4, 000 SFAs of WWER-440 (50 casks)).
- The capacity per year - 504 SFAs of WWER-1000 (16 casks) and 192 SFAs of WWER-440 (3 casks).
- Construction completion and commissioning of the initial facility (so-called "start-up complex") is planned till the end of 2018.
- Two operation CSFSF stages are determined:
- - active period (45-50 years) - the time while CSFSF are receiving SFAs on long-term storage;
- - passive period (50-55 years) – the time while SFAs are stored in containers and CSFSF systems are operated before deciding on further technology on handling of SNF in Ukraine.

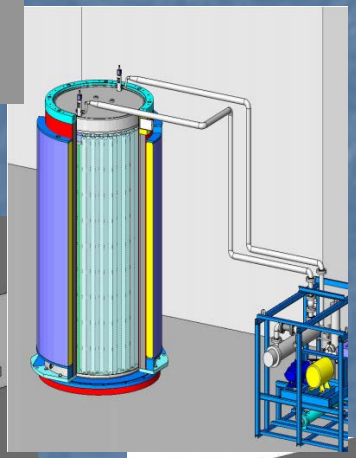
Technology of CSFSF

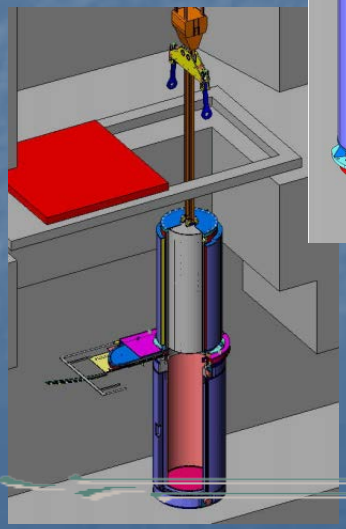


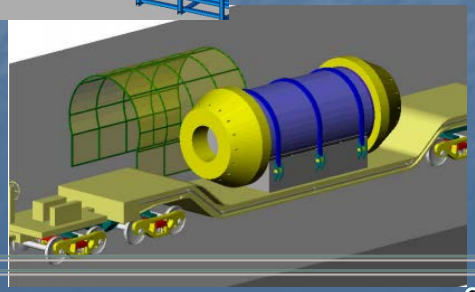
The system consists of the following main components:

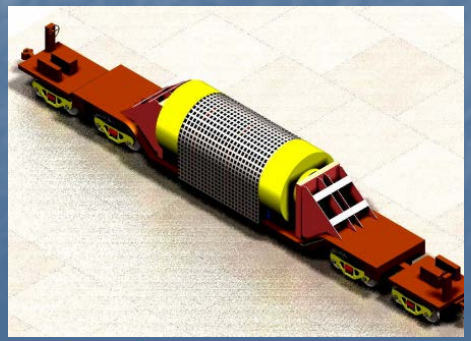
- Multipurpose canister (MPC);
- Metallic concrete container for storage (HI-STORM);
- Shipping cask (HI- STAR);
- Steel transfer cask (HI -TRAC).











8

Modifications of NPPs

- SNRIU has approved:
- "Conceptual decision on introduction of modified handling technology of spent nuclear fuel for transferring its to CSFSF on "pilot" units of Ukrainian NPPs";

- "The typical program on carrying out of experimental and commissioning tests using of full-dimensional simulators of CSFSF main equipment on units of Rivne NPP, KhNPP, SU NPP"

THANK YOU FOR ATTENTION!

Appendix C24

Project Management Group Creation, No Date. Centralized Storage of Spent Nuclear Fuel

MINISTRY OF ENERGY AND COAL INDUSTRY OF UKRAINE
State Enterprise
"National Nuclear Energy Generating Company" Energoatom "
EP "Atomproektinzhynirynh"

APPROVED
CEO
EP "Atmproektinzhynirynh"
_____ Oh. M. Rybchuk
«___» _____ 201 6 g.

POSITION

project management group creation
Centrally first storage facility for spent nuclear fuel
(Facility)

PL-D. 0.46. 6 038 -1

The term di th

Inventory number

Date
Validity extended until

Telephone messages

Date

P olozhennya
project management group creation
Centralized storage of spent nuclear fuel
(Facility)

Art at p 1

SHEET IN G ODZHENNYA

Position	Signature	Date	Initials, surname
Deputy General Director - Director of new nuclear plants			AND. F. Orlov
Deputy Director General on the establishment of a single set of Spent Nuclear Fuel			IN. AND. Trouser leg
Deputy Director of the new nuclear facilities - Head of NF, created			IN. D. Medun
Deputy Director of the new nuclear facilities - Head of professionals holvnyh			Y. IN. Cherepanov
Head of Quality and Licensing			JH Mitichkina
Head of Quality Assurance and Licensing			AT. G. Syrotyns cues

CONTENT

Art at p.

ACCEPT REDUCTION

TERMS AND DEFINITIONS

1 TERMS

2 OBJECTIVES AND FUNCTIONS

3 THE ORGANIZATIONAL STRUCTURE

4 RELATIONSHIP 11

SHEET REGISTRATION CHANGES 12

SHEET REVIEW

1 Accept REDUCTION

NPP	nuclear power station
VP	separated subdivision
SNF	spent fuel
SE "" Energoatom "	State Enterprise "National Nuclear Energy Generating Company" Energoatom "
SCNS	State Nuclear Regulatory Inspectorate of Ukraine th us
SSTC	D erzhavne Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety"
CMU	cabinet of Ministers of Ukraine
CD	K ontseptualne decision "On Introduction to" pylotnыh "unit AES Ukraine modyfytsyrovannoy circulation technology with otrabotavshym yadernыm fuel required to implement Sending ego in TSHOYAT"
Minenergouglya	**1.1 Ministry of Energy and Mines Ukraine**
RAPS	Rivne nuclear power plant
FZ	physical protection
KNPP	Khmelnytsky nuclear power plant
Storage Facility	C entralizovane spent nuclear fuel
SUNPP	South Ukrainian nuclear power plant
NM	nuclear material
NRS	nuclear safety
NF	nuclear plant

1.2

2 Terms and definitions

Project	The only process that consists of a set of coordinated and controlled types of work with dates of beginning and end, performed to achieve goals that meet specific requirements and restrictions upon deadline, cost and resources (p. 3.5 of ISO 10006: 2005)
Storage Facility	Centralized storage of spent nuclear fuel
project management	Planning, organizing, monitoring, controlling and reporting on all aspects of the project and stimulate all participants to achieve the project objectives (p. 3.6 of ISO 10006: 2005)
Responsible executor	EP "Atomproektinzhynirynh" SE "" Energoatom "
Group project management	The group set up for the project, which **is implementing the project** (p. 4.1.2 of ISO 10006: 2005)
Project Manager	An official with clear responsibility and authority for managing the project and ensuring rozroblyannya, implement and maintain a quality management system in the project (p. 5.2.3 of ISO 10006: 2005)
Director PMU	The officer responsible for the management of the PMU
The Steering Committee	The collegiate body of technology implementation Holtec of spent nuclear fuel for power units SE "" Energoatom "functionally associated with the project; receives information from PMU and performs supervisory and advisory functions (strategic support project)
Creditors	International financial institutions participating in the co-financing projects
Venues	The territory, a second will be implemented P roekt Facility
Central PMU office	Part of the PMU, formed of managers and specialists EP "Atomproektinzhynirynh." Managed by PMU.
PMU on site	Part PMU formed with unit managers EP NPP. Managed by the PMU on the court.
Director PMU on site	The person appointed by the order of Director General of the EP AES, which is headed by the PMU on the court.

3 1 TERMS

3.1 1.1 This Regulation group project management centralized repository for spent nuclear fuel EP "Atomproe ktinzhynirynh" SE "" Energoatom "(hereinafter - Regulation) is designed for tasks to create a centralized repository for spent nuclear fuel (hereinafter - Project Facility, Draft).

3.2 1.2 Regulations determine the procedure of forming the PMU, its structure, the role of members of the PMU, tasks and functions, as well as interaction with structural divisions of the Company, the Consultant PMU, creditors and other stakeholders.

3.3 1.3 PMU is united group that formed the leaders and specialists of structural units OP "Atomproektinzhynirynh" SE "" Energoatom "(hereinafter - OP IPA) and VP AES.

3.4 1.4 SUE composition and distribution of tasks and responsibilities among the members of the PMU vyznachayet be orders of SS API and this Statute.

3.5 1.5 Location PMU.

3.6 ..... – Central office: Ukraine, 01032, Kyiv, str. Gaidar, 6 room EP "Atomproektinzhynirynh";

3.7 ..... – Sue finds at the site of ARE KhNPP, and RNPP SU NPP idno compliance, and quickly dominate ARE PMU Head Office.

3.8 1.6 Provisions designed to meet the requirements:

3.9 ..... – Law of Ukraine "On the management of spent nuclear fuel on location, design and construction of centralized storage facility for spent nuclear fuel VVER domestic nuclear power"

3.10 ..... – Conceptual solution "Oh Introduction to" pylotnыh "unit AES Ukraine modyfytsyrovannoy circulation technology with otrabotavshym yadernым fuel required to implement Sending ego in TSHOYAT"

3.11 ..... – Cabinet of Ministers of Ukraine of 26.11.2008 number 1027 "On the order initiation, preparation and implementation of economic and social development of Ukraine, supported by international financial organizations";

3.12 ..... – Of the Ministry of Finance of Ukraine, Ministry of Economy and European Integration of Ukraine, Ministry of Labour and Social Policy of Ukraine, Ministry of Ukraine th stytsiyi 29.10.2002 number 905/308/550/93/5 "On approval of the project management group for economic and social development of Ukraine, supported by international financial organizations";

3.13 ..... –

Ukraine National Standard "Quality Management Systems. Guidelines for quality management in projects "(of ISO 10006: 2005);

3.14 1.7 PMU operates in accordance with applicable regulatory acts and regulatory requirements, production, org anizatsiyno-thrust yadchyh and other existing VPD API documents.

3.15 1.8 This Regulation should know leaders who coordinated it, and all persons who are members of PMU.

3.16 1.9 This provision should be aware of all persons involved in the project and have relationships with PMU.

3.17 1.10 This provision should be in the fund documentation productive th VP API (original) EP KNPP EP RAPS, VP NPP (copies included).

4 2 OBJECTIVES AND FUNCTIONS

4.1 2.1 The aim of the PMU is to perform n roektu create a centralized repository for spent nuclear fuel.

4.2 2.2 Implementation of the objectives provided by the staff of structural Mr idrozdiliv VP API's under her jurisdiction and work of PMU staff is Redeemed work in the Project Facility must have high qualifications and experience sufficient to understand their goals, project objectives and ways to achieve them.

4.3 2.3 The task of the PMU:

- Current project management;
- ealizatsiyi development plan, the project and its support to date;
- ensuring use for the current project in the Company's regulatory and industrial dock umentatsiyi, preventing the creation of unnecessary documents (requirements which duplicate existing procedures in force);
- Development and support overall project schedule;
- development and update of detailed schedules for the implementation of each phase of the Facility; Organization of PMU on implementation of K (i) SDS according to the schedule of the Project;
- the conditions for redytnyh agreements;
- effective cooperation with the project, for oordynatsiynym committee structural divisions of the Company's central authorities, for redytoramy within the powers defined in this Regulation.

4.4 2.4 In order to fulfill its tasks central office PMU sells industrial-technical and financial-economic functions are closely and directly linked to each other (but arbitrarily divided in this section for ease of perception):

4.5 2.5 Production and technical features:

- Monitoring of the Project;
- Organization drafting the contract;
- implementation (if necessary) preparation of documents on amendments to the Project;
- preparing reports on the project for submission to the Steering Committee;
- of the final report on the results of the project;
- exercise overall control of the project, including the schedule of the project;
- Risk Management Project;
- the organism uation and holding meetings and negotiations on the Project;
- organization development and approval of documentation for the tender;
- drafting orders, and other documents roses poryadchyh the Project; Organization approval of organizational and administrative documents
- The Licensing;
- CONTROL P roektu implementation of a quality assurance (through self-assessments, internal audits or other posobamy with - the established procedure);

- control use for P roektu active in the Company's regulatory and production documentation uu to avoid creating unnecessary documents;
- Organization of the plan of environmental and social measures;
- providing (for) the reference to the press-center of the Company.

4.1 2.6 **Financial and economic functions:**

- organization of the financial management project;
- drafting of payment documents for application EP - curator agreement (payment orders, statements etc.);
- Dr. accompanied the implementation of payment instruments;
- preparation of financial reporting documents, storage, financial and other reporting docu ing required to audit roektu P;
- training plan in the procurement of goods (works, services) under the Project;
- organization reporting on procurement of the Project;
- diysnennya of training and support competitive bidding for goods and services;
- Monitoring of performance contracts.

4.2 2.7 **PMU on the site:**

- responsible for implementing the project in stages;
- CAP provides professionals involved in nuclear engineering and organizational meetings for the Project;
- prepares reports, reports, reference materials to requests PMU Head Office;
- supervises the development and approval of the relevant technical documents NPP specialists (conceptual solutions, specifications and delivery conditions, technical solution for editing, testing program, etc.);

5 3 THE ORGANIZATIONAL STRUCTURE

5.1 3.1 Personal structure of PMU appointed by order of the President of the Company.

5.2 3.2 Management of all project carries Project Manager - Mr ershyy vice-president - technical director. For this, he has the necessary powers specified in the job description and relevant provisions (of collegial bodies and structural subdivisions of the Company).

5.3 3.3 With Project Leader Om functionally linked Steering Committee on the implementation of technology that gets information from the PMU and performs supervisory and advisory functions (strategic support for the project).

5.4 3.4 The composition of the steering committee:

5.5 ..... Head Steering Committee - President GP "" Energoatom ".

5.6 ..... Members of the governing comitat:

- a singer and dpovidalnyy "Holtec International";
- Head of nuclear energy and atomic complex promysldovoho Minenergouglya;
- deputy director of safety of nuclear installations - Inspector Nuclear Regulatory Committee of Ukraine;
- Director of SSTC;
- First Vice President - Director of tehnchnyy "" Energoatom ", deputy chairman of the committee;
- Vice President GP "" Energoatom ";
- CEO RNPP;
- CEO KhNPP;
- CEO of SU NPP;
- chairman of JSC KIEP;
- Technical Director of HIEP;
- CEO VP API;
- President Head of State Enterprise "" Energoatom ".

4 RELATIONSHIP

4.1 4.1 Director PMU manages the activities of the PMU.

4.2 4.2 Leader in operating SUE SUE Managers are on-site.

4.3 4.3 Personal structure of the PMU in areas relevant orders appointed CEO VP AES.

4.4 4.4 Director PMU is responsible for the Project.

4.5 4.5 Project Manager and Head of PMU appointed President of the Company.

Coordinating Committee and the personal composition of the Group's control pan innya project appoint ARE president of the submission of the project manager.
Director and staff of the PMU orders on platforms appointed CEO VP AES.
Candidates for the posts of specialists SUE SUE submitted to the head manager of the unit VP API.

4.6 4.6 Project Manager provides management and supervision of all work on the project.

4.7 4.7 Director PMU monitors the implementation of the plan procurement action plans to implement the project and financing; cooperates on the project with the lender.

4.8 4.8 First Deputy Head of the PMU interaction with public authorities and creditors has vyschezaznach Annie functions and serves as the K erivnyka PMU in his absence.

4.9 REGISTRATION SHEET CHANGES

change	number of sheets				message		signature	date
	modified	Collapsed	new	canceled	number	Amount sheet		
1	2	3	4	5	6	7	8	9

SHEET REVIEW

Name	Position	Date	Signature

МІНІСТЕРСТВО ЕНЕРГЕТИКИ ТА ВУГІЛЬНОЇ ПРОМИСЛОВОСТІ УКРАЇНИ
державне підприємство
“Національна атомна енергогенеруюча компанія “Енергоатом”
ВП «Атомпроектінжиніринг»

ORIGINAL

ЗАТВЕРДЖУЮ
Генеральний директор
ВП «Атмпроектінжиніринг»
_____ О. М. Рибчук
«___» _____ 2016 р.

ПОЛОЖЕННЯ

про групу управління проектом створення
Централізованого сховища відпрацьованого ядерного палива
(ЦСВЯП)

ПЛ-Д.0.46.038-16

Термін дії	
Інвентарний №	
Дата	

Термін дії продовжено до	
Номер повідомлення	
Дата	

АРКУШ ПОГОДЖЕННЯ

Посада	Підпис	Дата	Ініціали, прізвище
Заступник генерального директора – директор з нових ядерних установок			І. Ф. Орлов
Заступник генерального директора з питань створення єдиного комплексу поводження з відпрацьованим ядерним паливом			В. І. Холоша
Заступник директора з нових ядерних установок – начальник управління ЯУ, що створюються			В. Д. Медун
Заступник директора з нових ядерних установок – начальник управління голвних фахівців			Ю. В. Черепанов
Начальник управління з якості та ліцензування			І. М. Мітічкіна
Начальник відділу забезпечення якості та ліцензування			О. Г. Сиротинський

ЗМІСТ

Стор.

ПРИЙНЯТІ СКОРОЧЕННЯ 19

ТЕРМІНИ ТА ВИЗНАЧЕННЯ 20

1 ЗАГАЛЬНІ ПОЛОЖЕННЯ 21

2 ЗАВДАННЯ ТА ФУНКЦІЇ 23

3 ОРГАНІЗАЦІЙНА СТРУКТУРА 25

4 ВЗАЄМОВІДНОСИНИ 11

АРКУШ РЕЄСТРАЦІЇ ЗМІН 12

АРКУШ ОЗНАЙОМЛЕННЯ 28

ПРИЙНЯТІ СКОРОЧЕННЯ

АЕС	атомна електрична станція
ВП	відокремлений підрозділ
ВЯП	відпрацьоване ядерне паливо
ДП «НАЕК «Енергоатом»	Державне підприємство «Національна атомна енергогенеруюча компанія «Енергоатом»
Держатомрегулювання	Державна інспекція ядерного регулювання України
ДНТЦ ЯРБ	Державне підприємство «Державний науково-технічний центр з ядерної і радіаційної безпеки»
КМУ	Кабінет Міністрів України
КР	Концептуальне рішення "О внедрении на "пилотных" энергоблоках АЭС Украины модифицированной технологии обращения с отработавшим ядерным топливом для обеспечения отправки его в ЦХОЯТ"
Міненерговугілля	Міністерство енергетики та вугільної промисловості України
РАЕС	Рівненська атомна електростанція
ФЗ	фізичний захист
ХАЕС	Хмельницька атомна електростанція
ЦСВЯП	Централізоване сховище відпрацьованого ядерного палива
ЮУ АЕС	Южно-Українська атомна електростанція
ЯМ	ядерний матеріал
ЯРБ	ядерна та радіаційна безпека
ЯУ	ядерна установка

ТЕРМІНИ ТА ВИЗНАЧЕННЯ

Проект	Єдиний процес, який складається із сукупності скоординованих та контрольованих видів робіт з датами початку та закінчення, виконуваний задля досягнення цілі, що відповідає конкретним вимогам, і містить обмеження щодо строку, вартості та ресурсів (п. 3.5 ДСТУ ISO 10006:2005)
ЦСВЯП	Централізоване сховище відпрацьованого ядерного палива
Управління проектом	Планування, організування, моніторинг, контролювання та звітування щодо всіх аспектів проекту, а також стимулювання всіх його учасників для досягнення цілей проекту (п. 3.6 ДСТУ ISO 10006:2005)
Відповідальний виконавець	ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом»
Група управління проектом	Група, створена на період виконання проекту, яка **виконує проект** (п. 4.1.2 ДСТУ ISO 10006:2005)
Керівник проекту	Посадова особа з чітко визначеними відповідальністю та повноваженнями щодо керування проектом і забезпечення розробляння, запроваджування та підтримування системи управління якістю в проекті (п. 5.2.3 ДСТУ ISO 10006:2005)
Керівник ГУП	Посадова особа, відповідальна за керування роботою ГУП
Керівний комітет	Колегіальний орган із впровадження технології Холтек із поводження з відпрацьованим ядерним паливом на енергоблоках АЕС ДП «НАЕК «Енергоатом», функціонально пов'язаний з керівником проекту; отримує інформацію від ГУП і виконує наглядово-дорадчі функції (стратегічна підтримка проекту)
Кредитори	Міжнародні фінансові організації, що приймають участь у співфінансуванні Проекту
Майданчики	Територія, на якій буде реалізовуватись Проект ЦСВЯП
Центральний офіс ГУП	Частина ГУП, сформована з керівників та спеціалістів ВП «Атомпроектінжиніринг». Очолюється керівником ГУП.
ГУП на майданчику	Частина ГУП, сформована з керівників структурних підрозділів ВП АЕС. Очолюється керівником ГУП на майданчику.
Керівник ГУП на майданчику	Особа, призначена наказом генерального директора ВП АЕС, яка очолює ГУП на майданчику.

6 ЗАГАЛЬНІ ПОЛОЖЕННЯ

6.1 Це Положення про групу управління проектом будівництва Централізованого сховища відпрацьованого ядерного палива ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом» (далі – Положення) розроблене для виконання завдань зі створення Централізованого сховища відпрацьованого ядерного палива (далі – Проект ЦСВЯП, Проект).

6.2 Положення визначає порядок формування ГУП, її структуру, ролі членів ГУП, завдання та функції, а також взаємодію з структурними підрозділами Компанії, Консультантом ГУП, Кредиторами та іншими зацікавленими сторонами.

6.3 ГУП є об’єднаною групою, що сформована з керівників та спеціалістів структурних підрозділів ВП «Атомпроектінжиніринг» ДП «НАЕК «Енергоатом» (далі – ВП АПІ) та ВП АЕС.

6.4 Склад ГУП та розподіл завдань і функцій серед членів ГУП визначається наказом ВП АПІ і цим Положенням.

6.5 Місцезнаходження ГУП.

- Центральний офіс: Україна, 01032, Київ, вул. Гайдара, 6, приміщення ВП «Атомпроектінжиніринг»;
- ГУП на Майданчиках знаходяться у ВП ХАЕС, ВП РАЕС та ВП ЮУАЕС відповідно, і оперативно підпорядковуються ГУП Центрального офісу.

6.6 Положення розроблено з урахуванням вимог:

- Закону України «Про поводження з відпрацьованим ядерним паливом щодо розміщення, проектування та будівництва централізованого сховища відпрацьованого ядерного палива реакторів типу ВВЕР вітчизняних атомних електростанцій»
- Концептуального рішення "О внедрении на "пилотных" энергоблоках АЭС Украины модифицированной технологии обращения с отработавшим ядерным топливом для обеспечения отправки его в ЦХОЯТ"
- Постанови Кабінету Міністрів України від 26.11.2008 № 1027 «Про порядок ініціювання, підготовки та реалізації проектів економічного і соціального розвитку України, що підтримуються міжнародними фінансовими організаціями»;

- Наказу Міністерства фінансів України, Міністерства економіки та з питань європейської інтеграції України, Міністерства праці та соціальної політики України, Міністерства юстиції України від 29.10.2002 № 905/308/550/93/5 «Про затвердження Порядку діяльності груп управління проектами економічного і соціального розвитку України, які підтримуються міжнародними фінансовими організаціями»;
- Національного стандарту України «Системи управління якістю. Настанови щодо управління якістю в проектах» (ДСТУ ISO 10006:2005);

6.7 ГУП здійснює свою діяльність згідно з чинними нормативно-правовими актами і вимогами нормативних, виробничих, організаційно-розпорядчих та інших діючих у ВП АПІ документів.

6.8 Це Положення повинні знати керівники, які його погоджували, а також усі особи, що входять до складу ГУП.

6.9 З цим Положенням мають бути ознайомлені всі особи, що залучаються до проекту і матимуть стосунки з ГУП.

6.10 Це Положення повинно знаходитись у фонді виробничої документації ВП АПІ (оригінал), ВП ХАЕС, ВП РАЕС, ВП ЮУАЕС (враховані копії).

7 ЗАВДАННЯ ТА ФУНКЦІЇ

7.1 Метою діяльності ГУП є виконання проекту створення Централізованого сховища відпрацьованого ядерного палива.

7.2 Реалізація завдань Проекту забезпечується персоналом структурних підрозділів ВП АПІ відповідно до їх компетенції та роботою ГУП Працівники залучені до роботи в Проекті ЦСВЯП, повинні мати високу кваліфікацію і досвід, достатні для розуміння ними мети, завдань проекту і шляхів їх досягнення.

7.3 Завдання ГУП:

- поточне управління Проектом;
- розробка Плану реалізації Проекту і його підтримка в актуальному стані;
- забезпечення використання для цілей проекту діючої в Компанії нормативної і виробничої документації, запобігання створенню зайвих документів (вимоги яких дублюють наявні чинні процедури);
- розробка та оновлення загального графіку Проекту;
- розробка та оновлення детальних графіків для реалізації кожного етапу створення ЦСВЯП; організація діяльності ГУП з впровадження заходів К(з)ПБ відповідно до графіку Проекту;
- виконання умов кредитних угод;
- ефективна взаємодія з керівником проекту, координаційним комітетом, структурними підрозділами Компанії, центральними органами виконавчої влади, кредиторами в межах повноважень, визначених цим Положенням.

7.4 З метою виконання покладених на нього завдань Центральний офіс ГУП реалізує виробничо-технічні та фінансово-економічні функції, тісно і безпосередньо повязані між собою (але умовно розділені в цьому розділі для зручності сприйняття):

7.5 Виробничо-технічні функції:

- здійснення моніторингу реалізації Проекту;
- організація підготовки проекту договору;
- здійснення (у разі потреби) підготовки документів про внесення змін до Проекту;
- підготовка звітів щодо Проекту для подання до Керівного комітету;
- підготовка остаточного звіту за результатами реалізації Проекту;
- здійснення загального контролю за реалізацією Проекту, в тому числі дотримання графіку реалізації Проекту;
- управління ризиками Проекту;
- організація і проведення наради та переговори з питань Проекту;
- організація розробки та погодження документації для проведення конкурсних торгів;

- підготовка проектів наказів, розпоряджень та інших розпорядчих документів за Проектом; організація погодження цих організаційно-розпорядчих документів;
- управління ліцензуванням;
- контроль реалізації Проекту в частині забезпечення якості (шляхом проведення самооцінки, внутрішніх аудитів або іншими способами – в установленому порядку);
- контроль використання для цілей Проекту діючої в Компанії нормативної та виробничої документації з метою запобігання створенню зайвих документів;
- організація виконання плану природоохоронних та соціальних заходів;
- надання (за запитом) довідкової інформації до Прес-центру Компанії.

2.6 Фінансово-економічні функції:

- організація діяльності з фінансового управління Проектом;
- підготовка проектів платіжних документів за заявкою ВП – куратора договору (платіжних доручень, заяв тощо);
- здійснення супроводу платіжних документів;
- підготовка звітних фінансових документів, зберігання фінансових та інших звітних документів, необхідних для проведення аудиту Проекту;
- підготовка плану закупівель товарів (робіт, послуг) у рамках Проекту;
- організація підготовки звітів з питань закупівель щодо Проекту;
- здійснення підготовки і супроводження конкурсних торгів на закупівлю товарів, робіт, послуг;
- здійснення моніторингу виконання контрактів.

2.7 ГУП на майданчику:

- відповідає за реалізацію Проекту на майданчиках;
- забезпечує участь спеціалістів ВП АЕС у технічних та організаційних нарадах з питань реалізації Проекту;
- готує звіти, доповіді, довідкові матеріали на запити Центрального офісу ГУП;
- контролює розробку та погодження відповідних технічних документів спеціалістами АЕС (концептуальне рішення, технічні вимоги та умови постачання, технічне рішення на монтаж, програма випробувань та інше);

8 ОРГАНІЗАЦІЙНА СТРУКТУРА

8.1 Персональний склад ГУП призначається наказом президента Компанії.

8.2 Керівництво всім Проектом здійснює Керівник проекту – перший віце-президент – технічний директор. Для цього він має необхідні повноваження, визначені в посадовій інструкції і відповідних положеннях (про колегіальні органи і про структурні підрозділи Компанії).

8.3 З Керівником проекту функціонально пов'язаний керівний комітет із впровадження технології, який отримує інформацію від ГУП і виконує наглядово-дорадчі функції (стратегічна підтримка проекту).

8.4 Склад керівного комітету:

Голова керівного комітету – президент ДП «НАЕК «Енергоатом».

Члени керівного комітату:

- відповідальний виконавець «Холтек Інтернешнл»;
- начальник управління ядерної енергетики та атомно-промислдового комплексу Міненерговугілля;
- заступник директора департаменту з питань безпеки ядерних установок – державний інспектор Держатомрегулювання України;
- директор ДНТЦ ЯРБ;
- перший віце-президент – технчний директор ДП «НАЕК «Енергоатом», заступник голови комітету;
- віце-президент ДП «НАЕК «Енергоатом»;
- генеральний директор ВП РАЕС;
- генеральний директор ВП ХАЕС;
- генеральний директор ВП ЮУАЕС;
- голова правління ПАТ КІЕП;
- технічний директор ВАТ ХІЕП;
- генеральний директор ВП АПІ;
- керівник служби президента ДП «НАЕК «Енергоатом».

4 ВЗАЄМОВІДНОСИНИ

4.1 Керівник ГУП здійснює управління діяльністю ГУП.

4.2 В оперативному управлінні Керівника ГУП перебувають Керівники ГУП на майданчиках.

4.3 Персональний склад ГУП на майданчиках призначається відповідними наказами генеральних директорів ВП АЕС.

4.4 Керівник ГУП відповідає за виконання Проекту.

4.5 Керівник проекту та керівник ГУП призначаються президентом Компанії.
Координаційний комітет та персональний склад Групи управління проектом призначаються президентом Компанії за поданням Керівника проекту.
Керівник та персонал ГУП на майданчиках призначається наказами генеральних директорів ВП АЕС.
Кандидатури на посади спеціалістів ГУП подаються керівнику ГУП керівником відповідного підрозділу ВП АПІ.

4.6 Керівник проекту забезпечує управління і нагляд за всією роботою з реалізації Проекту.

4.7 Керівник ГУП здійснює контроль за виконанням плану закупівель, планів заходів з реалізації Проекту та з фінансування; взаємодіє з питань реалізації проекту з Кредиторами.

4.8 Перший заступник керівника ГУП із взаємодії з органами державної влади та кредиторами здійснює вищезазначені функції та виконує функції Керівника ГУП в разі його відсутності.

АРКУШ РЕЄСТРАЦІЇ ЗМІН

зміни	номери аркушів				повідомлення		підпис	дата
	змінених	замінених	нових	Анульованих	номер	к-сть аркушів		
1	2	3	4	5	6	7	8	9

АРКУШ ОЗНАЙОМЛЕННЯ

П.І.Б.	Посада	Дата	Підпис

Appendix C25

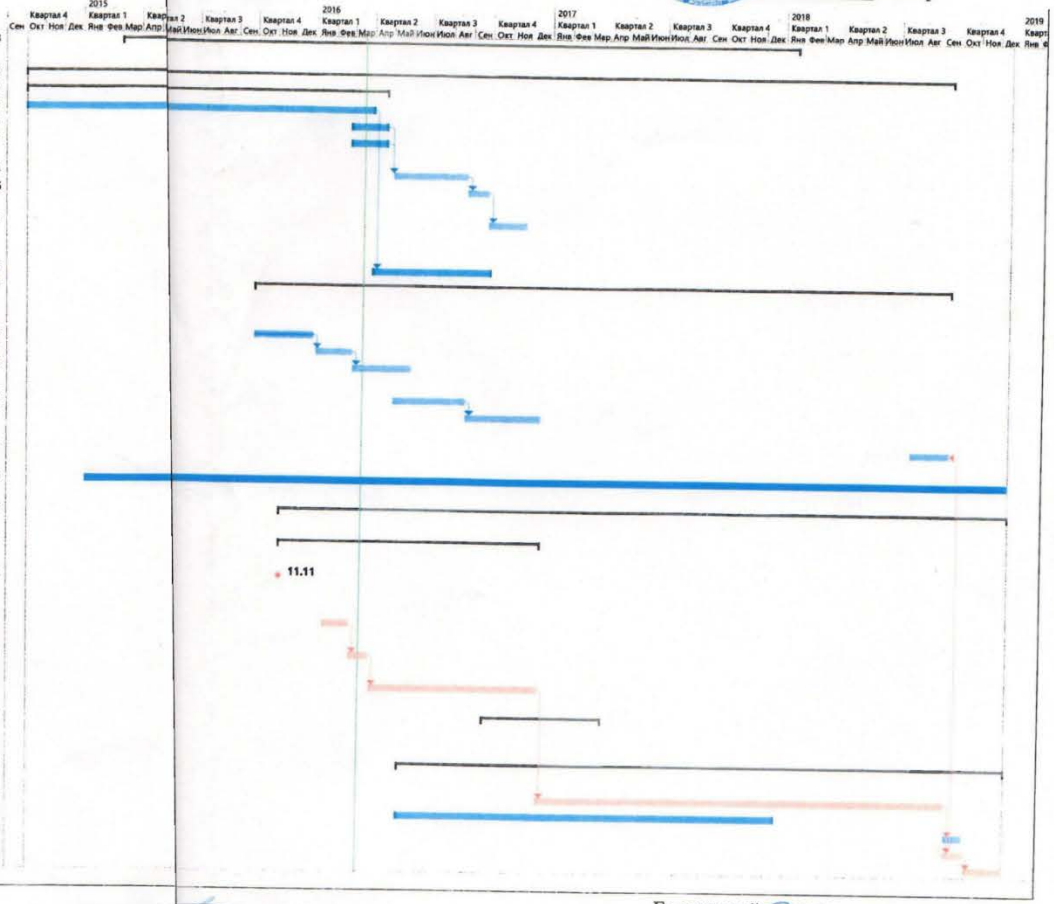
Summary Project Schedule

«ПОГОДЖЕНО»
Голова ДІЯРУ
лист №15-18/4-2328 С.Г. Божко
«12» 04 2016 р.

Графік виконання робіт з проектування та будівництва ЦСВЯП

«ЗАТВЕРДЖУЮ»
Президент НАЕК «Енергоатом»
_____ Ю.О. Недашковський
«____» _____ 2016 р.

Ид.	Режим задачи	Название задачи	Name of the task	Начало	Окончание
1		**Постачання спеціального технологічного обладнання (контракт з Холтек)**	**Supply of technological equipment (Contract with Holtec International)**	**Пн 02.03.15**	**Пт 19.01.18**
14		**Проектування ЦСВЯП**	**CSFSF Design**	**Пт 03.10.14**	**Чт 20.09.18**
15		**Розробка проекту ЦСВЯП стадія "П"**	**Development of CSFSF design (Stage «**	**Пт 03.10.14**	**Чт 21.04.16**
16		Перша редакція ПКД		Пт 03.10.14	Чт 31.03.16
17		ОВНС		Пт 26.02.16	Чт 21.04.16
18		Звіт відповідності вимогам санітарного законодавства		Пт 26.02.16	Чт 21.04.16
19		Держекспертиза проекту ЦСВЯП	State Expertize of CSFSF Design	Пн 02.05.16	Ср 24.08.16
20		Остаточна редакція після коригування ПКД та погодження Держекспертизи		Чт 25.08.16	Пн 26.09.16
21		Затвердження проекту будівництва ЦСВЯП (Міненерговугілля,Мінрегіон, рішення КМУ)	Approval of CSFSF Design (by Ministry of energy, Ministry of Regional Development, Construction and	Вт 27.09.16	Пт 25.11.16
22		Розробка проекту ЦСВЯП стадія "Р"	Development of CSFSF design (Stage «\	Пт 01.04.16	Пт 30.09.16
23		**Науково-проектна робота - обґрунтування безпеки ЯУ (розробка звітів з аналізу безпеки)**	**Design-research works for safety substantiation of power installation (development of preliminary safety**	**Ср 30.09.15**	**Чт 20.09.18**
24		Вибір виконавця, підписання договору	Definition of contractor and contract o	Ср 30.09.15	Ср 30.12.15
25		Збір вихідних даних	Input data	Пн 04.01.16	Вт 01.03.16
26		Розробка документації, підготовка попереднього звіту з аналізу безпеки	Development of documentation, preparation of preliminary safety	Ср 02.03.16	Ср 01.06.16
27		Експертиза ДІЯРУ ПЗАБ	SNRIU expertize	Чт 05.05.16	Ср 24.08.16
28		Одержання Ліцензії ДІЯРУ на будівництво і введення в експлуатацію	Obtaining the SNRIU license for Construction and Comissioning	Чт 25.08.16	Вт 20.12.16
29		Отримання дозволу на введення в експлуатацію	Obtaining permission for comissioning	Пт 20.07.18	Чт 20.09.18
30		Впровадження модифікованої технології поводження з ВЯП на АЕС	Implementation of the Modified Technology for Management of Spent	Чт 01.01.15	Ср 19.12.18
31		**Виконання підготовчих робіт, будівництво ЦСВЯП, ПНР та введення в експлуатацію**	**Implementation of preparatory works, Construction, adjustment**	**Ср 11.11.15**	**Ср 19.12.18**
32		**Виконання підготовчих робіт на майданчику ЦСВЯП**	**Implementation of preparatory works at the CSFSF cite**	**Ср 11.11.15**	**Вт 20.12.16**
33		Затвердження проектів землеустрою на відведення ділянок під будівництво ЦСВЯП та залізничної колії		Ср 11.11.15	Ср 11.11.15
34		Реєстрація прав на користування земельними ділянками		Ср 20.01.16	Вт 01.03.16
35		Оформлення в ДАБІ Декларації на виконання підготовчих робіт		Ср 02.03.16	Пт 01.04.16
36		Виконання підготовчих робіт відповідно до затвердженої ПКД		Пн 04.04.16	Вт 20.12.16
37		**Вибір генерального підрядника з БМР ЦСВЯП, підготовка до початку БМР**	**Tender on construction and installation works, preparation for construction**	**Вт 27.09.16**	**Ср 29.03.17**
42		**Будівництво ЦСВЯП та ПНР**	**Construction and adjustment works**	**Пт 20.05.16**	**Ср 19.12.18**
43		Будівництво ЦСВЯП	CSFSF Construction	Ср 21.12.16	Ср 19.09.18
44		Будівництво підїзної колії		Пт 20.05.16	Чт 28.12.17
45		ПНР обладнання ЦСВЯП на блоках АЕС	Adjustment works for CSFSF equipmen	Чт 20.09.18	Пт 19.10.18
46		ПНР систем та обладнання ЦСВЯП	Adjustment works for CSFSF equipmen	Чт 20.09.18	Пт 19.10.18
47		Введення в експлуатацію	Comissioning	Пн 22.10.18	Ср 19.12.18



Перший віце-президент –
технічний директор
_____ О.В. Шавлаков
«____» _____ 2016 р.

Віце-президент
_____ А.А. Айсін
«____» _____ 2016 р.

Генеральний директор
ВП «Атомпроектінжиніринг»
_____ О.М. Рибчук
«____» _____ 2016 р.

Appendix C26

Dzenkiv, I. A. No Date. CSFSF Construction Time Schedule.

Annex E(6)
(mandatory)
CSFSF Construction Time Schedule

Names of chapters, facilities, work items, and costs	Estimated cost, UAH '000		Allocation of capital investments and volumes of construction and installation work over project years										
	Total	including construction and installation work	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Chapter 1. Preparation of the construction site	**7,012.069**	**4,708.610**	7,012.069 4,708.610	-	-	-	-	-	-	-	-	-	-
Chapter 2. Core facilities of the Project													
Reception building	1,831,951.074	45,333.889	219,834.129 9,293.447	1,172,448.687 30,827.045	439,668.258 5,213.397								
Cask storage area	122,716.699	84,013.489	31,906.342 21,003.372	90,810.357 63,010.117	-	3,582 3,582	3,582 3,582	2,604 2,604	3,472 3,472	3,472 3,472	3,472 3,472	3,689 3,689	3,472 3,472
Installation of HI-STORM casks	223,582.427	222.754	-	-	223,582.427 222.754	1,815,169.878 1,817.905	1,806,074.100 1,817.905	1,314,340.497 1,327.284	1,642,488.521 1,767.999	1,642,488.521 1,767.999	1,642,488.521 1,767.999	1,749,647.399 1,880.372	1,642,488.5; 1,767.999
Chapter 2 sub-total	**25,797,404.702**	**154,697.944**	**251,740.471** **30,296.819**	**1,263,259.045** **93,837.161**	**663,250.685** **5,436.151**	**1,815,173.460** **1,821.487**	**1,806,077.682** **1,821.487**	**1,314,343.101** **1,329.888**	**1,642,491.993** **1,771.471**	**1,642,491.993** **1,771.471**	**1,642,491.993** **1,771.471**	**1,749,651.088** **1,884.061**	**1,642,491.98** **1,771.471**
Chapter 3. Ancillary and service facilities	**222,559.076**	**30,630.566**	**12,642.925** **7,652.510**	**208,840.117** **22,787.090**	**1,076.034** **190.966**	-	-	-	-	-	-	-	-
Chapter 4. Power supply facilities	**44,124.245**	**19,327.361**	**20,905.650** **5,683.617**	**23.218.595** **13,643.744**	-	-	-	-	-	-	-	-	-
Chapter 5. Transportation and communication facilities	**738,160.730**	**58,638.936**	**2,734.221** **2,734.221**	**728,722.966** **49,201.172**	**6,703.544** **6,703.544**	-	-	-	-	-	-	-	-
Chapter 6. Outside water supply, waste water disposal, heat supply, and gas supply networks and structures	**37,747.071**	**27,578.181**	**12,978.992** **10,164.422**	**23,710.364** **16,448.506**	**1,057.715** **965.253**	-	-	-	-	-	-	-	-
Chapter 7. Landscaping and greenery planting	**99,280.335**	**52,398.021**	**24,169.379** **14,173.864**	**56,478.739** **25,275.539**	**18,632.217** **12,948.618**	-	-	-	-	-	-	-	-
Chapter 8. Provisional buildings and structures	**19,434.198**	**16,447.402**	**9,796.550** **9,796.550**	**4,651.744** **3,009.006**	**4,985.904** **3,641.846**	-	-	-	-	-	-	-	-
Chapter 9. Other work items and costs	**67,031.764**	**9,232.471**	**16,160.158** **1,391.801**	**40,021.832** **3,806.556**	**9,010.953** **3,589.352**	**133.294** **32.240**	**133.294** **32.240**	**97.319** **23.539**	**129.634** **31.355**	**129.634** **31.355**	**129.634** **31.355**	**137.873** **33.348**	**129.634** **31.355**
Chapter 10. Maintenance of the Client's office	**17,045.35**	-	**6,969.403**	**6,751.813**	**3,324.134**	-	-	-	-	-	-	-	-
Chapter 11. Training of the operating personnel	**551.586**	-	-	-	**551.586**	-	-	-	-	-	-	-	-
Chapter 12. Design and surveying work	**26,779.427**	-	-	-	-	-	-	-	-	-	-	-	-
Chapters 1 to 12 sub-total	**27,077,130.553**	**373,659.492**	**365,109.818** **86,602.414**	**2,355,655.213** **228,008.775**	**708,592.772** **33,475.729**	**1,815,306.754** **1,853.727**	**1,806,210.976** **1,853.727**	**1,314,440.420** **1,353.427**	**1,642,621.627** **1,802.826**	**1,642,621.627** **1,802.826**	**1,642,621.627** **1,802.826**	**1,749,788.961** **1,917.409**	**1,642,621.62** **1,802.826**
Estimated profit (P)	13,374.943	13,374.943	3,219.364 3,219.364	8,470.641 8,470.641	1,129.145 1,129.145	40.289 40.289	40.289 40.289	29.415 29.415	39.183 39.183	39.183 39.183	39.183 39.183	41.673 41.673	39.183 39.183
Administration costs of construction contractors	3,116.226		750.416	1,974.459	263.197	9.290	9.290	6.783	9.035	9.035	9.035	9.609	9.035
Contingency costs of all parties to the construction process	1,624,627.834	22,419.570	52,073.769 5,245.150	137,014.090 13,800.796	18,264.113 1,839.660	102,736.743 111.195	102,736.743 111.195	75,009.243 81.185	99,915.706 108.142	99,915.706 108.142	99,915.706 108.142	106,266.084 115.015	99,915.706 108.142
Extra costs caused by inflation processes	2,296,917.118	36,002.803	72,529.402 8,383.455	190,836.005 22,058.158	25,438.628 2,940.374	145,565.872 189.980	145,565.872 189.980	106,279.269 138.707	141,568.796 184.763	141,568.796 184.763	141,568.796 184.763	150,566.533 196.506	141,568.79 184.763
Total without the VAT	**31,015,166.674**	**445,456.808**	**493,682.768** **103,450.382**	**2,693,950.407** **272,338.370**	**753,687.855** **39,384.908**	**2,063,658.948** **2,195.192**	**2,054,563.170** **2,195.192**	**1,495,765.131** **1,602.734**	**1,884,154.347** **2,134.914**	**1,884,154.347** **2,134.914**	**1,884,154.347** **2,134.914**	**2,006,672.860** **2,270.604**	**1,884,154.8** **2,134.914**

Value-added tax (VAT) (20%)	6,202,308.859	-	99,309.696	541,917.630	151,612.567	412,736.041	410,916.867	299,156.108	376,834.751	376,834.751	376,834.751	401,338.706	376,834.75
Total:	**37,217,475.533**	**445,456.808**	**592,992.463**	**3,235,868.037**	**905,300.422**	**2,476,394.989**	**2,465,480.037**	**1,794,921.238**	**2,260,989.098**	**2,260,989.098**	**2,260,989.098**	**2,408,011.567**	**2,260,989.0**
			103,450.382	**272,338.370**	**39,384.908**	**2,195.192**	**2,195.192**	**1,602.734**	**2,134.914**	**2,134.914**	**2,134.914**	**2,270.604**	**2,134.914**
Construction of social facilities (10%)	3,721,747.553	-			476,066.216	249,434.097	248,184.337	180,612.714	225,707.392	225,707.392	225,707.392	240,432.782	225,707.392

The allocation of capital investments and volumes of construction/installation work over the project years is presented as a fraction with the volume of capital investments in the numerator and the volume of construction/installation work in the denominator.

Design and survey work (other than designer’s supervision) have not been incorporated in the allocation over the project years.

Chief Design Engineer I. A. Dzenkiv

Signed off by

Client

Appendix C27

Malakhov, Y. V., Dzenkiv, I. A., Stepaniuk, Y. L., and Rybchuck, A. N. 2016. Aggregate Cost Estimate of Project: Construction of the Central Spent Fuel Storage Facility for the VVER Reactors of Nuclear Power Plants of Ukraine. November 10.

Form 5

(name of the approving organization)

Approved

Aggregate cost estimate in the amount of UAH 37,217,475,533

Including recoverable amounts of UAH 0,000

Plus the construction of social facilities: 3,721,747,553*(reference to an approval document)*

Date: " _____!" 20__

AGGREGATE COST ESTIMATE OF PROJECT No.

Construction of the Central Spent Fuel Storage Facility for the VVER Reactors of Nuclear Power Plants of Ukraine

Prepared in current prices as at November 10, 2016

No.	Numbers of cost estimates and calculations	Names of chapters, facilities, work items, and costs	Estimated cost, UAH '000			
			of construction work	of equipment, furniture, and inventories	other costs	total cost
1	2	3	4	5	6	7
		Chapter 1. Preparation of the construction site				
1	1-1	PK-1. Removal of greenery	2,522.542	-	-	2,522.542
2	1-2	PK-1. Removal and storage of the top soil	2,186.068	-	-	2,186.068
3	Calculation of costs	Forest surveying for the allocation of felling areas for the subsequent obtainment of a special forest resource use permit (felling ticket) on the land plot allocated for the CSFSF construction			22.987	22.987
4	Cost estimate of TOV Transproekt for the siting and allocation of the construction geodetic grid of the CSFSF	Development of the geodetic grid for the project (reference geodetic grid and external layout grid, frontage lines, construction grid); Development of the construction site			145.600	145.600

1	2	3	4	5	6	7
5	Statement of the Client's expenses on the land plot allocation	Payment for the land plot allocated for the CSFSF construction			1,577.397	1,577.397
6	Calculation of costs	Examination of the CSFSF site for the presence of explosives	-	"	254.150	254.150
7	Calculation of costs	Radiometric examination of the CSFSF construction site	"	"	303.325	303.325

		Chapter 1 sub-total	4,708.610	-	2,303.459	7,012.069
		Chapter 2. Core facilities				
8	2-1	PK-1. Reception building	45,333.889	1,786,617.185	-	1,831,951.074
9	2-2	PK-1. Cask storage area	84,013.489	38,703.210	-	122,716.699
10	2-3	PK-1. Installation of 4 × HI-STORM casks	222.754	223,359.673	-	223,582.427
11	2-4	PK-2. Cask storage area	3.582	-	-	3.582
12	2-5	PK-2. Installation of 33 × HI-STORM casks	1,817.905	1,813,351.973	-	1815169.878
13	2-6	PK-3. Cask storage area	3.582	-	-	3.582
14	2-7	PK-3. Installation of 33 × HI-STORM casks	1,817.905	1,804,256.195	-	1,806,074.100
15	2-8	PK-4. Cask storage area	2.604	-	-	2.604
16	2-9	PK-4. Installation of 24 × HI-STORM casks	1,327.284	1,313,013.213	-	1,314,340.497
17	2-10	PK-5. Cask storage area	3.472	-	-	3.472
18	2-11	PK-5. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
19	2-12	PK-6. Cask storage area	3.472	-	-	3.472
20	2-13	PK-6. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
21	2-14	PK-7. Cask storage area	3.472	-	-	3.472
22	2-15	PK-7. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
23	2-16	PK-8. Cask storage area	3.689	-	-	3.689
24	2-17	PK-8. Installation of 34 × HI-STORM casks	1,880.372	1,747,767.027	-	1,749,647.399
25	2-18	PK-9. Cask storage area	3.472	-	-	3.472
26	2-19	PK-9. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
27	2-20	PK-10. Cask storage area	3.472	-	-	3.472
28	2-21	PK-10. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
29	2-22	PK-11. Cask storage area	3.472	-	-	3.472
30	2-23	PK-11. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
31	2-24	PK-12. Cask storage area	3.472	-	-	3.472
32	2-25	PK-12. Installation of 32 × HI-STORM casks	1,767.999	1,640,720.522	-	1,642,488.521
33	2-26	PK-13. Cask storage area	3.689	**	-	3.689
1	2	3	4	5	6	7
34	2-27	PK-13. Installation of 34 × HI-STORM casks	1,880.372	1,742,742.128	-	1,744,622.500
35	2-28	PK-14. Cask storage area	3.689	-	-	3.689
36	2-29	PK-14. Installation of 34 × HI-STORM casks	1,880.372	1,742,742.128	-	1,744,622.500
37	2-30	PK-15. Cask storage area	4.126	-	-	4.126
38	2-31	PK-15. Installation of 38 × HI-STORM casks	2,098.344	1,945,110.372	-	1,947,208.716
		Chapter 2 sub-total	154,697.944	25,642,706.758	-	25,797,404.702
		Chapter 3. Ancillary and service facilities				
39	3-1	PK-1. Maintenance building with an MPC warehouse	16,425.791	180,686.819	-	197,112.610
40	3-2	PK-1. HI-STORM shell concrete-casting shop	0.685	85.283	-	85.968

41	3-3	PK-1. Office building (subject to civil protection)	13,913.654	9,073.483	-	22,987.137
42	3-4	PK-1. Automated radiation monitoring system post	222,567	2,082.925		2,305.492
43	3-5	PK-1. Meteorological mast	67,869	-		67,869
		Chapter 3 sub-total	30,630.566	191,928.510	-	222,559.076
		Chapter 4. Power supply facilities				
44	4-1	PK-1. On-site power supply networks	15,065.520	-	-	15,065.520
45	4-2	PK-1. Off-site power supply networks	660,158	859,757	-	1,519.915
46	4-3	PK-1. Electrical equipment building	3,601.683	23,937.127	-	27,538.810
		Chapter 4 sub-total	19,327.361	24,796.884	-	44,124.245
		Chapter 5. Transportation and communication facilities				
47	5-1	PK-1. Off-site motor roads	3,417.776		-	3,417.776
48	5-2	PK-1. On-site motor roads	15,049.971		-	15,049.971
49	5-3	PK-1. On-site railway tracks	29,709.175	557,443.411	-	587,152.586
50	5-4	PK-1. Garage	8,584.201	117,453.453	-	126,037.654
51	5-5	PK-1. Filling station	240,896	181,683	-	422,579
52	5-6	PK-1. Communication and alarm systems	1,636.917	4,443.247	-	6,080.164
		Chapter 5 sub-total	58,638.936	679,521.794	-	738,160.730
		Chapter 6. Outside water supply, waste water disposal, heat supply, and gas supply networks and structures				
53	6-1	PK-1. On-site fire water supply lines	2,216.017		-	2,216.017
54	6-2	PK-1. Water supply and wastewater disposal networks and structures	10,440.990	1,849.246	-	12,290.236
55	6-3	PK-1. Fire water supply pump station	1,464.906	5,967.087	-	7,431.993

1	2	3	4	5	6	7
56	6-4	PK-1. Fire water tanks	1,311.053	2,800	-	1,313.853
57	6-5	PK-1. Storm water treatment structures	6,844.575	1,810.930	-	8,655.505
58	6-6	PK-1. Household wastewater pump station	52.932	335.757		388.689
59	6-7	PK-1. Oil drain tank	17.705	203.070	-	220.775
60	6-8	PK-1. Off-site water supply and wastewater disposal networks	1,849.024	-	-	1,849.024
61	6-9	PK-1. Strengthened drain ditch	3,380.979	-	"	3,380.979
		Chapter 6 sub-total	27,578.181	10,168.890	-	37,747.071
		Chapter 7. Landscaping and greenery planting				
62	7-1	PK-1. Grading and leveling	6,259.304	-	-	6,259.304
63	7-2	PK-1. Fence	13,073.062	5,318.898	-	18,391.960
64	7-3	PK-1. Outside and security lighting	5,905.915	44.496	-	5,950.411

65	7-4	PK-1. Security structures	14,653.604	20,577.174	-	35,230.778
66	7-5	PK-1. Checkpoint 1	4,396.815	12,393.497	-	16,790.312
67	7-6	PK-1. Checkpoint 2	1,619.155	8,516.923	-	10,136.078
68	7-7	PK-1. Landscaping	6,490.166	31.326		6,521.492
		Chapter 7 sub-total	52,398.021	46,882.314		99,280.335
		Chapters 1 to 7 sub-total	347,979.619	26,596,005.150	2,303.459	26,946,288.228
		Chapter 8. Provisional buildings and structures				
69	8-1	PK-1. Provisional motor roads and grounds	8,564.645	-	-	8,564.645
70	8-2	PK-1. Provisional sanitary and amenities building for 50 persons (5 buildings)	488.047	"		488.047
71	8-3	PK-1. Provisional heated indoor warehouse	464.515	-	-	464.515
72	8-4	PK-1. Provisional non-heated indoor warehouse (2 buildings)	626.209	-	-	626.209
73	8-5	PK-1. Provisional checkpoint	55.618	-	-	55.618
74	8-6	PK-1. Provisional off-site and on-site technical and potable water supply networks	333.212		-	333.212
75	8-7	PK-1. Provisional on-site domestic waste water disposal networks	162.812	-	-	162.812
76	8-8	PK-1. Provisional off-site and on-site power supply networks	179.428	-	-	179.428
77	8-9	PK-1. Provisional concrete plant	5,572.916	2,986.796	-	8,559.712
		Chapter 8 sub-total	16,447.402	2,986.796	-	19,434.198
		Chapters 1 to 8 sub-total	364,427.021	26,598,991.946	2,303.459	26,965,722.426
		Chapter 9. Other work items and costs				
78	9-1	PK-1. Renewal of existing motor roads after the project completion	2,782.113		-	2,782.113
1	2	3	4	5	6	7
79	DSTU B D.1.1-1:2013, Annex K (paragraph 26)	Additional costs due to the performance of construction work in winter (1.5 × 1)%	5,466.405			5,466.405
80	DSTU B D.1.1-1:2013, Annex K (paragraph 27)	Additional costs due to the performance of construction work in summer	983.953			983.953
81	DSTU B D.1.1-1:2013, Annex K (paragraph 35)	Cost of research, experimental or trial work for the purposes of the adoption of engineering solutions for the project			16,865.305	16,865.305
82	DSTU B D.1.1-1:2013, Annex K (paragraph 36)	Cost of science and technology support			2,040.148	2,040.148
83	Cost calculation	Motor transport decontamination	-	-	629.506	629.506
84	Calculation No. P-	Supplement for the work in the alienation zone	-	-	34,214.223	34,214.223

	912-1					
85	Order of the State Nuclear Regulation Committee of Ukraine No. 156 of August 28, 2008	Organization of the militarized security guards service at the CSFSF construction site			4,050.111	4,050.111
		Chapter 9 sub-total	9,232.471	-	57,799.293	67,031.764
		Chapters 1 to 9 sub-total	373,659.492	26,598,991.946	60,102.752	27,032,754.190
		Chapter 10. Maintenance of the Client's office				
86	Cost calculation	Maintenance of the Client's office (including technical supervision expenses)		-	15,191.579	15,191.579
87	Cost calculation	Cost of the procurement procedure	-	-	139.704	139.704
88	Cost calculation	Cost of setting up a provident documents collection	-	-	77.886	77.886
89	DSTU B D.1.1-1:2013, Annex K (paragraph 47)	Payment for services related to the mobilization, work performance, and facilities commissioning (including the services related to connecting the project facility to the existing utilities) (116.939+77.960+935.512+194.725+77.960=1,403.096)			1,403.096	1,403.096
90	Calculation No. P-104-2	Disposal of the household waste at Leliv landfill	-	-	233.085	233.085
		Chapter 10 sub-total	-	-	17,045.350	17,045.350
		Chapter 11. Training of the operating personnel				
91	Calculation of the cost	Training of the operating personnel			551.586	551.586
		Chapter 11 sub-total		-	551.586	551.586
1	2	3	4	5	6	7
		Chapter 12. Design and survey work, designer's supervision				
92	Consolidated cost estimate for survey activities; cost estimate No. 2-2-P	Cost of surveying (UAH 1,160,461 for geology, UAH 324,489 + 151.223 for survey operations); Suite of engineering surveys for the design of the storm water disposal system at the CSFSF (UAH 74,435.59)			1,710.609	1,710.609
93	Cost estimate No. 1-ZP	Cost of design work	-	-	15,350.499	15,350.499
94	Contract	Cost of design documents expert appraisal	-	-	874.650	874.650
95	Consolidated cost estimate No. 1-P	Cost of designer's supervision	-	-	1,535.110	1,535.110

96	Estimated cost calculation	Development of special reports (PZAB, PrZAB, ZAB) (3,292.38606+1,637.000+1,637.000)			6,566.386	6,566.386
97	Service cost calculation	Development of measures for the validation of physical barriers to the propagation of radiating materials from the CSFSF	-	-	742.173	742.173
		Chapter 12 sub-total	-		26,779.427	26,779.427
		Chapters 1 to 12 sub-total	373,659.492	26,598,991.946	104,479.115	27,077,130.553
	DSTU BD.1.1-1:2013, sub-item 5.8.16	**Estimated profit (P)**	13,374.943	-	-	13,374.943
	DSTU BD.1.1-1:2013, sub-item 5.8.16		-	-	3,116.226	3,116.226
	DSTU BD.1.1-1:2013, sub-item 5.8.16	**Administration costs of construction contractors (AR)**				
	Calculation No. P-145	**Contingency costs of all parties to the construction process**	22,419.570	1,595,939.517	6,268.747	1,624,627.834
		Extra costs caused by inflation processes (I)	36,002.803	2,260,914.315	-	2,296,917.118
	Calculations P-154	**Sub-total**	445,456.808	30,455,845.778	113,864.088	31,015,166.674
		Value-added tax			6,202,308.859	6,202,308.859
	Calculation No. P-142-1	**Total aggregate estimated cost**	445,456.808	30,455,845.778	6,316,172.947	37,217,475.533
		Construction of social facilities (10% of the total estimated project cost)			3,721,747.553	3,721,747.553
		---------- --- ---------				

Chair of the Management Board of PAO KIEP—Yu. V. Malakhov — Signature, seal of Kyiv Science, Research, Design and Engineering Institute ENERGOPROEKT, identification code 16392628

Chief Project Engineer—I. A. Dzenkiv — Signature, seal of Design Engineer Iryna Oleksiyivna Dzenkiv (registration number 667) (Ministry of Regional Development, Construction, Housing and Utilities of Ukraine, Assessment Commission for Architecture and Construction, Qualification Certificate No. *illegible*

Head of the Production Technology Department—Ye. L. Stepaniuk — Signature

SIGNED-OFF by A. N. RYBCHUK — Signature, seal of ATOMPROEKTINZHYNIRYNG Separated Unit (identification code 36469530) of State-owned Enterprise ENERGOATOM National Nuclear Energy Generation Company (identification code 24584661)

Appendix C28

EnergoProjekt. 2016b. Construction of the Central Spent Fuel Storage Facility for the VVER Nuclear Power Plants of Ukraine. Volume 1.1. Explanatory Note. Final. 571402.201.001-P301

Public Joint Stock Company
ENERGOPROEKT
Kyiv Research and Development Institute

STATE-OWNED ENTERPRISE
“ENERGOATOM NATIONAL NUCLEAR ENERGY GENERATING COMPANY”—
SEPARATED SUBDIVISION “ATOMPROEKTINZHINIRING”

CONSTRUCTION OF THE CENTRAL SPENT FUEL STORAGE FACILITY FOR VVER NUCLEAR POWER PLANTS OF UKRAINE

PROJECT

VOLUME 1.1

Explanatory Note

Final

571402.201.001-P301

Chair of the Management Board	Yu. V. Malakhov
Chief Engineer	V. N. Chernavskyi
Deputy Chief Engineer	T. Yu. Baibuzenko
Project Manager	A. D. Andriushchenko
Chief Project Engineer	I. A. Dzenkiv

Public Joint Stock Company
ENERGOPROEKT
Kyiv Research and Development Institute

2016

Technical Archive 1

Designation	Title	Note
571402.201.001-P301-S	Volume Contents	P. 2
571402.201-SP	Project Scope	P. 3
571402.201-PD	Endorsement by the Chief Project Engineer	P. 6
571402.201.001-P301 -VU	Information about Project Participants	P. 7
571402.201.001-P301	Explanatory Note	P. 9

Volume Number	Designation	Title	Notes
1.1	571402.201.001-P301	Explanatory Note	
1.2.1	571402.201.001-P302.01	Initial Input Data. Book 1	
1.2.2	571402.201.001-P302.02	Initial Input Data. Book 2	
1.3	571402.201.001-P303	Description of the SNF Management Technology at NPP Power Units	
2	571402.201.002-GT	Master Plan and Transport	
3.1	571402.201.003-TH01	Process Design Part 1. Spent Nuclear Fuel Handling	
3.2	571402.201.003-TH02	Process Design. Part 2. Waste Management during Operation	
3.3	571402.201.003-TH03	Process Design. Part 3. Auxiliary Systems	
4.1	571402.201.004-AS01	Architectural Planning Solutions. Part 1. Explanatory Note. Architectural Solutions	
4.2.1	571402.201.004-AS02.01	Architectural Planning Solutions. Part 2. Explanatory Note. Construction Solutions. Book 1. Explanatory Note	
4.2.2	571402.201.004-AS02.02	Architectural Planning Solutions. Part 2. Explanatory Note. Construction Solutions. Book 2. Calculation Results	
4.3.1	571402.201.004-AS03.01	Architectural Planning Solutions. Part 3. Drawings. Book 1. Architectural Solutions	
4.3.2	571402.201.004-AS03.02	Architectural Planning Solutions. Part 3. Drawings. Book 2. Reinforced Concrete Structures.	
4.3.3	571402.201.004-AS03.03	Architectural Planning Solutions. Part 3. Drawings. Book 3. Metal Structures.	
5.1	571402.201.005-ETR01	Electrical Design. Part 1. Explanatory Note	
5.2	571402.201.005-ETR02	Electrical Design. Part 2. Drawings.	
6	571402.201.006-SKU	Control and Monitoring Systems	

Volume Number	Designation	Title	Notes
7	571402.201.007-OV	Heating, Ventilation, Air Conditioning	
8	571402.201.008-VK	Water Supply and Sanitation	
9	571402.201.009-PB	Fire Safety Measures	
10.1	571402.201.010-G001	Engineering and Technical Measures of Civil Protection (Civil Defense). Part 1. General Explanatory Note	
10.2	571402.201.010-GO02	Engineering and Technical Measures of Civil Protection (Civil Defense). Part 2. Civil Protection (Civil Defense) Structures	
11	571402.201.011-POS	Construction Method Statement	
12.1	571402.201.012-OVOS01	Environmental Impact Assessment. Part 1. EIA Materials	
12.2	571402.201.012-OVOS02	Environmental Impact Assessment. Part 2. Annexes	
13	571402.201.013-OSSZ	Sanitary Code Conformance Report	
14	571402.201.014-SFZ	Physical Security System	Classified
15.1.1	571402.201.015-SD01.01	Estimate Documents. Part 1. Consolidated Budget Calculation and Facility Estimates. Book 1	
15.1.2	571402.201.015-SD01.02	Estimate Documents. Part 1. Consolidated Budget Calculation and Facility Estimates. Book 2. Total Resource Statements	
15.2.1.1	571402.201.015-SD02.01.01	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Design. Part 1	
15.2.1.2	571402.201.015-SD02.01.02	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Design. Part 2	
15.2.1.3	571402.201.015-SD02.01.03	Estimate Documents. Part 2. Local Calculations. Book 1. Civil Design. Part 3. Bills of Quantities	
15.2.2	571402.201.015-SD02.02	Estimate Documents. Part 2. Local Calculations. Book 2. Heating, Ventilation, Air Conditioning	

Volume Number	Designation	Title	Notes
15.2.3	571402.201.015-SD02.03	Estimate Documents. Part 2. Local Calculations. Book 3. Water Supply And Sanitation	
15.2.4	571402.201.015-SD02.04	Estimate Documents. Part 2. Local Calculations. Book 4. Process Design	
15.2.5.1	571402.201.015-SD02.05.01	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Design. Part 1	
15.2.5.2	571402.201.015-SD02.05.02	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Design. Part 2	
15.2.5.3	571402.201.015-SD02.05.03	Estimate Documents. Part 2. Local Calculations. Book 5. Electrical Design. Part 3	
15.2.6	571402.201.015-SD02.06	Estimate Documents. Part 2. Local Calculations. Book 6. Instrumentation And Automation	
16	571402.201.016-PPR	Site Preparation Works	

The design has been developed in accordance with the applicable code, rules, and standards.

I. A. Dzenkiv

Chief Project Engineer

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INTRODUCTION 14
1. INITIAL INPUT DATA 15
1.1 Initial Input Data for the Design Development 15
1.2 Initial Input Data of the HOLTEC Technology 15
1.3 Documents Serving as the Basis for the Design 16
2. BRIEF DESCRIPTION OF THE CSFSF AND ITS COMPOSITION 17
2.1 Conformity of Design Solutions to Feasibility Study Solutions 17
2.1.1 Core Solutions of the Feasibility Study 17
2.1.2 Conformity of Design and Feasibility Study Solutions 19
2.2 Design Limits within the Scope of the CSFSF Design 21
3. ENGINEERING SURVEYS DATA 25
3.1 Topographic Survey 25
3.2 Geological Survey 27
3.2.1 Physical and Geographical Conditions of the Area 27
3.2.2 Geological Structure 27
3.2.3 Hydrogeological Conditions 28
4. FUEL, WATER, THERMAL, AND ELECTRICAL ENERGY DEMAND, ENERGY SAVING MEASURES 32
4.1 Fuel, Water, Thermal, and Electrical Energy Demand 32
4.1.1 Fuel Demand 32
4.1.2 Water Demand 32
4.1.3 Thermal Energy Demand 32
4.1.4 Electrical Energy Demand 32
4.2 Energy Saving Measures 32
4.2.1 Energy Saving Measures in Process Solutions 32
4.2.2 Measures to Ensure Reasonable Choice of Materials and Designs 40
4.2.3 Energy Saving Measures in Architectural and Construction Solutions 41
4.2.4 Energy Saving Measures in Electrical Design Solutions 41
4.2.5 Energy Saving Measures in Ventilation, Heating, and Air Conditioning Systems 43
4.2.6 Measures to Save Energy in Water Supply and Waste Water Disposal Systems 43
4.2.7 Energy Conservation in Control and Monitoring Systems 45
4.2.8 Resource Consumption Metering 45
4.2.9 Conclusions 47
5. INFORMATION ABOUT PROJECT PHASING AND STARTUP FACILITIES 49
6. CORE SOLUTIONS AND INDICATORS OF THE MASTER PLAN OF UTILITY NETWORKS AND SERVICES 50
7. SOLUTIONS FOR THE ENGINEERING PROTECTION OF THE SITE, AND THE PROTECTION OF BUILDINGS AND STRUCTURES AGAINST HAZARDOUS NATURAL AND ARTIFICIAL FACTORS 53
7.1 Spatial and Layout Planning Solutions for the CSFSF Site, Landscaping, Site Preparation 53

7.2 Engineering Protection of the Site against Waterlogging and Floods 54
7.2.1 Engineering Protection of the Area, Protection of Buildings and Structures against Hazardous Geological Processes 54
7.3 Engineering Protection of the Area, Protection of Buildings and Structures against Natural/Artificial Impacts 55
8. OCCUPATIONAL SAFETY 57
8.1 List of Core Regulations 57
8.2 Process Safety Measures 59
8.3 Toxic, Fire/Explosion Safety Specifications of Materials, Semi-finished Products, Process Waste, and Control over Safety Requirements 60
8.4 Description of Processing Areas, Calculation or Substantiation of Explosion and Fire Hazard Categories or PBE Classes 62
8.5 Determination of the energy potential of explosion hazardous units, radiuses of potential destruction zones, actions to protect the personnel from injuries, and to arrange safe evacuation of workers in case of possible emergencies and fires 64
8.6 Data on illumination of workplaces, noise, vibration, methods of extraction and neutralization of wastes with hazardous properties 65
8.7 Means to prevent fires and explosions, and store and transport materials, semi-finished products with hazardous and dangerous properties, performance of loading and unloading operations 69
8.8 Actions to protect the workers from external and internal factors, availability of sanitary facilities and amenities, medical service 71
8.9 Information on benefits, permissibility of women's and teenagers' work 73
9. PERSONNEL NEEDS 75
10. NUCLEAR AND RADIATION SAFETY 79
10.1 Safety Assurance Principles 79
10.2 General Design Safety Criteria and Requirements 81
10.3 Design Basis 81
10.3.1 SNF Characteristics 81
10.3.2 Design Features of the CSFSF 86
10.3.3 Criteria conditioned by the environment, natural phenomena and man-induced impacts 87
10.3.4 Design criteria of mechanical loads 91
10.3.5 Heat criteria 97
10.3.6 Nuclear safety assurance criteria 99
10.3.7 Radiation safety and protection criteria 101
10.3.8 Fire and explosion protection 103
10.3.9 Control criteria 105
10.3.10 Criteria of the SNF extraction from the CSFSF 106
10.3.11 Criteria or Guarantees and Physical Protection Assurance 106
10.4 Nuclear Safety 107
10.4.1 Technical solutions on assurance of the nuclear safety 107
10.4.2 Subcriticality assessment 110

10.5 Analysis of Thermal Conditions....114
10.5.1 Methods....114
10.5.2 Analysis Results....115
10.6 Strength Analysis....119
10.6.1 Methods....120
10.6.2 Analysis Results....120
10.7 Radiation Safety....121
10.7.1 Radiation Safety at Construction....122
10.7.2 Radiation Safety During CSFSF Operation....141
10.7.3 Estimated Doses Under Normal Operation....149
10.7.4 Radiation Safety In Case Of Accident....156
10.7.5 Radiation Safety During Decommissioning....164
11. ENGINEERING AND TECHNICAL MEASURES OF CIVIL PROTECTION (CIVIL DEFENSE)....166
12. RELIABILITY AND SECURITY PROVISIONS....168
12.1 General Site Security Provisions....168
12.2 Ensuring Of Compliance With The Requirements Of Safe Operation Of The Facility At The Stage Of Development Of Design Documentation....169
12.3 Reliability And Structural Safety Of Buildings And Structures....169
12.4 Specific Features Of Enforcement Of Requirements As To Operational Safety During Design Of Structures Located In The Areas With Unfavorable Natural And Technological Phenomena....170
12.5 Safety Barriers And Prevention Of Accidents In Buildings And Structures....171
12.6 Specific Features Of Assurance Of Safe Operation Of The Architectural Object At The Stages Of Construction And Installation....172
12.7 Operating Safety Requirements At The Stage Of Use Of The Site For Its Intended Purpose Within The Prescribed Period Of Operation....173
12.8 Providing For Security During The Facility Commissioning....178
13. IDENTIFICATION OF POTENTIALLY HAZARDOUS FACILITIES....179
13.1 General Provisions....179
13.2 Identification Of Potentially Hazardous Facilities....179
13.2.1 Selection Of Emergency Classification Codes, The Occurrence Of Which Is Possible At The Facility....180
13.2.2 Indicators Of Emergency Signs And Determination Of Threshold Values....181
13.2.3 Identification Of Hazards That May Be Sources Of Emergencies....185
13.2.4 Definition Of Hazards Factors For Specific Sources Of Hazards....186
13.2.5 Definition Of A List Of Hazardous Substance Used At The Facility, Their Amounts And Hazard Classes....186
13.2.6 Evaluation Levels Of Possible Emergencies....187
13.2.7 Identification Of State (Sectoral) Registers (Cadastres) Used For Registration Of The Facilities....187
13.2.8 Identification Of The Facility's Relation To The Acting Regulations....188

13.2.9 Conclusion On The Results Of Identification Of PHFs 189
13.2.10 Identification Of The Facility Under Design In Terms Of High Hazard 190
13.2.11 List Of Potentially Hazardous Facilities With Hazardous Substances, Isolated For Identification 190
13.2.12 Mass of Hazardous Substances Located At PHFs 191
13.2.9 Conclusion On The Results Of Identification Of HRFs 192
14. ENVIRONMENTAL IMPACT ASSESSMENT 193
14.1 Description Of Activities 193
14.2 Service Life 194
14.3 Socio And Economic Need For The Proposed Activity 194
14.4 Need For Resources During Construction And Operation 194
14.4.1 Land Resources 194
14.4.2 Primary Resources 194
14.4.3 Energy Resources 194
14.4.4 Water Resources 195
14.4.5 Human Resources 195
14.4.6 Transport 195
14.5 Process Waste and Opportunity for Their Reuse, Recycling, Decontamination or Safe Disposal 195
14.6 Environmental And Other Constraints On The Proposed Activity 195
14.7 Public Participation 196
14.8 Assessment Of Impact Of Construction, Operation And Accidents At The CSFSF On The Territory Of The Neighboring States 197
14.9 Obligations In Relation To Environmental Safety 197
14.10 Results Of The Environmental Impact Assessment Of The Planned Activity 197
15 ASSESSMENT OF SAVINGS FROM IMPLEMENTATION OF ENERGY-EFFICIENCY MEASURES 200
15.1 Source Data 200
15.2 Thermotechnical Calculation of Enclosing Structures for Offuice Building (CD Facility), Guard Building (CD Facility), Checkpoint 1 and Checkpoint 2 200
15.2.1 Office Building (CD Facility) 201
15.2.2 Guardhouse (CD Facility) 204
15.2.3 Checkpoint 1 205
15.2.4 Checkpoint 1 207
15.3 Thermotechnical Calculation of Enclosing Structures for Acceptance Building 208
15.3.1 Thermotechnical Calculation of Enclosing Structures for Acceptance Building (within Axes 1-8, A-B) 208
15.3.2 Thermotechnical Calculation of Enclosing Structures for Acceptance Building (within Axes 1-8, B-D) 212
15.4 Thermotechnical Calculation for Heated Portion of Maintenance Building with MPC Storage Room 215
15.5 Thermotechnical Calculations of Wall Claddings for Electrical Equipment Building,

Fire Pump Station and Garage 218
15.5.1 Calculation of Wall Claddings for Electrical Equipment Building, Fire Pump Station and Garage 219
15.5.2 A Calculation of Wall Basement for Electrical Equipment Building, Fire Pump Station and Garage 220
15.5.3 A Calculation of Roof Covering for Electrical Equipment Building and Fire Pump Station 222
15.5.4 Calculation of Garage Building Roof Covering....224
15.6 Conclusions....225
15.7 Annual Heat Consumption by Heating Systems....226
16 AVAILABILITY OF CSFSF FOR MOBILITY IMPAIRED PEOPLE 230
17 PERFORMANCE INDICATORS 231
18 R&D SUPPORT....235
18.1 Methodological Support and Work Objective....235
18.2 Source Data 235
18.3. List of Work Items for R&D Support....237
18.4 Arrangement of R&D Support Activities....239
19 CALCULATION OF A CONSEQUENCE (RESPONSIBILITY) CLASS AND A DIFFICULTY CATEGORY....240
20 SCHEDULE OF QUANTITIES 244
Abbreviations and Acronyms 245
Terms and definitions....247
References....249

INTRODUCTION

The Central Spent Fuel Storage Facility (CSFSF) is a nuclear facility of national importance. The decision on construction and location of CSFSF was made by the Law of Ukraine “On Management of the Spent Fuel with Regard to the Location, Design and Construction of the Centralized Storage Facility for the Spent Fuel of Domestic VVER Reactors of Nuclear Power Plants” on the basis of the Investment Feasibility Study approved by Resolution of the Cabinet of Ministers of Ukraine No. 131-r of 04 February 2009. Main results of the Feasibility Study are as follows:

- The CSFSF is to be located on the site between the villages of Stara Krasnytsia, Buriakivka, Chystohalivka and Stechanka in Kyiv Region within the exclusion zone with radioactive contamination after the Chernobyl disaster;
- the storage of spent nuclear fuel to be used is a surface “dry” storage with double-barrier insulation system;
- CSFSF lifetime — 100 years;
- CSFSF capacity — 16529 SFAs, including: 12010 pcs of VVER-1000 SFAs and 4519 pcs of VVER-400;

The CSFSF is based on the technology by Holtec International (hereinafter — Holtec). Main elements of the technology:

- MPC — multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—a transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—a storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT);
- car transporter for the HI-STAR.

The design provides for the reception of HI-STARs with MPCs, transfer of the MPCs from the HI-STARs to HI-STORMs, concrete-casting of the HI-STORMs’ shells, and the storage of the HI-STORMs, filled with spent nuclear fuel in the territory of the CSFSF.

The description of the SNF management technology at the power units, submitted by the technology providers, is set out in Volume 1.3. The adjustment of the technology to a specific nuclear power unit will be made under the modification designs in accordance with the current legislation in the field of nuclear energy.

This design of the CSFSF is developed on the basis of the approved Feasibility Study, Design Brief, Planning Requirements and limitations under Agreement No. 571402 of 03 October 2014 between State Enterprise “National Nuclear Energy Generating Company “Energoatom” and Public Joint Stock Company “Kyiv Research and Design Institute “Energoproekt””.

Modification 1 has been developed on the basis of Letters No. 01-46/699 of 21 April 2016, No. 01-46/761 of 28 April 2016, and No. 01-46/769 of 29 April 2016 as a result of the review of design documents by the Client.

The final version of the CSFSF design has been developed with the incorporation of results of the comprehensive state expert appraisal carried out by State-owned Enterprise Ukrderzhbudekspertyza.

1. INITIAL INPUT DATA

1.1 Initial Input Data for the Design Development

- Design Brief for the Construction of a Centralized Storage Facility for the Spent Nuclear Fuel of VVER Reactors of Nuclear Power Plants of Ukraine. Phase P (Design) and Phase R (Detailed Design Documents).
- Planning Conditions and Land Plot Development Restrictions;
- Terms of Reference for the Design of the Physical Protection System of the Central Spent Fuel Storage Facility (TZ.01/2015-SFZ.CSVIAP);
- Terms of Reference for the Development the Civil Protection (Civil Defense) Engineering and Technical Measures as a Part of Design Documents for the Project of “Construction of the Central Spent Fuel Storage Facility for VVER Reactors of Nuclear Power Plants of Ukraine”;
- Technical Specifications for the Engineering Support to the Construction Project in terms of Fire and Technology Safety;

a) Technical Specifications for the connection of electrical networks of the CSFSF No. K-00-16-0403;

- Technical Solution for the connection of the outside railway to the on-site railway tracks of the CSFSF;
- Letter No. 03-46/1539 of 26 August 2016 “Railroad Grade Elevation”;
- Technical Specifications No. TD-15-16490 of 10 September 2015 “Mutual Connection of the Central Spent Fuel Storage Facility of DP NAEK Energoatom as a Subscriber and MTS Ukraine Private Joint Stock Company on the KIE REC VEC Site”;
- Letter No. 202/676 of 30 April 2015 “Determination of KP Vector’s potential to support the CSFSF”.

1.2 Initial Input Data of the HOLTEC Technology

- Central Spent Fuel Storage Facility Report. Technology Process Description, HI-2156591, Version 3;
- Accident Analysis Report, HI-2083899, Version 3;
- HI-STAR-190 and HI- STORM-190, Cask Systems’ Subcriticality Report, HI-208399;
- HI-STAR-190, HI-TRAC-190 and HI-STORM-190 Radiation Protection Analysis Report, HI-2084031;
- HI-STAR-190 ML and HI-STORM-190 Confinement/Containment Assessment Report, HI-2084018;
- CSFSF Material Compatibility Assessment Report, HI-2073839;
- HI-STAR-190 and HI-STORM-190 Systems Strength Analysis Report, HI-2084001;
- HI-STAR-190, HI-TRAC-190 and HI- STORM-190 Systems Thermal Analysis Report, HI-208390;
- HI-STORM-190 Unloading and Preparation for the Completion on Site Procedure, HSP-169;
- CTF Initial Input Data (Letter from OP API No. 03-46/390 of 10 March 2016);
- VCT General View Drawing (Letter from OP API No. 03-46/55 of 16 January 2016);

- Initial Input Data for the Main Crane of the Transfer Building and the VCT (Letter from OP API No. 03-46/169 of 2 February 2016).

U.S. regulations, which had been used by Holtec for the design of the CSFSF equipment, were used in materials of the CSFSF Design for the equipment based on the Holtec technology together with Ukrainian regulatory documents. The confirmation that U.S. regulations may be used for the development of the CSFSF equipment and the analysis of its safety was provided in a document entitled “Report on Results of the Comparative Analysis of Regulatory Documents of the USA and the Relevant Requirements of Regulatory Documents of Ukraine Used for the Development of the Equipment and Systems”.

1.3 Documents Serving as the Basis for the Design

- Law of Ukraine # 4384-VI “On the Management Of Spent Fuel: Location, Design And Construction of the Centralized Storage Facility for Spent Fuel of Domestic VVER Nuclear Power Plants” following Investment Feasibility Study”—Annex Ш(25);
- Instruction of the Cabinet of Ministers of Ukraine No. 131-r of 4 February 2009 “On Endorsement of the Investment Feasibility Study of the Construction of a Central Spent Fuel Storage Facility for Domestic VVER Reactors of Nuclear Power Plants;
- Investment Feasibility Study “Construction of the Central Spent Fuel Storage Facility for the VVER Nuclear Power Plants of Ukraine (57-204.201.002.OE);
- Comprehensive (Positive) Opinion of Ukrderzhbudekspertyza State-owned Enterprise No. 84/54/2880 of 26 August 2008 “Construction of the Central Spent Fuel Storage Facility for the VVER nuclear power plants of Ukraine”

Copies of initial input data are provided in Volume 1.2.1 “Initial Input Data. Book 1”—Annexes A(1) to P(17), and Volume 1.2.2 “Initial Input Data. Book 2”—Annexes C(18) to Ю(31).

2. BRIEF DESCRIPTION OF THE CSFSF AND ITS COMPOSITION

2.1 Conformity of Design Solutions to Feasibility Study Solutions

2.1.1 Core Solutions of the Feasibility Study

DBN A.2.2-3-2004 [108] requires the design for complex facilities such as the CSFSF to be developed in three stages:

- the Investment Feasibility Study (FS);
- the Design;
- the detailed design documents.

This structure of the design process will make it possible to update solutions and indicators adopted in the Feasibility Study at the Design stage taking into account the data of the technology adopted on the basis of the tender, and the additional design documents, for instance, developed by the successful tenderer.

No major changes are expected in the Feasibility Study as a result of detailing the SNF storage technology data at the Design stage on the basis of data available at the Feasibility Study stage.

The goal of the planned activity under the Feasibility Study is to build a long-term storage facility for the SNF from VVER-1000 and VVER-440 reactors of Ukraine's nuclear power plants.

The CSFSF is to be designed on the basis of the SNF dry storage technology with the storage in an inert medium with natural air cooling. The SNF management technology considered in the Feasibility Study has been developed by Holtec (USA), and is applied at nuclear power plants in the USA.

The CSFSF within the scope of the Feasibility Study includes:

- areas for loading spent fuel assemblies (SFA) into the MPC, and for preparing HI-STAR containers for the transportation at each nuclear power plant unit with a VVER reactor;
- the transportation of HI-STAR casks with SFA from NPPs to the CSFSF;
- the reception building on the CSFSF site;
- the storage area for HI-STORM cask with SFA;
- the on-site transportation system.

Areas for loading spent fuel assemblies (SFA) into the MPC, and for preparing HI-STAR containers for the transportation are provided in reactor compartments of units of Khmelnitskyi, Rivne, and Pivdenno-Ukrayinska NPPs. Spent fuel assemblies cooled in a cooling pond for at least 5 years are loaded in the reactor service hall of a reactor compartment into an MPC; MPCs are dehydrated and dried, sealed, and filled with helium. An MPC offers two hermetic barriers to the propagation of radioactive substances from the SFA into the environment. A HI-TRAC transfer cask and a HI-STAR are used for the biological protection of the personnel in the course of transfers.

MPCs with SFA are transported from NPPs to the CSFSF using HI-STAR transportation casks designed in accordance with the USA safety requirements which will be certified in Ukraine as B(U)-type packages in accordance with requirements of PBTRM-2006 [123].

The reception building is intended for the transfer of MPC with SFA from HI-STAR transportation casks into a HI-STORM long-term storage cask. An MPC with a SFA is transferred in an isolation unit using a HI-TRAC transfer cask.

The SNF cask storage area is a passive system for the storage of HI-STORM casks that have two MPC hermetic barriers and the biological protection barrier of a HI-STORM cask.

The following buildings and structures have been identified in the course of the design of the master plan layout for the site:

- an MPC reception and transfer building, including, for instance, “dirty” workshops, the decontamination station, and the central control panel of the CSFSF;
- a HI-STORM cask storage area;
- a maintenance building with an MPC warehouse, including a shed for filling HI-STORM cask shells with concrete;
- a garage building for the parking and maintenance of the crawler transporter;
- a four-car garage with workshops for minor repairs and a decontamination station;
- a shed for the maintenance and repair of one container car and an open parking area for one escort car;
- an electrical equipment building;
- a filling station with two fuel dispensers with two underground tanks for two types of fuel;
- an administrative building with offices, an assembly hall, a canteen, and a civil defense structure;
- a motor road checkpoint;
- a railroad checkpoint;
- holding tracks for the spent fuel train consisting of five container cars, one car for a HI-TRAC transfer cask, one platform for welding and ancillary equipment, one escort car, and two buffer cars;
- a household wastewater pump station;
- a fire water pump-house;
- a fire water tank;
- storm water accumulating tanks;
- a guardhouse.

The fenced area of the site is 644 × 182 m large. Two access motor roads to the site are designed (in the north and in the south), and one access railway track (on the northern side).

The land for the CSFSF (11.72 hectares) shall be allocated within the Chernobyl NPP exclusion zone and a 6.4-km access railway track needs to be built.

A dedicated unit of NAEK Energoatom with all the necessary infrastructure and personnel will be established to support operations of the CSFSF as a nuclear installation.

The CSFSF must make it possible to prepare for storage at least 504 spent fuel assemblies from VVER-1000 reactors and 192 spent fuel assemblies from VVER-440 reactors per year. The time needed to fill the CSFS with the nuclear fuel from the NPPs currently in operation ranges from 45 to 50 years. On this basis, two major CSFSF operation periods have been identified:

- an active period (45 to 50 years) during which MPCs with spent fuel assemblies are delivered and handled, and HI-STORM casks are placed for the long-term storage;
- a passive period (50 to 55 years) during which MPCs with spent fuel assemblies are kept in metal/concrete HI-STORM casks and CSFSF systems are operated until a decision is made on the future technology of the CSFSF management in Ukraine.

A start-up facility and stages of the CSFSF construction have been identified in accordance with the design brief of the Client.

The start-up facility includes all of the above mentioned buildings and structures and all of the holding and marshaling tracks.

The cask storage area and the manufacture of HI-STORM containers will be built gradually in four stages. Foundations for HI-STORM casks in the storage area are belts designed to

accommodate 32 HI-STORM casks each. The storage area includes fifteen foundations for 32 HI-STORM casks each; thus, the storage area is designed to accommodate 480 HI-STORM casks.

The total number of HI-STORM casks needed to secure the design capacity of the CSFSF is 458 casks. This number of casks will support the storage of 12010 spent fuel assemblies of VVER-1000 reactors and 4519 spent fuel assemblies of VVER-440 reactors with an assumption that 5 percent of spent fuel assemblies of VVER-1000 reactors will not be sealed hermetically resulting in the reduction of the number of spent fuel assemblies in a VVER-1000 MPC to 24 SFAs, and that 3 percent of spent fuel assemblies of VVER-440 reactors will not be sealed hermetically resulting in the reduction of the number of spent fuel assemblies in a VVER-440 MPC to 78 SFAs.

The start-up facility (Stage I) will include three foundations for 96 HI-STORM casks with 32 HI-STORM casks to be stored on each foundation. However, only 94 casks are to be built within the scope of Stage I (81 casks for VVER-1000 reactors and 13 casks for VVER-440 reactors).

Stage II will include four foundations for 128 HI-STORM casks with 32 HI-STORM casks to be stored on each foundation. However, 130 casks are to be built within the scope of Stage II.

Stage III will include four foundations for 128 HI-STORM casks with 32 HI-STORM casks to be stored on each foundation. 128 casks are to be built within the scope of Stage III.

Stage IV will include four foundations for 128 HI-STORM casks with 32 HI-STORM casks to be stored on each foundation. However, 106 casks are to be built within the scope of Stage IV.

It is assumed for the purposes of the assessment of the number of HI-STORM casks that a HI-STORM cask contains one MPC with 31 hermetically sealed spent fuel assemblies from VVER-1000 reactors or 85 hermetically sealed spent fuel assemblies from VVER-440 reactors, or 24 damaged spent fuel assemblies from VVER-1000 reactors or 78 damaged spent fuel assemblies from VVER-440 reactors.

2.1.2 Conformity of Design and Feasibility Study Solutions

The Design is the second stage of the design subject to approval. It has been developed on the basis of the Investment Feasibility Study approved in accordance with the legislation of Ukraine.

The following are the core solutions matching the solutions adopted in the Feasibility Study:

- the design is based on the technology of the dry storage of the spent nuclear fuel in an inert medium;
- the CSFSF is based on the technology offered by Holtec International;
- the list of core facilities is aligned with solutions adopted in the Feasibility Study;
- the storage facility is designed to accommodate 458 HI-STORM casks with the spent nuclear fuel. This number of casks will hold 12,010 VVER-1000 SFAs and 4,519 VVER-400 SFAs;
- the design calls for the delivery of the spent nuclear fuel to the CSFSF by rail in HI-STAR transportation casks.

The system developed by Holtec comprises the following major components:

- MPC—a multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—a transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—a storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—a transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT);
- HI-STAR car transporter.

Revisions of the Feasibility Study solutions at the Design stage have been caused by the following circumstances:

- updates in some technical solutions offered by Holtec as storage technology providers;
- the adoption of the Law of Ukraine No. 3038-VI “On Regulation of City Development

Activities";

- the adoption of DBN A.2.2-3:2014 "Make-up and Contents of Design Documents for the Construction of Facilities";
- the engineering surveys carried out on the construction site;
- the optimization of design solutions;
- the implementation of fuel assemblies of new types at the Ukrainian NPPs TBC-W (LTA), TBC-W, and TBC-WR (manufactured by Westinghouse);
- the Terms of Reference for the Physical Protection System incorporating new requirements for the organization of access areas in accordance with new regulatory documents;
- new regulations adopted after the Feasibility Study endorsement.

The CSFSF is being designed after the adoption of the Law of Ukraine No. 3038-VI "On Regulation of City Development Activities". In connection with this, the design has been developed on the basis of the following initial input data:

- the Design Brief;
- the Planning Conditions and Restrictions;
- the Technical Specifications for connections to existing systems of KP Vector;
- the Technical Specifications for the power supply.

The Planning Conditions and Restrictions have been issued for the construction of the CSFSF in the exclusion zone in accordance with Law of Ukraine # 4384-VI "On the Management Of Spent Fuel: Location, Design And Construction of the Centralized Storage Facility for Spent Fuel of Domestic VVER Nuclear Power Plants". The CSFSF site has been approved by Law No. 4384-VI: The CSFSF is to be located on a site situated among villages of Stara Krasnytsia, Buriakivka, Chystohalivka, and Stechanka of Kyiv Province within the exclusion zone in the area subjected to the radioactive contamination as a result of the Chernobyl Disaster. According to the Planning Conditions and Restrictions, the technical solutions related to the loading in reactor compartments of power units of Khmelnitskyi, Rivne, and Pivdenno-Ukrayinska NPP, and the transportation from NPPs to the CSFSF are not covered within the scope of this design.

The adoption of new regulatory documents in Ukraine made it necessary to update design solutions in terms of:

- the assessment of the CSFSF risk consequences class and complexity category;
- the increase in the number of structures for the security guards of the facility;

- the refinement of design solutions in terms of the fire safety;
- the refinement of technical solutions in terms of the water supply and waste water disposal systems taking into consideration the condition of KP Vector's infrastructure;
- the refinement of the identification of project stages and start-up facilities in view of the construction of foundations for HI-STORM casks as a part of the PK-1 start-up facility;
- the refinement of estimation documents on the basis of new cost estimation approaches;
- the update of the grade elevation of the site as a result of the engineering survey.

2.2 Design Limits within the Scope of the CSFSF Design

The design limits within the scope of this CSFSF design have been set by:

- the Design Brief;
- the Law of Ukraine No. 3038-VI "On Regulation of City Development Activities";
- the Rules of Connection of Electrical Installations to Electrical Networks.

The general flow diagram of the CSFSF design limits within the scope of this design is presented on Figure 2.1.

Khmelnitskyi NPP

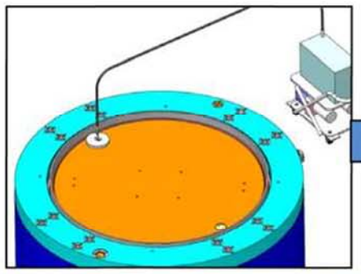
1. Technical retrofit of the SNF management system at Unit Kh-1 of Kh-NPP (Pilot Modification B-320)
2. Technical retrofit of the SNF management system at Unit Kh-2 of Kh-NPP (Modification Adaptation (B-320))

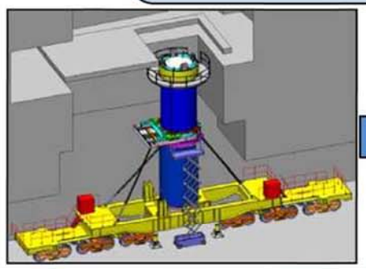
Yuzhnoukrayinsk NPP

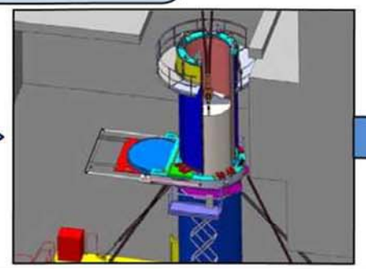
1. Technical retrofit of the SNF management system at Units YU-1 and YU-2 of YU-NPP (Pilot Modification (B-302, B-338)
2. Technical retrofit of the SNF management system at Unit YU-3 of YU-NPP (Modification Adaptation (B-320))

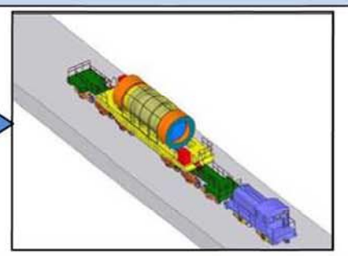
Rivne NPP

1. Technical retrofit of the SNF management system at Units R-1 and R-2 of R-NPP (Pilot Modification B-213)
2. Technical retrofit of the SNF management system at Unit R-3 of R-NPP (Modification Adaptation (B-320))
3. Technical retrofit of the SNF management system at Unit R-4 of R-NPP (Modification Adaptation (B-320))





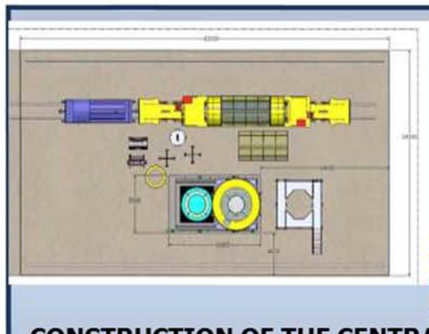


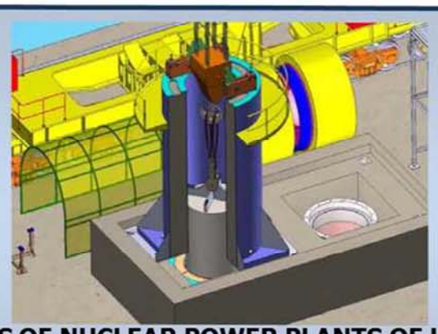


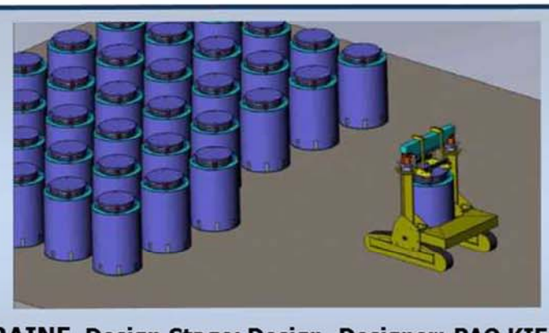
Train Transportation along Public Railways

Rail access track from the existing Vilcha—Yaniv railway to the construction site of the central spent fuel storage facility (CSFSF) (Design Stage: Design)

Designer: TOV NVO GIPROTRANS







CONSTRUCTION OF THE CENTRAL SPENT FUEL STORAGE FACILITY FOR VVER REACTORS OF NUCLEAR POWER PLANTS OF UKRAINE. Design Stage: Design. Designer: PAO KIEP

Figure 2.1. **General Flow Diagram of Design Limits**

The following is considered to be within the scope of this CSFSF design in accordance with the Design Brief:

- the reception of a special train with SNF-loaded casks, main and auxiliary equipment used at the NPP to the main marshaling track (after the radiometric check);
- the unloading of a special train in the reception building with the transfer of the MPC with SNF from transportation casks into storage casks;
- the removal of storage casks from the reception building into the storage area with a cask transporter;
- the decontamination of the main and auxiliary process equipment for the spent nuclear fuel management;
- the maintenance, testing, checking, and repair of the main and auxiliary process equipment for the spent nuclear fuel management;
- the road transport for the transportation of the process equipment for the spent nuclear fuel management, the protective clothing, the environmental monitoring.

The Law of Ukraine No. 3038-VI “On Regulation of City Development Activities” provides that:

- the design shall be developed within boundaries of the allocated land plot;
- the utility networks shall be designed up to the connection point;
- the restrictions shall be specified in Planning Conditions and Restrictions.

The connection to the electrical networks is designed in accordance with the Rules of the Connection to Electrical Networks and the Technical Specification in the Connection Point (Buriakivka SS 110/10 substation).

The connections to utility networks of KP Vector have been designed in accordance with Technical Solutions agreed upon between KP Vector and API NAEK Energoatom.

The connection to the off-site railroad is designed at the boundary of the CSFSF land allotment in accordance with the Technical Solution endorsed by TOV NVO Protrans as a designer of the off-site railroad, the general designer of the CSFSF, and API NAEK Energoatom as a Client taking into account Letter No. 03-46/1539 of 26 August 2016 “Railroad Grade Elevation”.

It has been taken into consideration in the course of the cost estimation documents development that the start-up and commissioning work on the equipment, which is only used at NPP units, will take place at the respective NPP units.

The Design Brief provides that no radioactive waste treatment will take place in the CSFSF, that the radioactive waste will be collected, assessed, and dispatched to specialized facilities within the exclusion zone. At the Design stage, the design calls for the shipment to facilities of the State-owned Specialized Enterprise Chernobyl NPP.

According to the requirements of the Exclusion Zone ARMS, the data from the ARMS of the CSFSF will be transmitted by radio.

The Design Brief does not provide for any handling of spent fuel assemblies at the CSFSF. If there is a defective MPC in the process of storage, it is to be shipped to the NPP unit for the re-loading.

The initial input data provided by Holtec have been used for the design development with regard to the equipment to be supplied by Holtec. All substantiations for the equipment, including the nuclear and radiation safety analysis, are to be developed by Holtec. The CSFSF safety assessment and analysis are presented in a Safety Analysis Report to be developed by another contractor. This activity is not included into the scope of work.

Issues of the SNF management after the completion of the target period of the storage of MPCs with spent fuel assemblies on the CSFSF site will be covered in the Concept of the Management of the Spent Nuclear Fuel from Ukrainian Nuclear Power Plants with VVER-Type Reactors to be developed by the Operator separately.

3. ENGINEERING SURVEYS DATA

The topographic and geologic surveys [1] have been undertaken by ENERGOPROEKT Institute in 2015 on the construction site for the development of the design of the Construction of a Central Spent Fuel Storage Facility of Ukraine.

The CSFSF site is located in the Chernobyl NPP area next to the Vector facility.

3.1 Topographic Survey

The comprehensive engineering topographic survey with the development of a plan to a scale of 1 to 500 has been carried out according to the geological and topographic survey program and in accordance with the Terms of Reference for the Engineering Topographic Survey.

All activities carried out are in line with requirements of regulatory documents and standards of Ukraine.

The performed survey work items are listed in Table 3.1.

Table 3.1. Survey Work

	Work Items	Unit of Measurement	Quantity
1	Search for traverse stations	station	10
2	Laying reference transit traverses	km	5
3	Laying reference grade lines	km	5
4	Comprehensive engineering topographic survey in a built-up area to the scale of 1:500	ha	5.1
5	Comprehensive engineering topographic survey in a non-built-up area to the scale of 1:500	ha	30.9
6	Developing a digital terrain model (DTM)	table	5.76
7	Preliminary stake-out and horizontal/vertical tie-in of engineering geological excavations	excavation	68

The work was carried out in November 2014 to January 2015 by a topographic survey team being a part of the comprehensive survey party.

The system of coordinates is a local frame of reference to Prypiat.

The elevation system is the Baltic vertical datum.

The topographic survey team has had in its possession surveying equipment and tools of the appropriate accuracy level, such as two sets of SOKKIA electronic tacheometers, a C.A.T.^{3}+Genny^3+ Radiodetection line locator set, a LeicaDisto electronic distance gauge, and a set of Motorola radios.

The survey control was based on reference stations of the construction net under Nos. PBS1, PBS2, PBS170, PBS173, and PBS186. The network has been developed as a system of transit traverses whose points were used for the engineering leveling.

Traverse points were marked with metal rods or dowel pins.

All measurements and calculations were based on the local (“Prypiat”) frame of reference.

The survey network is a system of 12 traverses.

Angles and sides of transit traverses were measured with a Sokkia SET 230R3 No. 139993 electronic tacheometer
(subjected to the metrological control by State-owned Enterprise Ukrmetrteststandart on 30 January 2014 under No. 23-21/0000105).

Networks were balanced on a PC using CREDO DAT 4 LITE software.

Angular closing errors in transit traverses and polygons did not exceed 2Wn, where n is the number of angles per traverse.

The ultimate relative error over the traverse has not exceeded 1 in 2000.

Traverse stations Nos. 114, 115, and 118, and reference stations of the construction net Nos. PBS1, PBS2, PBS170, PBS173, and PBS186, which are accurate vertically at least at the fourth-order leveling, were used as reference geodetic stations.

The elevation network is a system of technical transit traverses over stations of the plane network.

The survey network is a system of 9 traverses.

The technical leveling has been carried out with Sokkia SET 230R3 No. 21827 electronic tacheometer (subjected to the metrological control by State-owned Enterprise Ukrmetrteststandart on 30 March 2014 under No. 23-21/0000173). The elevation network was balanced on a PC using CREDO DAT 4 LITE software.

Errors were determined using the formula of $f = \pm 50\sqrt{L}$, where L is the traverse length in km.

The topographic survey to a scale of 1 in 500 was carried out from stations of the survey network by means of tacheometry using Sokkia SET 4010 and SET 230R3 electronic tacheometers. At each station, a sketch was drawn up with all contours of buildings, structures, roads, fences, manholes, underground and overhead utilities. Underground and overhead utilities were subjected to an additional inspection with the indication of pipe diameters and elevations of gutters, well bottoms, and pipe tops. The underground and overhead utility survey results were endorsed by operating organizations and departments of GSP TsPORO of KP Vector.

Measurement results were accumulated in the built-in memory of the electronic tacheometer. After the completion of the field work, the information has been transferred to a PC for further processing via the standard interface.

The field data were subjected to the office analysis on a PC using CREDO DAT 4 LITE software suite to create a digital terrain model (DTM). At the next stage, the DTM was converted into digital and electronic topographic plans in AutoCAD for Windows software. As a result, a smooth delineation map for the replication was obtained.

Geological excavations for set out on site by means of the instrumental procedure on the basis of their positioning plan.

Excavations set out on site and marked with wooden stakes were handed over to a responsible representative of the geological unit on the basis of protocols.

After the engineering topographic survey, the horizontal and vertical tie-in of all excavations was carried out on the basis of stations of the survey basis.

A catalog of coordinates and elevations of excavations with a diagram of their positions was issued as a result of the setting out and vertical/horizontal tie-in work.

The instruments used for work were subjected to the technical control (visual examination, checks) on a daily basis prior to the commencement of measurements in the course of the field work.

The contractor in charge and the site manager controlled the compliance of the staff with regulatory requirements on a regular basis in the course of the field work. Control measurements of transit traverses of the topographic survey and surveys of underground utility networks were carried out on a selective basis after the completion of the field and office work. Measurement results obtained at the control stage confirmed that the horizontal and vertical geodetic basis was developed with the required accuracy and that errors of the landscape, contours, and utilities survey were within the acceptable range.

3.2 Geological Survey

3.2.1 Physical and Geographical Conditions of the Area

In terms of geomorphology, the CSFSF site is located in the north-eastern part of the Kyiv moraine outwash plains (Kyiv Polissia being the part of the Polissia lowlands.

The CSFSF site area is the right-bank watershed the Pripyat River valley and the left-bank watershed of the Uzh River valley, and is characterized by the undulating relief created by the water-glacial accumulation. The distance to the Pripyat River is 8 km, that to Uzh River is 18 km.

The Pripyat River is the Dnieper's right tributary. It is a typical lowland river characterized by the expressed spring flood and the relatively low summer water level. The river is 200 to 300 m wide and 3 to 8 m deep. The bottom is sandy or, sometimes, silty. Kyiv Reservoir serves as backwater at the bottom, and Pripyat River's estuary is flooded by the waters of Kyiv Reservoir. The river valley is well developed with four upland fringes. Absolute elevations of the ground within Pripyat River valley range from 105 to 135 m.

The Uzh River is the right tributary to the Pripyat River. Its valley is also well developed, and has the floodplain with three upland fringes. Absolute elevations of the ground within Uzh River valley range from 105 to 125 m.

The area under survey is located in a forest situated in the exclusion zone; a part of the area belongs to the territory of the Vector facility. The absolute elevations of the construction site are 136.98 to 140.78 m.

3.2.2 Geological Structure

In terms of tectonic structure, the investigated area is located within the Dnieper/Donetsk basin near its connection to the Ukrainian Crystal Shield; they are separated by the Dnieper fault.

The analysis of the published tectonic maps, the neo-tectonic map, the rupture anomalies map points toward the southern near-edge fault zone close to the CSFSF area, including the southern near-edge zone of Pripyat depression and the southern near-edge zone of Dnieper/Donetsk separated by the Teteriv Fault.

Currently, the CSFSF site is outside the area of the latest faults.

DBN V.1.1-12:2014 "Protection against Hazardous Geological Processes, Harmful Operating Impacts, and Fire. Construction in Seismic Areas of Ukraine" specifies the following values of the seismic rating of the investigated area at MSK-64 scale (Annex B to the DBN building code):

- the map fragment OCP-2004-A — 5 points with the seismic gap of 500 years (the seismic intensity exceedance probability for 50 years — -10 %);
- the map fragment OCP-2004-B — 5 points with the seismic gap of 1000 years (the seismic intensity exceedance probability for 50 years — 5 %);
- the map fragment OCP-2004-C — 6 points with the seismic gap of 5000 years (the seismic intensity exceedance probability for 50 years — -1 %).

The geological structure to the depth of 42.0 m is formed by the Middle Pleistocene deposits (fgRII) of fluvioglacial, lacustrine, fluvioglacial and moraine origin.

In general, these rocks are of the glacial complex of the Dnieper glaciation. The fluvioglacial deposits are sandy-clay soils. The sands are light gray, yellowish-gray to brown, small- and medium-grain, with layers of dust-like sands. In the thick sands at different depths, there are fixed lenses of clay soils. The clay soils are presented by yellowish brown sandy loam and loam. They occur as lenticles and layers generally 2 to 6 m thick. The drilled depth is 41.8 m. On the surface, the fluvioglacial sediments are covered by a layer of soil and vegetation. Near "Vector" facilities, bulk soils with the depth of 0.5 to 1.9 m occur.

The deposits of the Kyiv stratum of the Eocene (R2kv) lie at the depth of 40.0 m, the absolute altitudes of the top range from 99 to 110 m; there are marls, bluish-green and mica clays. The deposits are found everywhere, but washed out (with gaps) in some areas.

The features of the geological and hydro-geological conditions of the CSFSF construction site are determined by its affinity to the watershed plateau between the valleys of the rivers Pripyat and Uzh. Physical and mechanical properties of the soil were determined on the basis of results of laboratory tests of soils and the geophysical studies in the wells (radioisotope logging).

Archives of soil investigations carried out by the Institute at sites in the close vicinity of the CSFSF site have been analyzed for dividing the soil massive in geotechnical units and determining their physical and mechanical properties.

The geological survey resulted in the identification of 7 geotechnical units (IGEs). Their physical and mechanical properties are specified in Table 3.2.

3.2.3 Hydrogeological Conditions

The hydrogeological conditions of the CSFSF site are determined by the characteristics of aquifers and the locally developed poorly permeable sediments in the following stratigraphic sequence:

- the aquifer system of the Quaternary deposits;
- the poorly permeable deposits of the Kyiv Eocene stratum (the marl stratum);
- the aquifer system of the Eocene sediments;
- the poorly permeable deposits of marl-chalk in the upper part of the Upper Cretaceous;
- the aquifer system of the mid-Cretaceous sediments.

No.	Properties of a Geotechnical Unit (IGE)	Geological Index	Grain Size Distribution, %, mm										Uniformity Coefficient	Natural Humidity, W	Humidity at Boundary		Index of Plasticity, IP	Index of Liquidity, IL	Soil Particle Density, Ps, g per cm3	Soil Unit Weight, P, g per cm3	Soil Dry Unit Weight, pb, g per cm3	Porosity, e	Internal Friction Angle, φ°	Cohesion, c, kPa	Deformation Modulus, E, MPa	Design Values						Soil Class in Terms of Excavation Complexity
			Gravel		Sand					Dust		Clay			Liquid Limit, WL	Plastic Limit, WP										a=0.85			a=0.95			
			10 5	5-2	2-1	1.0 0.5	0.5 0.25	0.25 0.1	0.10 0.05	0.05 0.01	0.01 -	<0.05														ρII	φII	cII	PI	φI	cII	
1	Top soil	eH																														8b
1a	Bulk layer — fine sand	tH																														29b
2	Fine, dense sand of heterogeneous grain-size distribution, with the water saturation from poor to rich	fgPII		0.3	0.4	4.2	27.0	55.0	13.1				3.1	0.6 0.20					2.65	1.83 2.07	1.72	0.54	33	2	33	1.83 2.07	33	2	1.74 1.97	30	1	29a
3	Silty, dense sand of heterogeneous grain-size distribution, with the water saturation from poor to rich	fgPII		0.2	0.4	2.7	13.9	49.3	33.5				3.3	0.09 0.19					2.66	1.89 2.06	1.73	0.54	32	4	28	1.89 2.06	32	4	1.80 1.96	29	3	29a
4	Sandy loam, solid above the groundwater level and plastic below the groundwater level	fgPII		0.5	0.4	1.5	12.0	31.6	11.0	20.9	13.0	9.2		0.13 0.17	0.19	0.13	0.06	0.00 0.64	2.67	2.01 2.08	1.78	0.50	24	34	25	2.01 2.08	24	34	1.91 1.98	23	32	36a
5	Light stiff and plastic sandy loam	fgPII		0.7	0.9	2.6	16.0	35.0	7.0	14.8	12.1	10.9		0.17	0.23	0.13	0.10	0.39	2.68	2.07	1.77	0.51	19	54	23	2.07	19	54	1.97	18	51	35a
6	Medium-grained sand of homogeneous particle-size distribution, dense, with the water saturation from poor to rich	fgPII		1.9	2.7	13.3	45.8	30.1					2.7	0.04 0.18					2.65	1.80 2.04	1.73	0.53	35	2	36	1.80 2.04	35	2	1.71 1.94	32	1	29a

Note:
Soil properties above the groundwater level are specified in the numerator; soil properties below the groundwater level are specified in the denominator.

Because of certain permeability and uneven spread of the poorly permeable sediments, all the listed aquifers are interconnected and form a single hydraulic system.

The Quaternary aquifer system dominates the explored depth (42 m). During the survey period (December to January 2014, February 2015), the underground water of the Quaternary deposits aquifer system occur everywhere. This water occurs in the Mid-Pleistocene glaciofluvial sediments. The aquifer system is unconfined. In terms of salt composition, the water is mainly hydro-carbonate calcium, non-aggressive to concrete. Results of the aggressiveness analysis of the underground water are presented in Table 3.4.

In terms of protection from the surface radioactive chemical pollution, the Quaternary aquifer is vulnerable.

The depth of the groundwater layer varies from 12.2 to 19.2 m. Absolute elevations range from 120.45 to 126.95 m. The survey site is located on the watershed divide, which divides the movement of the underground water toward north and southeast. In the area of Vector facility, the perched water has been found at a depth of 3.6 to 3.7 m, which corresponds to absolute elevations of 133.45 to 133.51 m. The groundwater depth at the Vector facility ranges from 13.25 to 19.62 m according to the response of the State-owned Specialized Enterprise “Chernobylskyi Spetskombinat” to our inquiry about the groundwater situation.

The aquifer is recharged by the infiltration of the atmospheric precipitation, and discharged into the Pripyat and Uzh Rivers. In general, the hydrogeological situation is stable, there were no significant fluctuations of the water level during the survey (winter-spring).

The soil permeability (filtration factor) in the area of the CSFSF is shown in Table 3.3.

Table 3.3. Soil Permeability (Filtration Factor)

Soil Type	Soil Permeability, m/day
Silty sand in the aerated zone	1.75
Silty sand in the saturation zone	3.5
Chalky-sand in the aerated zone	3.0
Chalky-sand in the saturation zone	4.0
Medium-grain sand	15
Fluvioglacial loam	0.1
Fluvioglacial sandy loam	1.0

Temporary water table of the perched water may form in the thick deposits on top of the impermeable layers of clay soils.

No water confining strata have been found within the drilling depth. The top of the poorly permeable sediments is located at the depth of more than 40.0 m in the watershed area. The poorly permeable sediments of the Kyiv stratum (the marl stratum) are of regional distribution, they separate the Quaternary deposits aquifer from the pressure-unconfined aquifer system of the Eocene (the Buchaksko-Kanevsky) deposits.

Table 3.4. Underground Water Aggressiveness (Quaternary (Q) Aquifer)

Table No. in DSTU B V.2.6-145:2010 "Protection of Concrete and Reinforced Concrete Structures against Corrosion"	**Indicators of aggressiveness**	**Impact on concrete and reinforced concrete structures by water tightness class of concrete**			**Impact on cement-based brickwork mortar**	**Impact on asbestos cement structures**
		W_4	W_6	W_8		
B.2	Bicarbonate alkalinity, mg-ecu/dm^3 (grad)	Non-aggressive	-	-	Non-aggressive	Non-aggressive
	pH factor	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Aggressive carbon dioxide content, mg/dm^3	Non-aggressive	Non-aggressive	-	Non-aggressive	Non-aggressive
	Magnesium salt content, mg/dm^3, in terms of Mg^{2+}	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Ammonia salt content, mg/dm^3, in terms of NH_4^+	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Caustic alkali content, mg/dm^3, in terms of Na^+ and K^+	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Total content of chlorides, sulfates, nitrates, and other salts, mg/dm^3	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
B.4	Portland cement under GOST V.2.7-46-96	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Portland cement under GOST V.2.7-46 with the content of C3S in clinker not more than 65%, C3A not more than 7%, C3A+C4AP not more than 22%, and portland blast furnace slag cement	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
	Sulfate resistant cements under GOST V.2.7-85-99	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive	Non-aggressive
B.5	Chloride content in terms of Cl^-, mg/dm^3	Corrosivity of the liquid inorganic medium against reinforcement in reinforced concrete structures				
		Immersed permanently			Wetted intermittently	
		Non-corrosive			Mildly corrosive	

4. FUEL, WATER, THERMAL, AND ELECTRICAL ENERGY DEMAND, ENERGY SAVING MEASURES

4.1 Fuel, Water, Thermal, and Electrical Energy Demand

4.1.1 Fuel Demand

One type of fuel (diesel fuel) is consumed at the CSFSF.

The aggregate annual fuel consumption at the CSFSF site will amount to 25 m^3 per year.

4.1.2 Water Demand

The annual water consumption of the CSFSF amounts to 3,309.5 m^3 per year.

4.1.3 Thermal Energy Demand

No thermal energy is consumed at the CSFSF.

4.1.4 Electrical Energy Demand

The annual electrical energy consumption of the CSFSF facility amounts to 4,750.98 MWh per year.

4.2 Energy Saving Measures

The Law of Ukraine “On Energy Saving” [40] is the main document in the field of the energy conservation in Ukraine. The said law defines legal, economic, social, and environmental principles of the energy savings for all enterprises, associations, and organizations in Ukraine, as well as for the citizens. The law defines “energy saving” as “organizational, scientific or practical activity focused on the sustainable use and efficient consumption of the primary and transformed energy and natural energy resources in the national economy carried out using technical, economic, and legal methods”.

Principal legislative and regulatory documents adopted in Ukraine in the field of the energy efficiency create legal, economic, organizational, and methodological foundations, set energy efficiency indicators, energy metering rules and procedures.

The CSFSF is designed so as to ensure efficient and economical energy consumption in accordance with DBN V.1.2-11-2008 [41] during a reasonable period of the regular operation subject to meeting the requirements for the internal microclimate in rooms and other conditions of the human activity.

Energy saving measures compliant with the applicable regulations [40, 42, 43] in terms of the following aspects have been designed in the course of the development of the design of the Construction of the Central Spent Fuel Storage Facility for VVER Reactors of Nuclear Power Plants of Ukraine:

- thermal engineering indicators of fencing structures and roofing;
- heating, ventilation, air conditioning, and refrigeration systems;
- electrical energy supply and consumption;
- energy metering and control.

In accordance with regulatory documents, the equipment for the development of detailed design documents will be selected taking into account its energy efficiency performance.

4.2.1 Energy Saving Measures in Process Solutions

4.2.1.1 Spent Nuclear Fuel Handling

The CSFSF is based on the technology by Holtec International (hereinafter — Holtec). This technology is currently one of the best in the world in terms of equipment and logistics. The SFA management under the Holtec technology includes:

- the reception of a car of a special cask train at the CSFSF;
- the transfer of the MPC from the HI-STAR transfer cask into the HI-STORM storage cask in the reception building;

- the placement of the HI-STORM cask with the MPC on the storage area using a transfer vehicle;
- the long-term storage of HI-STORM casks with spent fuel assemblies.

Reception of a Train with Spent Nuclear Fuel at the CSFSF

Spent nuclear fuel is delivered from NPPs to the CSFSF by rail using a special cargo train. In accordance with the applicable regulations and technology requirements, a special train consists of:

- not more than five cars for the delivery of HI-STAR casks;
- one platform car for a HI-TRAC transfer cask;
- one platform car with auxiliary equipment;
- one escort car;
- two buffer cars.

The following equipment is used to set up a train:

- a locomotive;
- a car for the transportation of a HI-STAR cask (five cars);
- a buffer car;
- an escort car;
- a HI-TRAC transfer cask car;
- a platform car for the auxiliary equipment used at the NPP;
- a container for the auxiliary equipment.

Reception of a Car with Spent Nuclear Fuel in the Reception Building

The following equipment is suggested for use for the reception of casks with spent nuclear fuel in the reception building:

- a vertical cask transporter;
- a car for the transportation of a HI-STAR cask (five cars);
- a HI-STAR transportation and packaging set;
- a locomotive;
- a platform car for the auxiliary equipment;
- a container for the auxiliary equipment;
- a main crane in the reception building;
- auxiliary equipment.

The following equipment is used for the container car reception and reloading operations:

- an electric bridge crane with a load-lifting capacity of 185/20 tonnes;
- a HI-STAR transportation cask;
- a HI-STAR damper device (damper);
- a HI-STAR damper device lifting bar;
- a HI-STAR transportation cask lifting beam;
- a HI-STAR lifting beam storage rack;
- a HI-STAR protective case;
- a tool for screwing and unscrewing damper devices;
- a CSFSF working ground;
- multipurpose load-handling tools.

Transfer of an MPC from a HI-STAR cask into a HI-STORM cask

MPCs are transferred from a HI-STAR cask into a HI-STORM cask after the completion of the following operations:

- a HI-STAR is placed into the HI-STAR well on the CTF;
- a HI-STORM is placed into the HI-STORM well on the CTF;
- a CTD is placed above the HI-STAR well on the CTF.

The following equipment is used at the stage of the MPC transfer from a HI-STAR cask into a HI-STORM cask:

- an MPC-31 multipurpose cask;
- an MPC-85 multipurpose cask;
- an MPC lifting device;
- an MPC lifting lug;
- the cask transfer facility;
- a cask transfer device;
- MPC lifting device and lifting lug storage racks;
- a HI-STAR cap screwing/unscrewing system;
- a HI-STORM storage cask;
- a HI-STORM circular gap protector;
- multipurpose load-handling tools.

Transfer of a Loaded HI-STORM Cask and Its Placement in the Storage Area

A loaded HI-STORM cask can be placed after the completion of the following operations:

- a HI-STORM cask with a cap, temporary IAEA seals, and lifting lugs installed on the cap is placed in the central hall of the reception building in an area accessible by a vertical wheeled transfer vehicle;
- the place for the placement of the HI-STORM cask in the cask storage area has been defined;
- the passport of the HI-STORM has been prepared;
- a mobile working platform has been delivered to the HI-STORM installation location;
- an opening to fit an IAEA anchor has been prepared in the foundation slab of the storage area.

The following equipment is used at the stage of the transfer of a loaded HI-STORM cask from the reception and handling building:

- a HI-STORM storage cask;
- a HI-STORM lifting beam;
- HI-STORM lifting lugs;
- a vertical cask transporter (VCT) (transfer vehicle);
- a turning frame.

Auxiliary equipment is to be provided in accordance with the design to support the CSFSF operation and the application of the Holtec technology at NPP units in addition to the equipment to be supplied by Holtec.

A more detailed description of the equipment and SNF handling process operations is provided in Volume 3.1 “Process Design. Part 1. Spent Fuel Handling”.

The following are the major measures focused on saving energy in the course of the CSFSF operation:

- the use of modern technologies and structures that make it possible to save electrical energy and consumables during the operation with long repair intervals due to the reduction in startup peak loads (frequency regulated drives);
- the equipment design optimized for the performance and quantity in terms of the energy efficiency.

The equipment to be used at the CSFSF has optimal metal intensity and minimum energy intensity. The electrical energy is only consumed by transportation process operations carried out with the lifting equipment.

The main crane in the reception building is used to lift a loaded cask (MPC and HI-STAR), and the auxiliary equipment at the CSFSF. The crane is used for placing a loaded HI-STAR cask into upright position, its lifting from a rail platform, and its placement onto a low-profile transporter. It is also used for the transfer of a loaded MPC from a HI-STAR cask into a protective transfer tube and from a protective transfer tube into a HI-STORM cask.

The electric bridge crane with a load-lifting capacity of 185/20 tonnes is a bridge crane with

electric drive, whose main hoisting winch has been engineered on the basis of a single-failure principle; it is used for transportation and process operations with casks that contain spent nuclear fuel.

The crane is equipped with asynchronous squirrel cage electric motors controlled by variable speed drives.

The use of electric motors with variable speed drives results in the following:

- the high control accuracy;
- the electrical energy savings in the case of the variable load (the operation of an electric motor with the partial load);
- the starting torque equivalent to the maximum torque;
- the extended service life of the equipment;
- the gradual startup of the motor which reduces wear and tear;
- the controlled braking and the automated restart in the case of the power outage;
- the stabilization of the rotational speed when the load changes;
- the additional electrical energy savings due to optimizing the excitation of the electric motor;

the dynamic slowdown energy is recuperated by the drive and returned into the power supply system.

LED lights are used on the crane bridge to help reduce the electrical energy consumption.

4.2.1.2 Waste Management During Operation

During operation of the CSFSF, radioactive and non-radioactive waste is produced.

The design calls for the separate management of radioactive and non-radioactive waste, safe and reliable handling of all types of radioactive waste generated in the course of the CSFSF operation, the possibility of the mechanized loading of the radioactive waste, and the removal thereof by special vehicles for subsequent storage or treatment.

Radioactive waste management systems that ensure radioactive waste collection, categorization, and shipment to special facilities within the exclusion zone have been designed at the CSFSF to meet regulatory requirements. No long-term radioactive waste storage on the CSFSF site is planned.

The radioactive waste generated at the CSFSF are divided into liquid and solid radioactive waste.

Production waste and consumption waste are the sources of non-radioactive waste during operation of the CSFSF.

Collection, storage, and shipment of the floor drain water from the decontamination of the equipment arriving at the reception building, and the shower water from the personnel airlock are one of the main processes of handling the liquid radioactive waste. The floor drain water collection system includes piping, pumps, and tanks.

The energy saving measures within the scope of the design of LRW handling systems were focused on the selection of pumps. The design calls for using high efficiency productive pumps with a low power consumption level contributing to the attainment of high energy efficiency and reliability. Drain pumps are turned on and off by a floating switch to optimize the pump operation.

Specifications of pumps used in shower and decontamination water collection systems are presented in Table 4.1.

Table 4.1. Specifications of Pumps of the Shower Water and Decontamination Water Collection System

Model	Name	Quantity	Specifications
CM 10-1 Grundfos type	Floor drain water tank pump	2	Delivery flow rate: 10 m^3 per hour; head: 12 m; pump power: 0.65 kW; mass: 18.8 kg Flow channel: made of corrosion-resistant steel Type: centrifugal
CM 10-1 Grundfos type	Control tank pump	2	Delivery flow rate: -10 m^3 per hour; head: -12 m; pump power: 0.65 kW; mass: 18.8 kg Flow channel: made of corrosion-resistant steel

Model	Name	Quantity	Specifications
			steel Type: centrifugal
Pedrollo Dm 20 type	Drainage pump with a floating switch	5	Delivery flow rate: 1.5 m^3 per hour; head: -20 m; pump power: 0.75 kW; mass: 13.0 kg Type: submersible pump with a floating switch

A detailed description of the equipment of SNF management systems is provided in Volume 3.2 “Process Design. Part 2. Waste Management During Operation”.

4.2.1.3 Auxiliary Systems

The main CSFSF technology (SNF management) is supported by the following auxiliary systems:

- the compressed air supply system;
- the process vent system;
- the decontamination system;
- the inert gas system.

The compressed air is treated and supplied in order to supply compressed air of required quality at required pressure and flow rate to compressed-air drives of the process equipment supplied by Holtec International, and for the repair work.

The process vent system is intended to remove radioactive aerosols from the air displaced from drain waters and the shower water monitoring tank.

The decontamination system is intended for the decontamination of equipment, systems, and premises of the reception building and the garage during the operation, maintenance, repairs, and emergency management.

The inert gas system comprises two systems:

- a helium supply system;
- an argon supply system.

The helium supply system is used for operations carried out during the preparation of an MPC with the SNF in a HI-STAR cask to the power unit for re-packing, and for checking a HI-STAR cask for leaks.

The argon supply system is used in the course of welding activities in the course of manual welding.

Compressed Air Supply System

The design provides for a compressed air supply system to meet the demand of compressed air consumers.

The compressed air is supplied to consumers in the reception building from stationary compressors installed in the compressor room (116).

The following equipment is installed in the compressor room (116):

- two helical screw air-cooled compressors of GA11 type (Atlas Copco, Sweden) (1 main compressor, 1 standby compressor) with a capacity of 108.0 m^3 per hour (1.8 m^3 per minute) with a built-in 500-L air receiver each. The capacity of a single compressor is 11 kW;
- two adsorption-type dehumidifiers;
- valves and piping.

Compressors have high energy efficiency due to the modern profile of the helical screw, the use of modern materials and technologies, and a thoroughly engineered design of the compressor.

Due to the compressor's being mounted on the air receiving tank, it is turned on periodically when the pressure in the system drops to save electrical energy. The automated compressor load control system optimizes the amount of the compressed air for the specified operating mode.

Compressed air to consumers in the maintenance building, the MPC warehouse and the garage is supplied from mobile compressors.

Depending on the type of work to be carried out, compressors are carried to a compressed air consumer.

Design calls for the application of oil-free piston compressors of LF5-10 type (Atlas Copco, Sweden) with a capacity of 29.4 m^3 per hour (0.49 m^3 per minute) with a built-in 250-L air receiver. The compressor power rating is 4.0 kW.

These compressors are compact low-noise products mounted on their frames and equipped with all connecting pipes and fittings.

Decontamination System

Decontamination methods are divided in two groups: mechanical and physical/chemical. Mechanical methods of the decontamination call for the removal of the radioactive contamination together with a layer of the contaminated material without the application of chemicals. Physical/chemical methods of the decontamination call for the removal of the radioactive contamination by dissolving it, subjecting it to chemical breakdown or emulsification.

The system is intended for the decontamination of equipment, systems, and premises of the reception building and the garage during the operation, maintenance, repairs, and emergency management.

The following equipment is designed for the decontamination of the equipment, rooms, and plastic PPE equipment:

- a mobile high-pressure washer with electric water warming;
- a wash tub in room 104 of the workshop;
- a floor scrubber;
- a vacuum cleaner for dry and wet cleaning.

Specifications of the decontamination system equipment are presented in Table 4.2.

Name	Quantity	Specifications
Dry- and wet-cleaning vacuum cleaner of Kaercher NT 70/2 Ap Me Tc type	1	Vacuum: 25.4 kPa; container capacity: 75 dm^3; power rating: 2760 W; air flow rate: 2 × 74 dm^3 per second;

Table 4.2. Specifications of the Equipment of the Decontamination System

Name	Quantity	Specifications
		voltage: 220 to 240 V; mass: 26.5 kg
Floor scrubber of Kaercher BR 40/25 C ECO Ep type	1	Effective width of brooms: 400 mm; mass: 61 kg; overall dimensions: 800 × 575 × 830 mm; capacity of the clean water tank: 25 dm^3; capacity of the dirty water tank: 25 dm^3; power rating: 1580 W; width of the suction beam: 700 m
High-pressure water-heated wash of Kaercher HDS-E 8/16-4 M24 kW type	1	Mains frequency: 50 Hz 3 phases, voltage: 380 V; capacity: 300 to 750 dm^3 per hour; maximum pressure: 17.0 MPa; maximum temperature: 80 °C; input power: 29.5 kW; net mass: 112 kg; overall dimensions (L×W×H): 940×600×740 mm; decontamination solution tank: 20 dm^3;

Modern mobile energy efficient equipment will be used for the regular wet cleaning and decontamination of rooms in the reception building. The following energy saving measures have been focused on during the development of major technical solutions for the decontamination:

- the use of high-pressure washes and wet-dry vacuum cleaners of Kaercher HP type with highly efficient electric motors;
- the minimization of the water consumption for decontamination by using modern wet-dry vacuum cleaners and high-pressure units;
- the possibility for the local water heating in a high-pressure washing unit.

Inert Gas System

The inert gas system comprises two systems:

- a helium supply system;
- an argon supply system.

Helium Supply System

The helium supply system is used for operations carried out during the preparation of an MPC with the SNF in a HI-STAR cask to the power unit for re-packing, and for checking a HI-STAR cask for leaks.

Argon Supply System

The argon supply system is used in the CSFSF for welding operations in the course of the repair work.

Filling Station

A filling station is designed to support automobile operations on the CSFSF site.

The filling station consists of one fuel dispenser and two underground fuel tanks.

The fuel dispenser of NOVA-1101.21 SB type is designed for the metering and dispensing fuel. The dispenser has a local control panel for the metered dispensing of fuel directly from the dispenser.

The fuel dispenser is equipped with standard hydraulic equipment: a single housing design with a bypass valve and a gas removal system, a volumeter with a pulse transducer, a fine filter, a

return valve, and a fueling nozzle.

Diesel fuel tanks are operated in a broad range of temperatures from -50 to +50 °C. The internal zinc coating of the diesel fuel tank enhances the corrosion resistance of metal. All tanks are protected against diesel fuel leakage.

Diesel Power Plant (DPP)

The diesel power plant is designed to supply electric power without interruption in the case of electric power failures at the facility (in the stand-by mode).

The electrical equipment building accommodates the equipment of the diesel power plant (room 106).

The design provides for the installation of a single 320 kW diesel generator set. The diesel generator set is a modular open-type structure made by Caterpillar mounted on a single foundation frame.

The C13 ATAAC diesel generator sets are highly efficient and have a low fuel consumption.

The set has been designed in accordance with ISO 8528-5 requirements for the operation at a variable load, and can take 100 percent of the nominal load at a single step. The built-in control system, which includes a UPS, an automatic load transfer switch, and switchgear ensures uninterrupted power supply and stable local and remote control.

The air cooling system, the engine lubrication system, and fuel, oil, and air filters ensure the long service life. The automatic control system is capable of starting up or stopping the plant automatically, and controlling operating parameters of the engine and generator.

A detailed description of the equipment of auxiliary systems is provided in Volume 3.3 “Process Design. Part 3. Auxiliary Systems”.

4.2.2 Measures to Ensure Reasonable Choice of Materials and Designs

Requirements for the reasonable choice of materials and designs of buildings and structures are based, first of all, on the need to meet the following two conditions:

- the conformity of the chosen materials and structures with the applicable regulatory requirements for the strength and longevity of buildings and structures;
- the conformity of selected materials and structures with the building code in terms of the thermal insulation of buildings and structures to save energy while meeting sanitary hygiene requirements and maintaining optimal microclimate parameters in rooms.

The improvement of the thermal shielding of buildings and structures by means of the reasonable choice of materials and designs results in the reduction in environmental heat losses.

These measures are also considered from the point of view of the environmental protection, the sustainable use of non-renewable natural resources, and the reduction in the greenhouse effect by decreasing emissions of the carbon dioxide and other harmful substances into the atmospheric air.

Core requirements for the reasonable choice of materials and designs for the thermal insulation of buildings and structures are set forth in DBN V.2.6-31:2006 [44].

4.2.3 Energy Saving Measures in Architectural and Construction Solutions

The CSFSF are has moderately continental climate with a positive moisture balance. The winter is mild; the summer is warm and humid.

In view of climate conditions, the solutions have been adopted in the design to meet the core requirement of the sustainable use of energy resources by means of the proper selection of the building thermal insulation level taking into account the efficiency of thermal energy supply and microclimate maintenance systems on the basis of the holistic approach toward viewing the building and its systems.

The thermal properties of the building walls have been chosen on the basis of regulatory requirements for specific elements of the thermal insulation of the building.

The specific values of the unit thermal energy consumption have been reduced by means of:

- a sustainable spatial and layout concept that calls for bringing individual buildings and structures in a single unit, reducing the area, and the number corners of the outside walls of the building;
- reducing the area of window openings to the minimum level meeting the natural illumination requirements;
- the arrangement of anterooms at building entrances;
- the use of efficient thermal insulation materials, and their sustainable placement in the enclosing structures;
- the enhancement of the efficiency of microclimate systems, the use of efficient heating devices and equipment, and the reasonable positioning thereof.

Thicknesses of thermal insulation layers of enclosing structures of buildings have been adopted on the basis of the thermal engineering analysis (presented in Section 15).

Design solutions for the thermal insulation of all buildings and structures will ensure the minimum acceptable thermal losses throughout the calendar year, thus meeting the regulatory requirements in the field of energy efficiency and energy conservation.

4.2.4 Energy Saving Measures in Electrical Design Solutions

4.2.4.1 Design Measures to Ensure High Quality of Electrical Energy

The transformation ratio of the balance-of-plant (BOP) transformer will be made adjustable to meet the requirements for voltage fluctuations in plant mains. Cables of power supply lines have been checked for the allowed voltage drop.

The following circuit design solutions have been adopted to reduce the impact of the voltage unsinusoidality on plant circuits and the influence of the abruptly variable load on sensitive power consuming units:

- the uninterrupted power supply units, welding and lighting networks being non-linear loads are to be connected using dedicated power supply lines connected directly busbars beyond the transformer;
- the use of the equipment with the lower level of the ultraharmonics generation.

Single-phase loads will be uniformly distributed among phases to reduce systemic asymmetry in low-voltage networks.

Quality and reliability of the power supply to control and protection systems are ensured by the application of uninterrupted power supply units.

4.2.4.2 Power Supply Technical Solutions

Electrical energy losses in transformers are a type of process losses due to specifics of physical processes occurring in the course of the electric power transmission.

Using energy efficient power transformers, where savings in the course of the operation are attained due to the low losses in the ferromagnetic core and coil, and maintaining sustainable operating mode of transformers (the optimum load factor) contribute to the reduction in electrical energy losses in transformers.

Using transformers with ferromagnetic core losses (open-circuit losses) at a level of 2.0 kW rather than transformers with losses of 2.8 kW will save about 35,000 kWh per year.

Disconnecting the garage transformer will contribute to the reduction in electrical energy losses during the period when no electrical heating is used. The electrical energy losses will be reduced by 7,500 kWh*year over the period of not using the electrical heating.

The following measures have been adopted in the electrical design to ensure sustainable and economical consumption of the electrical energy in power networks to reduce losses:

- the optimal number of power supply lines;
- the optimal cross-sectional area of cables;
- the even distribution of loads among phases;
- energy efficient lights.

Lights with energy-saving bulbs are mainly used for the electrical lighting; their electrical energy consumption is much lower than that of incandescent lamps at the same illumination level.

Using gas discharge lamps in lights is more than 4 times as efficient as using incandescent lamps.

The design provides for both natural and artificial lighting.

For the electrical energy to be consumed sustainably, the general, emergency, and outer lighting systems will be controlled separately with the division into zones and rooms.

The design provides for using equipment with low energy consumption and low losses.

4.2.5 Energy Saving Measures in Ventilation, Heating, and Air Conditioning Systems

The design calls for measures to be taken in the course of the design of heating, ventilation and air conditioning systems to ensure efficient use of energy if they are implemented and operated properly.

Building walls meet the requirements of DBN V.2.6-31:2006 [44].

The design calls for the automated control of the heat output of the electric air heater depending on the established air temperature in the rooms during the cold season in order to ensure economical consumption of the electrical energy for the supply of heat to the plenum system.

All heaters are provided with temperature controllers that make it possible to control air temperature in the relevant rooms automatically.

The design provides for the centralized reduction in the air temperature within office and amenity rooms during non-working hours by not more than 4 °C off the target temperature. The air temperature in rooms is increased to the target temperature before the working hours. Temperature sensors installed in characteristic rooms of buildings provide inputs for the automatic and remote switching of space heaters on and off in the office and amenity rooms.

The heat emitted by the operating equipment will also be recovered for heating the electrical equipment rooms and the compressor room.

4.2.6 Measures to Save Energy in Water Supply and Waste Water Disposal Systems

The following systems are designed for the CSFSF:

- water supply systems:
- utility and drinking water;
- fire water;
- hot water;
- process water;
- waste water disposal systems:
- sanitary water;
- storm water;
- process water.

Pumping equipment is the major consumer of energy resources in water supply systems.

All pumping units have temperature sensors in each coil of the electric motor; a humidity sensor wire is pulled through stator wires into the oil chamber.

The automated pump control protects pumps against the following emergency operation modes:

- the overheating of the pump electric motor;
- the ingress of moisture into the oil chamber of the pump;
- the failure of pump sensors;
- the prevention of the pump startup if the electric motor insulation resistance is too low;
- the current overload;
- the wrong sequence of phases at the control panel input (to prevent the electric motor from the reverse rotation), the low or high mains voltage, the phase shift in mains, the phase loss.

4.2.6.1 Water Supply System

At the CSFSF site, the water is supplied from the existing DN 100 off-site network (V1) that supplies process water from artesian wells to the KP Vector site. The connection will be made using DN 80 electrically welded pipes.

At the place of the connection to the existing KP Vector network, a water supply pit made of reinforced concrete elements will be built for the installation of the cutoff valves and custody meters on the pipes. The pit cover will have a lock to protect against unauthorized access.

Quality of the water supplied to the CSFSF site does not meet requirements of DSANPIN 2.2.4-171-10 [45] for drinking water. A drinking water treatment plant will be installed in the office building at the CSFSF site to ensure conformity of the water with regulatory requirements.

Drinking water consumption at the CSFSF site will be metered by a custody transfer metering unit at the inlet into each building or structure as prescribed by paragraph 13.1 of DBN V.2.5-64:2012 [46].

Hot water pipes in buildings will be thermally insulated from the source to the tap in order to optimize thermal resources.

No drinking-quality water will be used for process purposes in order to optimize the water supply system and meet the requirements of applicable regulations.

4.2.6.2 Waste Water Disposal System

All sanitary waste water from buildings and structures of the CSFSF (other than checkpoint 2) flow by gravity to the domestic waste water pump station; therefrom, it is pumped to the sanitary waste water purification works at the KP Vector site.

The design calls for the collection of the storm water by a gravity flow storm water disposal network with the subsequent separation of the contaminated and notionally clean runoff in a separating well.

Downstream of the separating well, the contaminated portion of the storm runoff is pumped by booster pump stations to the contaminated storm water accumulating tanks; after the regulation and partial settling, the water is pumped to the storm water extra purification facility with pumps installed in the accumulating tank. After the treatment, the storm runoff is discharged into the clean storm sewer of KP Vector.

The notionally clean storm runoff is subjected to extra purification at bag filters in clean storm runoff accumulating tanks, and, after the chemical analysis, is either discharged into the clean storm sewer of KP Vector or used to water the grounds and greenery. To this end, a well is designed downstream of the notionally clean tank to enable connection of portable watering units or hoses. If the content of chemicals does not meet the requirements, the runoff is pumped into contaminated storm runoff accumulation tanks. The storm runoff from the CSFSF site is discharged into the clean storm sewer of KP Vector in accordance with the technical concept for the connection to KP Vector.

Regular radiation monitoring will be carried out in all storm runoff tanks.

Custody meters are installed in pits on pipelines used for the pumping of the sanitary waste water from the CSFSF site to the KP Vector site, and for the pumping of the storm runoff into the Maryanivka River.

4.2.7 Energy Conservation in Control and Monitoring Systems

The energy conservation in control and monitoring systems is ensured by:

- the selection of equipment with the minimum power consumption;
- the use of LEDs and LED displays in alarm circuitry;
- the assurance of the quality of the electrical energy.

Power outages and permitted short-term deviations of the steady state feeding voltage and frequency should not:

- result in failures;
- cause false signals resulting self-induced movements of actuators;
- cause loss of information in the memory of system units.

There is control over presence of the feed voltage with the generation of a malfunction signal in case of the outage. Uninterrupted power supply devices are provided for the protection of the hardware in software and hardware suites.

The hardware has short-circuit protection to disconnect it from the primary power supply.

4.2.8 Resource Consumption Metering

The design provides for metering:

- process water at the CSFSF;
- water at inlets into each building;
- sanitary waste water delivered from the CSFSF to purification works on the KP Vector site;
- (notionally clean) storm water discharged into the storm water sewer of KP Vector;
- storm water delivered to purification works of the KP Vector site;
- electrical energy supplied to the CSFSF.

A liquid meter will be installed to meter sanitary waste water. VR-1 induction liquid flow rate meter made in Ukraine is suggested. It is designed to indicate and record the flow rate and the volume of conducting liquids.

VR-1 induction liquid flow rate meter consists of a primary transducer, a signal converter, and a power supply module.

The VR-1 induction liquid flow rate meter measures flow rate of conducive liquids by converting flow velocity into an electric signal directly by means of electromagnetic induction.

Specifications of VR-1 induction liquid flow rate meter:

- Nominal diameter of the primary transducer, DN, mm: 32 40;
- Upper range limit, Q_{max}, m^3 per hour: 34.6—54;
- Nominal operating pressure, MPa: 16;
- Relative flow rate and quantity measurement error, %: not more than ±1.0.

One LK-32H cold water tangential flow turbine meter per building will be installed in the office building, guardhouse, and reception building.

The LK tangential flow turbine water meter is designed to measure volume of the drinking water flowing across it at a pressure under 1.0 MPa. The meter meets the requirements of DSTU 3580-97 [47] and technical specifications TU V 33.2-22987900-012-2003.

The meter is protected against influence of the permanent magnetic field created by a permanent magnet with the surface flux density ranging from 50 to 100 mT with the total area up to 60 square cm. Parts of the meter are made of LC40S brass and resistant plastics to ensure long service life.

Specifications of LK-23H water meters:

- Nominal diameter, mm 32;
- Class and working position ..... BH;
- Water temperature, °C ..... От 5 до 30;
- Nominal pressure, MPa 1.0;
- Water volume flow rate,m^3 per hour:

minimum (Q_{min})..... 0.12;
- transient (Q,) 0.48;
nominal (Q_n) 6.0;
maximum (Q_{max}) 12.0;

- minimum scale spacing, m^3 ..... 0.0001;
- acceptable relative error threshold, %, ... within flow rate ranges

- from Qmin (inclusive) up to Q t ±5%
- from Qt (inclusive) up to Qmax ±2%;

- sensitivity threshold, m^3/hour, not more than..... 0.06;
- pressure loss at Qmax, MPa, not more than ..... 0.1.

KV-1.5 tangential flow turbine cold water meters are installed in the checkpoint 1 building, the maintenance building with the MPC warehouse, the concrete plant checkpoint, the garage, and the fire water pumping station.

It is designed for metering (including custody metering) water consumption and monitoring processes. The meter meets requirements of TU U 3.48 002256544-017-94.

It consists of an impeller module which is a flow chamber with an impeller and a counting mechanism tightly isolated from the impeller module. The impeller rotation is transmitted to the counter via magnetic coupling. The total amount of water passing through is indicated on a digital display and dial gauge on the instrumentation panel of the water meter. They are ISO 4064-1:1993 [48] compliant.

Specifications of a KV-1.5 water meter:

- nominal diameter DN 15;
- metered water working temperature range, °C ..... from 5 to 40;
- metered water nominal pressure, MPa, not more than 1;
- minimum scale spacing, m^3 ..... 0.0001;
- operating position ..... H.V
- Class..... B:
  sensitivity threshold, m^3/hour, not more than 0.012
  water flow rate, m^3/hour, for class B:
  - ..... minimum, q_{min} 0.03;
  - ..... maximum, q_{max} 3;
- class .....A:
  sensitivity threshold, m^3/hour, not more than 0,03;
  water flow rate, m^3/hour, for class A:
  - minimum, qmin.....0,06;
  - maximum, qmax.....3;
- acceptable relative error threshold, %, in flow rate sub-ranges:
- minimum, qmin .....±5;
- maximum, qmax for cold water.....±2;
- maximum, qmax for hot water .....±3.

Local data acquisition and processing equipment (LOSOD) will be used for the electricity custody metering in 10 kV switchboard cells of PS110/10 kV Buriakivka substation feeding 10 kV lines to the 10 kV switchgear of the CSFSF in accordance with TU No. K-00-16-04-3 of 4 May 2016 issued by PAT Kyivoblenergo.

A multi-functional programmable electronic electricity meter that supports metering of active and reactive energy, automated reading and archival of measurement data, registration of the load profile by phase (including current and voltage indicators by phase), and the integration into the

existing automated electricity custody metering system (ASKOE). The meter meets the requirements of DSTU IEC 60521, SOU-NMPE 40.1.35.110:2005, and carries out control and monitoring of parameters of the electricity network and the quality of the electrical energy.

4.2.9 Conclusions

Principal legislative and regulatory documents adopted in Ukraine in the field of the energy efficiency create legal, economic, organizational, and methodological foundations, set energy efficiency indicators, energy metering rules and procedures.

The CSFSF is designed so as to ensure efficient and economical energy consumption in accordance with DBN V.1.2-11-2008 [41] during a reasonable period of the regular operation subject to meeting the requirements for the internal microclimate in rooms and other conditions of the human activity.

Buildings will be built in accordance with requirements for the thermal protection (insulation) of buildings for maintaining microclimate suitable for the human activity in buildings, ensuring required reliability and longevity of structures, providing proper climate conditions for the operation of the technical equipment at a minimum consumption of the thermal energy for heating and ventilation of buildings during the heating season.

The longevity of building walls is ensured by the application of properly resistant materials (resistant to freeze, humidity, biological impact, corrosion, high temperature, temperature fluctuation cycles, and other destructive environmental impacts) with the provision of the special protection of structural elements made of insufficiently resistant materials, if necessary.

The central spent fuel storage facility for VVER reactors of the Ukrainian nuclear power plants is designed for the disposal and long-term (at least 100 years) storage of the spent nuclear fuel (SNF) from VVER reactors.

All buildings and structures at the CSFSF site have been designed on the basis of their assumed tentative service life specified in Table 19.1.

Accordingly, during this period buildings and structures must meet energy efficiency requirements with the simultaneous conformity with requirements for technologies and materials in the course of construction.

The following solutions have been adopted to ensure energy efficiency during the development of the CSFSF design:

- use of the modern economical state-of-the-art equipment;
- implementation of energy-saving technical solutions;
- optimization of the power consumption and minimization of thermal losses.

5. INFORMATION ABOUT PROJECT PHASING AND STARTUP FACILITIES

As per the Design Brief, the CSFSF is to be commissioned in a single phase with the identification of the following fifteen start-up facilities (PK):

- PK-1 includes the construction of all buildings and structures under the design, and the installation of four HI-STORM casks (3 MPC-31 and 1 MPC-85);
- PK-2 includes the installation of 33 HI-STORM casks (28 MPC-31 and 5 MPC-85);
- PK-3 includes the installation of 33 HI-STORM casks (29 MPC-31 and 4 MPC-85);
- PK-4 includes the installation of 24 HI-STORM casks (21 MPC-31 and 3 MPC-85);
- PK-5 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-6 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-7 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-8 includes the installation of 34 HI-STORM casks (26 MPC-31 and 8 MPC-85);
- PK-9 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-10 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-11 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-12 includes the installation of 32 HI-STORM casks (27 MPC-31 and 5 MPC-85);
- PK-13 includes the installation of 34 HI-STORM casks (29 MPC-31 and 5 MPC-85);
- PK-14 includes the installation of 34 HI-STORM casks (29 MPC-31 and 5 MPC-85);
- PK-15 includes the installation of 38 HI-STORM casks (34 MPC-31 and 4 MPC-85).

6. CORE SOLUTIONS AND INDICATORS OF THE MASTER PLAN OF UTILITY NETWORKS AND SERVICES

According to layout solutions, the total fenced area of the CSFSF site, including the concrete plant site, is 13.80 hectares.

The CSFSF site comprises the following buildings and structures:

- the reception building;
- the cask storage area;
- the maintenance building with an MPC warehouse:
- buildings and structures for storage and maintenance of the transfer vehicle and the fleet (a garage, a filling station);
- the electrical equipment building;
- the office building;
- the security equipment buildings and structures (a set of security structures with the guardhouse, checkpoints 1 and 2, trench shelters, physical protection equipment);
- water supply and waste water disposal buildings and structures (fire water supply pump station, fire water tanks, storm water facilities, waste water pump station, oil drain tanks (separators), etc.;
- holding and marshaling tracks for spent nuclear fuel rail cars.

The following core functional areas have been identified during the development of the layout of the CSFSF site master plan:

- a utilities area outside the southern side of the site fence near the main entrance at checkpoint 1;
- a process area in the center of the site (reception building);
- an auxiliary area in the southern and southeastern parts of the site with the maintenance building with an MPC warehouse, the HI-STORM shell storage area, the electrical equipment building;
- a warehousing area in the central and northwestern parts of the site with the SNF cask storage area;
- an area of holding and marshaling rail tracks for rail cars with the SNF along the eastern side of the site near checkpoint 2;
- a security guard facilities area in the southwestern part of the site;
- an area of auxiliary water supply and waste water disposal facilities in the southeastern part of the site;
- an area of auxiliary structures for storage and maintenance of the transfer vehicle and the fleet (a garage, a filling station) near the warehousing and process areas.

This functional zoning of the CSFSF site has been carried out on the basis of process links, sanitary and fire fighting requirements, logistics, and types of transport in accordance with paragraph 3.3 of SNIP II-89-80 [50].

The total fenced area of the CSFSF site is 13.20 hectares.

Two access roads are designed to the CSFSF site: the main one from the south and the service access from the north, as well as the rail access track on the northern side of the site. Site entrances have checkpoints and inspection platforms for cars/trucks and rail cars respectively.

The reception building is located in the center of the site; it has
a railway entrance gate and an entrance gate for the transporter that transfers HI-STORM casks with MPCs from the reception building to the storage area.
The zero absolute elevation of the reception building has been set at 139 m.

The storage area for HI-STORM casks with the SNF occupies the major portion of the CSFSF site. The cask storage area is intended for the long-term storage of MPCs in HI-STORM casks. It consists of cast-in-situ foundation slabs on which casks are placed. Between slabs, process access ways are provided for the cask transporter and other equipment, as well as for the personnel. The storage area is rectangular in shape and extends along the CSFSF site in north to south direction up to its central part. The cask storage area has its own wire-mesh fence with radiation control along perimeter and a set of the physical protection equipment. Holding and marshaling tracks run along the eastern side of the storage area.

The building with a garage for the cask transporter maintenance and repair is also designed to accommodate four cars taking into account the cask transporter traffic flow chart in the immediate vicinity of the entrance of the SNF cask storage area and the reception building. A filling station is placed south of the garage at appropriate fire-gap distances of at least 30 m from the nearest buildings and structures (Table 1 from paragraph 1.9 of VSN 01-89 Automobile Maintenance Enterprises provides that the maximum distance from a filling station to process buildings and structures shall be 18 m; that to office and amenity buildings shall be 25 m). The filling station includes two underground fuel tanks of 5 cubic meters each, and a fuel dispenser installed on an open-air concrete ground.

The storage of the at-hand reserve of empty MPCs and the maintenance of cars of the trains arriving at the CSFSF will take place in the maintenance building with the MPC warehouse located south of the reception building. The maintenance building has a rail entrance used to deliver shells of HI-STORM casks and MPC casks to the CSFSF site.

Shells of HI-STORM casks will be stored on an open-air site near the maintenance building.

The electrical equipment building and the office building are placed along the southern fence of the CSFSF site.

Security structures include a guardhouse, a drill ground, a loading area, a dog kennel, etc.; they are surrounded by a dedicated mesh fence on the southwestern side of the site near the main entrance.

Water supply and waste water disposal buildings and structures are located in the southeastern part of the CSFSF site.

Paved access roads and turning areas have been designed to ensure access of the fire-fighting machinery to all buildings and structures at the CSFSF site.

Off-site and on-site motor roads have been designed in accordance with regulatory requirements of [50, 70, 71].

On-site motor roads and access passages are 7.0 m wide at the cask transporter routes with a minimum longitudinal slope; passages for automobiles are 6.00 or 4.50 wide.

On-site railway tracks have been designed in accordance with regulatory requirements of [70, 72] for 1524 mm wide tracks, and [73] for 1520 mm wide tracks.

On-site holding and marshaling tracks are one of the main areas where nuclear fuel is handled, MPCs with SFA are delivered in HI-STAR transportation casks, HI-STORM shells are supplied, unloading operations are performed, empty cars are accumulated and held, and shunting operations are carried out.

Surface water will be drained from pavements the main access road, on-site roads and grounds via gutter inlets into the designed storm water disposal network. The drainage of motor roads is organized by means of longitudinal and transverse gradients, and the installation of curbs. On holding and marshaling railway tracks, water is drained via a system of gutters between tracks into the designed storm water disposal network.

Designs of utility networks and services of the CSFSF site provide for the following main

systems:

- a power supply system (with outside earthing, security and outside lighting);
- a utility and drinking water supply system;
- a fire water supply system;
- a process water supply system;
- a sanitary waste water disposal system;
- a storm water disposal system;
- a process waste water disposal system.

Utility networks and services on the CSFSF site are designed to be laid underground.

The following are the major ways of access to the CSFSF site:

- personnel traffic ways;
- cargo and materials transportation;
- transportation of radioactive and non-radioactive waste;
- cask transporter movement;
- automobile traffic;
- rail traffic;
- traffic of the fire-fighting and emergency rescue machinery.

Access ways and various functional routes on the CSFSF site have been designed to have the least possible number of crossings. The personnel access to working places, cask transporter routes, and routes of cargo delivery by rail are separated.

Technical and economic specifications of the CSFSF site are as follows:

- the fenced area of the site is 13.20 hectares;
- the built-up area occupied by buildings and structures is 4.90 hectares;
- the area of paved motor roads, passageways, and grounds is 3.54 hectares including the pavement of the cask storage area of 2.18 hectares;
- the greenery area is 1.90 hectares;
- the building density is 37%.

Locations of buildings and structures under design, principal layout solutions, landscaping and utility network solutions, amenity and greenery solutions, and a layout of railway tracks are presented on drawings in Volume 2 “Master Plan and Transport”.

7. SOLUTIONS FOR THE ENGINEERING PROTECTION OF THE SITE, AND THE PROTECTION OF BUILDINGS AND STRUCTURES AGAINST HAZARDOUS NATURAL AND ARTIFICIAL FACTORS

Before the construction of the facility, the engineering protection of the site shall be carried out in order to prevent or mitigate negative consequences of natural or natural/artificial processes and factors with their interactions and mutual causality on the site with its buildings and structures.

The engineering protection of the site, and the protection of buildings and structures against natural and artificial factors are designed on the basis of the engineering survey science and technology report [1], and in accordance with regulatory requirements of DBN V.1.1-3-97 [2], DBN V.1.1-24-2009 [3], DBN V.1.1-25-2009 [4].

7.1 Spatial and Layout Planning Solutions for the CSFSF Site, Landscaping, Site Preparation

The CSFSF site shares a boundary with the Vector facility in the east, with a 110-kV aerial power transmission line in the west; it is bounded by a road access to the Vector facility in the south and a forest in the north.

The site is 5 km away from Shepelychy railway station, 1 km away from Buriakivka radioactive waste disposal facility, and 12 km away from Chornobyl Nuclear Power Plant.

The location of the site is shown on drawing 571402.201.002.GT-K1, Sheet 1, Situational Plan (Volume 2, “Master Plan and Transport”).

The grade elevation of the CSFSF site is 139.0.

The CSFSF comprises buildings and structures; most important of them make up dedicated functional zones.

Two access roads are designed to the CSFSF site: the main one from the south and the service access from the north, as well as the rail access track on the northern side of the site. Site entrances have checkpoints and inspection platforms for cars/trucks and rail cars respectively.

Surface water will be drained from pavements the main access road, on-site roads and grounds via gutter inlets into the designed storm water disposal network. The drainage of motor roads is organized by means of longitudinal and transverse gradients, and the installation of curbs. On holding and marshaling railway tracks, water is drained via a system of gutters between tracks into the designed storm water disposal network.

The CSFSF site is landscaped taking into account the specific features of the facility and the terrain.

At a preparatory stage, the work will be carried out to clear the construction site of the CSFSF site from forest and shrubs, and grade the area.

Greenery planting and landscaping, construction of sidewalks, and installation of external lights will be carried out to ensure proper working conditions at the site.

Sidewalks and pedestrian footpaths with a width ranging from 1.00 to 1.50 m have been designed for the pedestrian traffic on the site.

Greenery planting on the site has been designed taking into consideration locations of utilities, service lines, and zoning.

Lawn has been designed in the area free of any development or pavement; trees and bushes will be planted in areas free of utility networks. Types of trees and bushes have been chosen taking into account local climate. The soil in areas, where there is no lawn, will be graded and compacted.

The greenery planting area does not exceed 15 percent of the total area within boundaries of

the design (paragraph 3.73 of SNIP II-89-80 [50]).

Other than sidewalks, landscaping elements include rest areas, benches, and litter bins.

Design of landscaping and greenery planting for the CSFSF site is presented on drawing 571402.201.002-GT-K1, sheet 6, Landscaping and Greenery Planting Plan (Volume 2, “Master Plan and Transport”).

7.2 Engineering Protection of the Site against Waterlogging and Floods

The area of the CSFSF site is slightly sloping from north to south and is characterized by elevations from 142.00 to 139.00 m in the northern part and from 138.50 to 137.00 m in the south. The grade level for the CSFSF site in accordance with the master plan is 139.00 m.

In view of this, rainfall runoff that accumulates in the neighboring area in the north will flow along the natural gradient toward the fence of the CSFSF site. CSFSF site engineering protection measures have been designed to protect the CSFSF site against floods. The design calls for arranging a strengthened drain ditch on the western side of the site designed to convey the rank overflow (a storm water runoff calculation 571402.216.022.RK00 has archived at PAO KIEP).

The drain ditch has a rectangular cross section; it is 2 m wide at the bottom with 2 m high walls strengthened with reinforced concrete. The drain ditch bottom is covered with crushed rock and strengthened with geoweb and the grade of 0.0003 m. Since the CSFSF site consists of water-permeable sandy soil with a low groundwater level, the collected runoff will be partly filtered into the soil. Reinforced concrete slabs are laid for discharging the runoff into the terrain.

No waterlogging of the site with groundwater is expected in accordance with the geological survey [1] carried out on the site in 2015 because the underground water depth ranges from 12.2 to 19.2 m.

7.2.1 Engineering Protection of the Area, Protection of Buildings and Structures against Hazardous Geological Processes

No physical, geological and hydrogeological processes and phenomena capable of affecting buildings and structures negatively have been found on the site in accordance with the geological survey [1] carried out on the site in 2015. Exogenous geological processes (EGP), such as swamp development, soil erosion, development of gullies and landslides, do not occur because of the insignificant difference between absolute elevations of the site (~2.0 m). In addition, the terrain will be graded, paved, and landscaped in the course of the construction. No changes in geological conditions are expected in the course of construction and operation of the storage facility.

Foundations of buildings and structures have been designed in accordance with regulatory requirements of DBN V.2.1-10-2009 [6] and PiN AE-5,6 [7] taking into account physical properties of the soil. Foundations of buildings and structures are supported by the stable soil footing.

During the preparatory period, the CSFSF construction site will be prepared (with more detailed information on this subjected provided in paragraph 7.1 “Recommendation on the Technology of the Main Construction and Installation Work, Volume 11, Construction Method Statement, 571402.201.011-POS); the preparation will include a number of measures, including the grading of the site (cutting and backfilling of up to 2.9 m) to the grade level of 138.800.

As a result of the site preparation, the backfilled soil compacted with the consolidation rate of 0.95 according to specifications provided below will serve as footing for foundations of some of the CSFSF buildings and structures being designed:

- density at optimal humidity of 12%: ρ = 1.74 tonnes per cubic meter;
- dry soil bulk density: ρ = 1.64 tonnes per cubic meter;
- internal friction angle: φ =30°;
- specific cohesion: C=1.9 kPa.

Local fine grained sand will be used for backfilling. Silty sands present in places to be excavated in accordance with the geological survey may only be used for backfilling in the areas free of CSFSF buildings (the silty sand must be outside the footprint of buildings under design at all times). Soil to be compacted may not contain trash, black humus soil, construction debris, organic inclusions, lumps of frozen soil.

Existing backfilled soils (IGE-1a) shall be replaced with the graded soil that meets the following physical and mechanical specifications:

- consolidation rate: 0.95;
- density at optimal humidity of 12%: ρ = 1.74 tonnes per cubic meter;
- dry soil bulk density: ρ = 1.64 tonnes per cubic meter;
- internal friction angle: φ =30°;
- specific cohesion: C=1.9 kPa.

Before foundations are built in a pit, the subsoil shall be tested for meeting the required specifications. If not, the engineering solutions will have to be reviewed.

A system of monitoring of the condition of foundations of buildings and structures will be implemented to study deformations of the subsoil under buildings and structures, to determine the condition of the subsoil, the nature of subsoil deformations, and compare actual building settling and tilt values with regulatory targets and design requirements.

No further measures are required in the field of the engineering protection of the area, protection of buildings and structures against hazardous geological processes.

7.3 Engineering Protection of the Area, Protection of Buildings and Structures against Natural/Artificial Impacts

No natural/artificial processes and phenomena capable of affecting properties of the subsoil, as well as buildings and structures negatively have been found on the site in accordance with the geological survey [1] carried out on the site in 2015, namely:

- there are no undermining areas;
- - there are no oil or gas production fields;
- - there are no water-retaining structures;
- - there is no intake of underground water directly under the site.

No changes of natural/artificial (technology-induced) nature are expected in the course of construction and operation of the storage facility.

8. OCCUPATIONAL SAFETY

DP NAEK Energoatom is going to implement and operate an occupational safety management system at the CSFSF in accordance with the Law of Ukraine “On Occupational Safety” [8], Electrical Energy Sector Companies Occupational Safety System Policy approved by Order of the Ministry of Energy and Coal Industry No. 73 of 9 February 2015. According to the above Policy, the occupational safety policy must focus on:

- maintaining good manufacturing practices;
- improving the industrial safety level by means of the ongoing technical control over the condition of the production facilities, technologies, and equipment; the use of achievements of science and technology;
- providing training, professional re-training and qualification development opportunities to personnel in the field of the occupational safety;
- social protection of workers, restitution of damage to people affected by accidents and occupational diseases.
- the Policy specifies objectives in the field of occupational safety, such as:
- the prevention of accidents;
- the reduction in the number of violations of requirements of occupational safety regulations;
- the reduction in the level of risk for the most hazardous activities;
- the reduction in the number of employees working under conditions that are not compatible with sanitary/hygiene norms;
- the obtainment of the OSMS conformity certificate under DSTU OHSAS 18001:2010 “Occupational Hygiene and Safety Management Systems. Requirements”.

Since the CSFSF does not currently have any permanent personnel, the documents for the CSFSF OSMS, including the CSFSF OSMS Policy, are expected to be completed at the stage of the commissioning activities because the permanent personnel will be appointed to the CSFSF before the commissioning of the facility.

In DP NAEK Energoatom, the occupational safety management is focused on providing safe working conditions at each working place on the basis of the following tenets:

- the priority of human life and health of the personnel;
- the responsibility of every employee for the occupational safety level at his working station;
- the reduction in the number of violations of requirements of occupational safety regulations in the course of organizing and performing work;
- the encouragement of the commitment to the good manufacturing and occupational safety practices.

The above tenets will be implemented in the CSFSF occupational safety management system.

8.1 List of Core Regulations

Table 8.1 offers a list of the core occupational safety regulations applied by DP NAEK Energoatom and its separated subdivisions.

Document Name	Designation
Law of Ukraine “On Occupational Safety”	
Main Radiation Safety Assurance Rules of Ukraine	OSPU DSP 6 177-2005-09-02
Radiation Safety Standards of Ukraine. State Health Standards (NRBU-97)	DHN 6.6.1-6.5.001-98
Radiation Safety Standards of Ukraine. Amendment: Radiological Protection against Potential Exposures. State Health Standards (NRBU-97/D2000)	DHN 6.6.1-6.5.061-2000
Occupational Noise, Ultrasound and Infrasound Sanitary Standards	DSN 3.3.6.037-99.
Hazardous and Harmful Process Factors.	GOST 12.0.003-74*
Classification	(ST SEV 790-77) *(COMECON standard)*
Production Premises Microclimate Sanitary Standards	DSN 3.3.6.042-99.
Electrical Installation Rules	PUE 2009 in 2011 version
General Sanitary and Health Requirements for the Working Zone Air	GOST 12.1.005-88 SSBT
Alternating Current Switchgears and 330, 400, 500, and 750 kV Aerial Power Transmission Lines. Rules of Protection of the Maintenance Personnel against the Electromagnetic Field Impact	GKD 34.03.601-95
Rules of Occupational Safety for the Operation of the Thermomechanical Equipment of Power Plants, Heating Networks, and Installations Using Thermal Energy	NPAOP 0.00-1.69-13
Rules of Installation and Operation of Fire Alarm and Evacuation Management Systems in Buildings and Structures	NAPB A.01.003-2009
Natural and Artificial Lighting	DBN V.2.5-28:2006
Rules of the Safe Operation of Electrical Installations of Consumers	NAOP 40.1-1.21-98
Rules of Occupational Safety of Working at Height	NPAOP 0.00-1.15-07
Sanitary Rules of the Organization of Processes and Hygiene Requirements for the Process Equipment	SP 1042-73 (DNAOP 0.03-1.07-73)
Rules of Installation and Safe Operation of Pressure Vessels	NPAOP 0.00-1.07-94
Rules of Fire Safety in Ukraine	NAPB A.01.001-2014
DSANPIN. Health Categorization of Occupational Activities in Terms of Harmfulness and Hazard of the Process Environment Factors, Working Process Difficulty and Stress Level as approved by Order of the Ministry of Health of Ukraine No. 248 of 8 April 2014	-
Protective Electrical Safety Measures in Electrical Installations of Buildings and Structures	DBN V.2.5-27-2006
Rules of Safe Work with Electrical Power Tools and Accessories	NPAOP 0.00-1.30-01
Rules of Special Training and Education in the Technical Operation of Electrical Energy Sector Facilities	GKD 34.12.102-2004
Model Occupational Safety Instruction for the Work in Confined	GKD 34.03.804-97

Document Name	Designation
Spaces	
Model Charter of the Occupational Safety Function	NPAOP 0.00-4.21-04
Model Procedure of Occupational Safety Training and Knowledge Testing	NPAOP 0.00-4.12-05
Procedure of Investigation and Record-keeping of Occupational Accidents, Occupational Diseases, and Process Emergencies	-
Procedure of the Provision of Special Clothing and Footwear, and Other Personal Protection Equipment to the Personnel	NPAOP 0.00-4.01-08
List of Elevated Hazard Work Activities	NPAOP 0.00-2.01-05
Procedure of Medical Examinations of the Personnel of Certain Categories approved by Order of the Ministry of Health of Ukraine No. 246 of 21 May 2007	-

8.2 Process Safety Measures

The following processes will take place in the course of the operation of the CSFSF:

- monitoring and maintenance of HI-STORM storage casks;
- operation and maintenance of the thermomechanical and electrical equipment, and instrumentation equipment for keeping the facility safe;
- operation and maintenance of buildings and structures of the CSFSF;
- operation and maintenance (assessment) of load-lifting machinery;
- transportation and process operations that involve handling of spent nuclear fuel transportation and storage casks;
- operation of road and rail vehicles.

The production process safety is ensured by implementing the following organizational and technical measures:

- equipment, buildings, and structures shall be operated in strict conformity with operating instructions and requirements of the organizational and instructive documents of DP NAEK Energoatom, regulations, and requirements of the documentation of manufacturers;
- assessment of working places (in terms of working conditions) for the conformity with requirements of regulations and documents of DP NAEK Energoatom aimed at detecting and eliminating conditions that can result in the deterioration of the health of personnel (Resolution of the Cabinet of Ministers of Ukraine No. 442 of 1 August 1992 “Procedure of Assessment of Working Places for Working Conditions”);
- monitoring of the technical condition of equipment, buildings and structures in accordance with requirements, instructions, and operating regulations and documents of DP NAEK Energoatom;
- control over the compliance of the personnel with requirements of occupational and labor safety regulations and documents of DP NAEK Energoatom;
- organization of occupational safety training and knowledge tests and briefings of personnel in accordance with requirements of NPAOP 0.00-4.12-05 [9] and PL-S.0.26.029-05 [10].
- provision of special clothing, PPE and PRPE to the personnel in accordance with the OSPU [12] and NPAOP 0.00-4.01-08 [13];

use of safety signage and posters in accordance with requirements of the Technical Regulation for Occupational Safety and Health Signage approved by Resolution of the Cabinet of Ministers of Ukraine No. 1262 of 25 January 2007.

8.3 Toxic, Fire/Explosion Safety Specifications of Materials, Semi-finished Products, Process Waste, and Control over Safety Requirements

There are no toxic or fire/explosion-hazardous semi-finished products or process waste in the CSFSF.

Design calls for the application of decontaminants permitted in Ukraine, having sanitary/health certificates, and efficient in different conditions, to decontaminate rooms in the reception building, the equipment, and the special vehicles. Decontaminants listed in Table 8.2 will be used.

Table 8.2. **List and Specifications of Decontaminants**

Agent Name	**Agent Description**	**Agent Purpose**	**Contamination Type**	**Hazard Class under GOST 12.1.005-88**
FRES-20	Fire-safe freon (halocarbon compound) and ethyl alcohol blend Non-toxic	Decontamination of electrical equipment surfaces		-
Selan-3	Water solution of polyvinyl alcohol and glycerin with surfactants and sequestrants. Fire and explosion safe. Non-toxic	Dry decontamination of various surfaces of rooms and equipment (painted and non-painted carbon and corrosion resistant steel surfaces; concrete and plastered surfaces painted with decontaminable chemical-resisting enamel paints; organic and silicate glass surfaces; surfaces of self-leveling floors on the basis of epoxy and polyester resins.	Removal of alpha and beta-active contaminations at the ambient air temperature above zero and relative humidity up to 90 percent	-
Selan-4	Water solution of polyvinyl alcohol and glycerin with surfactants and sequestrants. Fire and explosion safe. Non-toxic	Dry decontamination of corroded metal surfaces	Removal of strongly fixed alpha- and beta-active contaminations at the ambient air temperature in the range from -15 °C to +40 °C, and relative humidity up to 90 percent	-

Agent Name	Agent Description	Agent Purpose	Contamination Type	Hazard Class under GOST 12.1.005-88
Baryer	Powder blend of surfactants, leachable and acidic additives. Fire and explosion safe. Non-toxic	Decontamination of metal building structures, equipment, and vehicles.		-

Other agents listed hereinbelow may also be used for the decontamination.

Fon and Raddez are aerosol foam standalone decontaminants. They are available in spray cans making it possible to decontaminate directly at a working place. These decontaminants are supplied as 0.5 dm^3 spray cans in corrugated boxes.

Fon-P (TU 6900-002-73039369-2004) decontaminant is used for the decontamination of various surfaces. It is a flavored solution of surfactants in an ethanol/water blend with a propellant, sequestrants, and organic acids.

Fon-K (TU 6900-003-73039369-2004) is used for the decontamination of the human skin. It is a flavored solution of surfactants in an ethanol/water blend with a propellant, sequestrants, and organic acids.

Fon-E (TU 6900-001-73039369-2004) is used to decontaminate electrical equipment and assembled devices. It is a saturated alcohol solution with special additives.

Raddez-P (TU 95 2700-98) is used to decontaminate metal and polymer surfaces. It is a flavored solution of surfactants in an ethanol/water blend with a propellant, sequestrants, and organic acids.

Raddez-D (TU 95 2701-98) is used for the decontamination of the human skin. It is a flavored solution of surfactants in an ethanol/water blend with a propellant, sequestrants, and organic acids.

These decontaminants are non-toxic, fire and explosion-safe.

Fire and explosion-hazardous materials are used at the filling station and in the garage; their specifications are specified in Table 8.3.

Table 8.3. Specifications of Fire and Explosion-hazardous Materials

Substance **Description**	**Fire or Explosion Hazard**	**Hazard Class under GOST 12.1.007-76**
Diesel fuel	Diesel fuel is a flammable liquid with the autoignition temperature of 300 °C (**L-branded** summer fuel) or 310 °C (**Z-branded** winter fuel). Ignition ranges are as follows: 69 to 119 °C (for **L-branded** summer fuel) and 62 to 105 °C (for **Z-branded** winter fuel.	IV
Engine oil	Engine oils are a flammable viscous liquid with a flash point in the range of 165 to 235 °C, an autoignition range of 300 to 350 °C; upper ignition limits of 193 to 225 °C and lower ignition limits of 154 to 187 °C.	IV

Control over compliance with safety requirements will be exercised by the nuclear, radiation and occupational safety inspector, and the engineer in charge of occupational safety in a process unit in accordance with the Electrical Energy Sector Companies Occupational Safety System Policy.

8.4 Description of Processing Areas, Calculation or Substantiation of Explosion and Fire Hazard Categories or PBE Classes

Categories of CSFSF rooms in terms of the fire and explosion hazard level have been determined in accordance with NAPB B.03.002-2007 [14] and listed in Table 8.4.

Table 8.4. Categories of CSFSF Rooms in Terms of Fire and Explosion Hazard

Room Number	Room Name	Area, square meters	Explosion/Fire and Fire Hazard Category
Reception building			
114	Central Room (transport-technological operations room)	953.5	Д(E)
103	Water metering room	18.8	Д(E)
104	Machine repair shop	48.2	Г(D)
105	Room for cleaning and decontamination machinery	9.1	Д(E)
106	Decontamination chemicals store room	9.6	Д(E)
107	Radiochemical laboratory	33.8	Д(E)
109	Floor drain tanks room	46.7	Д(E)
110	Monitoring tank room	28.1	Д(E)
111	Special sewage pumps room	29.2	Д(E)
116	Compressor room	24.8	Д(E)
117	BOP 0.4 kV switchgear room	87.4	B(C)
118	Plenum ventilation center	34.8	Д(E)
125	Tools store room	7.3	Д(E)
202	TLD dosimetry laboratory	17.0	Д(E)
203	Electrical switchboard room	8.3	B(C)
303	Control and management systems server room	32.5	Д(E)
304	Server room	36.4	Д(E)
305	Telecommunications room	30.1	Д(E)
306	CSFSF centralized control and management systems room	48.5	Д(E)
321	Instrumentation workshop	36.8	Д(E)
401	Plenum ventilation center	95.5	Д(E)
402	Exhaust ventilation center (exclusion area)	106.3	Д(E)
403	Exhaust ventilation center (normally occupied area)	23.5	Д(E)
406	Radiation monitoring system room	16.6	Д(E)
Maintenance building with an MPC warehouse			
101	Equipment maintenance and warehousing room	1300.0	Д(E)
102	Mechanical workshop	74.25	Г(D)

Room Number	Room Name	Area, square meters	Explosion/Fire and Fire Hazard Category
103	Concrete laboratory	43.81	Д(E)
104	Electrical switchboard room	10.52	B(C)
105	Electrical workshop	24.71	Д(E)
115	Spare parts store room	16.05	Д(E)
203	Plenum ventilation chamber	23.47	Д(E)
204	Exhaust ventilation chamber	22.5	Д(E)
205	Spare parts store room	22.48	Д(E)
209	Workshop (ventilation, water supply and waste water disposal systems)	17.74	Д(E)
Office building			
003	Filter and ventilation room	23.27	Д(E)
016	Drinking water preparation plant room	82.32	Д(E)
218	Ventilation chamber	17.65	Д(E)
Electrical equipment building			
101	Water metering room	3.65	Д(E)
102	BOP 0.4 kV switchgear	86.3	B(C)
103	BOP 10 kV switchgear	49.5	B(C)
104	Ventilation room	31.6	Д(E)
106	Diesel power plant room	49.8	B(C), F-I
Garage			
101	Covered parking lot	190.8	B(C), F-IIa
102	Maintenance and repair section	102.6	B(C), F-IIa
103	Washing and decontamination room	83.8	B(C), F-IIa
104	Mechanical workshop	42.8	Г(D)
105	Ventilation chamber	35.2	Д(E)
106	Ventilation chamber	17.1	Д(E)
107	Store room	17.1	B(C), F-I
111	Garage for the transfer vehicle	216.0	B(C), F-IIa
112	BOP 0.4 kV switchgear	102.6	B(C)
Fire water supply pump station			
1	Motor room at -2.500	74.8	Д(E)
1	Motor room at 0.000	20.8	Д(E)
Guardhouse			
003	Ventilation chamber	19.7	Д(E)
107	Armory	23.65	B(C), F-IIa
121	Garage	71.68	B(C), F-IIa
123	Study materials workshop and store room	11.23	Д(E)
221	Ventilation chamber	11.06	B(C), F-IIa
222	Ventilation chamber	19.35	Д(E)

8.5 Determination of the energy potential of explosion hazardous units, radiuses of potential destruction zones, actions to protect the personnel from injuries, and to arrange safe evacuation of workers in case of possible emergencies and fires

There are no explosion hazardous units at CSFSF.

In case of emergency response actions, operating personnel shall follow the guidelines on elimination of emergencies in the operation of the systems and equipment. A package of guidelines on elimination of emergencies at CSFSF pursuant to the practice utilized by SE NNEGC Energoatom will cover the entire list of operational occurrences and emergencies anticipated in the project. Emergency elimination guidelines identify the procedure of the personnel actions to ensure safety in case of emergencies.

Personnel evacuation measures, gathering locations and escape routes in case of emergency will be determined in the Emergency Plan.

For protecting the personnel in evacuation, pursuant to requirements set in EIC [16], Chapter 5 of the Ukrainian Building Code Document DBN V.1.1-7-2002 [17], foresees the following measures:

- evacuation is anticipated only via emergency exits;
- clear height and width of the emergency exits (doors) shall be not less than 2.0 m, and the width - 0.8 m;
- doors of the emergency exits and doors on escape routes open in the direction of the people's escape;
- doors of the emergency exits from the floor corridors and stairwells have no locks preventing their free opening from the inside without key;
- corridors are free from equipment and utilities protruding from the wall pane at a height under 2 m, and have no pipelines carrying flammable substances;
- current conducting parts of electric installations, as well as conductors of any purpose, satisfy requirements of the EIC [16] regarding their maximum permissible heating at all possible modes of the electric installation operation.

Distance from the most remote workplace to the nearest emergency exit does not exceed 20-30 m in the administrative and amenity buildings and premises and 50 m in the production buildings.

Floors on the escape routes are arranged without level differences and edges.

Walls and ceilings on escape routes are finished in accordance with requirements set in par.5.24 of DBN V.1.1-7-2002 [17] with use of materials having fire hazard index not higher than:

- G2, B2, D2, T2 - for wall and ceiling finish in the corridors;
- V2, RP2, D2, T2 - for flooring of the corridors.

Emergency exit signs are anticipated with built-in rechargeable batteries.

If the working lighting is off for any reasons, emergency (safety) lighting remains operational and enables to continue work at a permissible reduced illumination. Safety lighting is anticipated in premises without natural light, in main process areas, ventilation chambers, in MV SG premises, as well as in control panels.

In case of failure of the working lighting, safety lighting shall create on the working surfaces in serviceable production premises the lowest illumination in 5%, rated for the working illumination from the total one, but not less than 2 lx.

Escape lighting is arranged on escape routes, in places dangerous for pedestrian traffic, in premises where leaving from the premise in case of emergency failure of the working lighting is connected with the injury risk in case the production equipment remains in operation. LED Exit signs are anticipated with built-in rechargeable baterries ensuring at least 1 hour of offline operation (par.6.1.23, EIC [16]). Escape lighting shall ensure the lowest illumination of 1 lx on the floor of main passages and on the steps of the stairs in the premises (par.6.11, EIC [16]).

8.6 Data on illumination of workplaces, noise, vibration, methods of extraction and neutralization of wastes with hazardous properties

Electrical lighting is executed in accordance with Chapter 6, EIC [16] and par.4, DBN V.2.5-28-2006 [19].

Anticipated illumination by premises:

- corridors - 50-100 lx;
- clean room - 200 lx;
- stairs - 100 lx;
- electric premises, control and measurement instrumentation - 200 lx;
- local switchboards - 300 lx;
- ventilator premises - 100 lx;
- area with casks (reception, rehandling) - 600 lx;
- reloading of casks, treatment of assemblies, monitoring of casks, technical maintenance - 300-500 lx;
- pump, diesel and compressor rooms - 200 lx;
- radiation monitoring rooms – 150 lx
- office space - 300 lx;
- access control hall - 200 lx;
- water closet rooms - 100 lx.

Light sources are mainly luminaires with luminescent and mercury (sodium) lamps with power factors not below 0.9 and 0.85 respectively (par.6.2.1, EIC [16]).

Combinated lighting - general and local - is anticipated in the premises. In case of the local lighting, luminaires are installed at workplaces in direct vicinity of the working zone.

Required illumination in the premises is ensured by working and emergency lighting lamps thus ensuring required conditions both for normal operation and for cases of emergency failure of the main (working) power supply sources.

Storage area for the casks is lit by floodlight towers combined with lightning rods, searchlights with sodium lamps. This ensures 30 lx illumination for performance of works during the dark hours, and 2 lx for illumination of railway tracks.

Power supply for the working lighting of the storage area for the casks and of the railway tracks is fed from the reception building. The control is remote from the reception building (each tower separately) and local, from the lighting assembly installed at the entry to the cask storage area.

For security lighting along the roads, luminaires with sodium lamps are installed on reinforced concrete poles. The poles are installed at a distance of 1 m from

the internal fence (in the exclusion zone) with the interval not more than 20 m. In this case, it will ensure illumination across the width of the exclusion zone of at least 15 lx during the dark hours (horizontal at the ground level and vertical on the fence pane).

Security lighting of the cask storage area is arranged from floodlight towers combined with lightning rods, searchlights with sodium lamps. In this case, it will ensure illumination of at least 15 lx during the dark hours.

Source of the noise that has impact on the environment is dry type 10/0.4kV 1000kVA transformers installed in separate premises:

- reception building - two 1000kVA transformers;
- garage for 4 cars and cargo carrier - one transformer, 1000kVA;
- electrical equipment building - two transformers, 1000kVA.

Noise characteristics of the transformers are given in Table 8.5.

Table 8.5 - **Noise characteristics of the transformers**

Measured value:	Transformer noise level 1000 kVA
Average acoustic power level Lw(A), db(A)	73
Average acoustic pressure level (at 1 m distance) Lp(A), dB(A)	59

Noise generated by the transformer doesn't exceeds 80 dB and requires no special protective actions.

There are no vibration sources leading to exceedance of the standard thresholds in premises with permanent personnel presence.

There are no wastes with hazardous properties at CSFSF.

During operation of CSFSF, LRW and SRW may form, which handling system is described below.

Drain water storage and transportation system

Drain water from flood traps of the active drains are fed under gravity to the sump of the premise with drain water tanks. Flood traps are arranged in every premise where decontamination is anticipated. From the drain sump drain waters are pumped into one of the drain water tanks. The plan anticipates two tanks with the capacity of 4 m_3 each - one is operational, and one is backup. The tanks are connected by the joint manifold. Switching of the drain water arrival from one tank to another is performed by the operator according to the signal of the medium upper level in the receiver tank.

For pumping the accumulated LRW out to a vehicle - 5 m_3 tank truck for removal of LRW at Chernobyl NPP two pumps of the drain water tank are anticipated (one is operational and one is backup), each with the throughput of 12.5 m_3/hour. Pressure conduit from the pump room leads to the central hall to which the motor vehicle access is ensured. Flowmeter is installed on the pump heads to control LRW volume pumped into the vehicle.

In order to assess the activity of the LRW accumulated in the reception tank, stationary control of the drain water activity is performed. According to the results of such control, the following is assessed

actions to ensure radiation safety of the personnel during sampling and to coordinate reception of drain water at Chernobyl NPP.

After the receiver tank is full, personnel will take samples, for which purpose the design provides for the sampling cupboard located in the laboratory. The laboratory analyses the tank medium for the isotopic composition and activity. Based on the control results, the personnel compiles the LRW batch passport and calls a vehicle from the Chernobyl NPP to transport LRW to the Chernobyl NPP.

For control of the LRW handling system local console, on-the-spot control, and control from the central control and monitor panel are anticipated. On the central control and monitor panel most important system parameters (level in the drain water tanks, tank medium activity, status of the pumps operation (on/off), and readings of the flowmeter) are displayed.

Shower water storage and transportation system

The system is intended for reception, control and transportation of the water from showers and wash hand basins of the contamination control zone to the shower water control tanks. The system comprises manifolds, pipelines to connect manifolds and individual sources, as well as tanks and pumps of the shower water tanks.

The system is designed to receive up to 4 m3/day of the shower water. The water is low-activity LRW or non-radioactive at all.

Liquid wastes generated at CSFSF are considered radioactive if they satisfy the criterium of specific activity. With that said, it is considered that main radionuclides are ^{137}Cs, ^{90}Sr. Therefore, shower room water will refer to radioactive if their specific activity by ^{137}Cs exceeds 10^7 Bq/m3, and that by ^{90}Sr – 10^6 Bq/m3.

At normal operation, water from the shower rooms and wash hand basins is fed under gravity to the control tanks (2 pcs.) of shower waters. One of these tanks is used as a receiver tank and the second is used as a feeder tank. The system provides for 2 pumps: main and backup.

For the case of accidental spill of the water, there is a sump arranged, with the depth of 1 m and a drainage pump. Drain water can be pumped out into any of the control tanks.

After one of the tanks is full, the personnel will switch discharge from the system to the neighboring tank.

Samples are taken from the filled tank. The laboratory performs analysis of the specific activity of the samples. If the specific activity of the water in the tank by ^{137}Cs does not exceed 10^6 Bq/m3, and by ^{90}Sr – 10^5 Bq/m3, then the water from the control tanks is discharged under gravity to the domestic sewage system. If the specific activity exceeds the indicated values, then the water will be transported for treatment to the Chernobyl NPP. Information on the results of the sample analysis by the lab technician is recorded in the LRW control and accounting system.

If the water is radioactively contaminated, the shift supervisor approves its transportation to the Chernobyl NPP. After the reception is approved, LRW batch passport will be prepared.

Solid radioactive waste storage and transportation system

Low-activity and medium-activity SRW handling system is intended for handling of the solid radioactive wastes formed at the normal operation, at violations of the normal operation, and at design basis accidents at CSFSF.

SRW generated at CSFSF are considered radioactive if they satisfy the criterium of specific activity. Classification of SRW categories by the specific activity criterium is given in Table 8.6.

Table 8.6 - **Classification of SRW categories by the specific activity**

RW categories		Range of SRW specific activity values, kBq/kg	
		Alpha radionuclides Group 2	Beta, gamma radionuclides Group 3
1	Low-level radioactive	$>10_0<10_2$	$>10_1<10_3$
2	Medium-level	$\geq10_2<10_6$	$\geq10_3<10_7$

During the operation, solid radioactive wastes may form at performance of the scheduled works on radiation situation control, at decontamination, at equipment maintenance and repair and at replacement of the active ventilation filters.

SRW are:

- materials utilized at the maintenance and repair (M&R);
- failed (used) and irreparable equipment;
- used protective clothing that refers to radioactive wastes by the contamination criterium and is not subject to decontamination;
- spent PPE;
- wipe rags, wiping materials, swabs;
- spent active ventilation filters;
- contruction wastes.

Handling of low- and medium-activity SRW is a set of technological operations, which includes:

- collection in the generation locations, radiation control and packing in the primary packaging (PE bags);
- delivery of the primary packages with SRW to the SRW collection and temporary storage area;
- KT-0.2a cask identification in the RW control and accounting system by the RW handling operator;
- packing of the primary packages into KT-0.2a cask under control of the dosimetrist and RW handling operator;
- entry of the information about the wastes into in the RW control and accounting system;
- closing of the KT-0.2a cask cap;
- radiation control of the surface contamination of KT-0.2a cask and local decontamination if required;
- completion of a SRW batch passport at the control station of the RW control and accounting system;
- loading of the transfer cask onto the vehicle and removal to the Chernobyl NPP.

At each SRW collection point there are KT-0.2a casks installed, with the inserted primary plastic, PE package, and craft bags. Depending on the wastes activity, the casks are painted as follows:

- for 1 category SRW - white color;
- for 2 category SRW - blue color.

In addition to stationary SRW collection areas, the provision is made for temporary - for the duration of the equipment repair - collection areas, where casks for different SRW categories are placed. Quantity of the casks and their types are determined during preparation for the repair and planning of the works. Temporary collection areas are arranged in the premises where repair is performed, in direct vicinity of the work locations.

The following shall be used for transporting Group I and II SRW from CSFSF to the Chernobyl NPP:

- primary package - type KT-0.2a cask (200 dm3);
- shipping package - protective transfer cask, type KTZ-3.0;
- self-opening cask, 1.8 m3;
- vehicle - special purpose vehicle.

8.7 Means to prevent fires and explosions, and store and transport materials, semi-finished products with hazardous and dangerous properties, performance of loading and unloading operations

No storage and transportation of materials and semi-finished products with dangerous and hazardous properties are performed within the CSFSF.

The following fire safety system are anticipated for the designed facility:

- external fire safety water pipeline with installation of fire plugs, designed in accordance with DBN V.2.5-74:2014 [20] requirements;
- internal fire safety water pipeline with installation of fire hose cabinets, designed in accordance with DBN V.2.5-64:2012 [46] requirements;
- fire alarm system, designed in accordance with requirements set in DBN V.2.5-56:2014 [21], DSTU-N CEN/TS 54-14:2009 [23];
- automatic gas and powder type fire suppression systems, designed in accordance with requirements set in DBN V.2.5-56:2014 [21], DSTU 4466-1:2008 [24], and DSTU 4466-8:2008 [25];
- public address and evacuation control system, designed in accordance with requirements set in DBN V.2.5-56:2014 [21], DSTU-N CEN/TS 54-14:2009 [23];
- alarm messaging system, designed in accordance with requirements set in DBN V.2.5-56:2014 [21];
- smoke control systems, designed in accordance with requirements set in DBN V.2.5-56:2014 [21];
- emergency lighting (escape, safety), designed in accordance with requirements set in DBN V.2.5-28-2006 [19];
- lightning protection, designed in accordance with requirements set in DSTU B V.2.5-38:2008 [26].

The design also provides for equipping the facility area, buildings and structures with primary fire extinguishing means (fire safety boards placed within the facility area and equipped with fire extinguishers, boxes with sand, fire blanket of nonflammable materials, pike poles, crowbars, buckets, as well as fire extinguishers placed inside the facility buildings and structures) in accordance with requirements set in the regulatory documents NAPB A.01.001-2014 [27] and NAPB B.03.001-2004 [28].

For the purpose of localization of the fire source, alarm about its outbreak, control of fire annunciators, signal lines and buses, receipt and processing of the data, formation and issue of signals about fire and failure, the design makes provision for the analog addressing automatic fire safety and control system certified in Ukraine.

Fire alarm and automatic fire suppression (AFSS) systems include

:

- fire alarm control unit (FACU) with address automatic and manual fire alarm boxes, controlled loop signal lines,

- control and protection modules, and programmable addressable control modules, installed - depending on the purpose - as close as possible to the protected object, which are responsible for execution of the algorithms of control and elaboration of control actions onto operating mechanisms, as well as data transmission to FACU.

Fire alarm system control units are also responsible for generation of the *Fire in CSFSF* signal and its feeding to the centralized surveillance post.

Fire safety of the cabling is ensured by means of the following actions:

- use of the cables of all purposes (power, control, automatics, communications etc.) with flame-retardant insulation;
- use of the power cables of the automatic fire alarm, suppression and public address systems with flame-retardant and fireproof insulation, with fire resistance of at least 30 mins IAW DBN V.2.5-56: 2014 [21];
- arrangement of passive fire proofing of the cabling.

Passive fire proofing includes application of fire protective compound onto cable routes (assurance of flame retardance), creation of flame arresting belts on cable routes, and fire protection padding (closing) of cable passages (localization of fire within one route or premise). Fire prevention measures to ensure fire proofing (cable coating, flame arresting belts, fire protection padding of cable passages) shall be taken in accordance with requirements set in the Fire Proofing Rules (Order of the Ministry of Emergencies of Ukraine no.460 of 02 July 2007) and regulatory documents establishing requirements to installation of engineering utilities: DBN V.1.1.7-2002 [17], VBN V.1.1-034-03.307-2003 [29] and NAPB B.01.014-2007 [30].

The provision is made of the use of fire protective materials Siloterm EP-6 by ELOKS.

The design provides for 10 kV cables and under 1 kV cables with class A flame-retardant insulation.

After the tender, the Customer may choose other manufacturers of cable products and fire protective materials on condition if they are manufactured under the similar specification requirements and if there are UkrSEPRO conformity certificates as for the products, upon which fire safety requirements are imposed.

Loading and unloading operations operations are performed by the personnel in accordance with requirements of NPAOP 0.00-1.01-07 [31], namely:

- at the work site and on the load lifting cranes and machines no persons having no direct relation to the performed work are allowed;
- in case of a need for inspection, repair, adjustment of mechanisms, electrical equipment, exit to the crane bridge deck, inspection and repair of hardware, crane operator shall switch the incoming switchgear off;
- cargo slinging is arranged by means of slings matching the weight of a lifted load, with consideration of the number of branches and their inclination to the vertical axis;
- general purpose slings are selected so as to ensure that inclination angle of the branches to the vertical axis does not exceed the permitted value;
- prior to transportation, the load is preliminary lifted to a height from 200 mm to 300 mm to check for proper slinging and reliable action of the brakes;
- during the lifting, relocation and lowering of the load placed near the wall, column, pile etc, no people (including the workers who attach the load) are allowed between the lifted load and the indicated parts of the building or equipment;

- load is lifted, relocated and lowered in case there are no people under it. Slingsman may stay near the load during the lifting or lowering operation if the load is at a height of not more than 1 m from the site on which the slingsman stands;
- the load is lowered down to a designated place where the load falling, tripping or sliding is excluded;
- loading and unloading operations, load relocation and piling with use of load lifting cranes and machines at permanent depots, sites, bases, in production and other premises, shall be be carried out under the process flowcharts developed and approved in accordance with the established procedure;
- load piping with use of load lifting cranes and machines is carried out at piping sites or in special places. This work may be performed only under the technology previously developed and approved by a company dealing with these operations, where order of operations, methods of load slinging, and measures on safe performance of works are determined.

In order to exclude electrocution of the personnel, the respective measures on the grounding of load lifting machinery are implemented in power supply systems in accordance with par.4.9 of NPAOP 0.00-1.01-07 [31], and on the use of appropriate PPE.

8.8 Actions to protect the workers from external and internal factors, availability of sanitary facilities and amenities, medical service

Most dangerous of the factors established by GOST 12.0.003-74* [32] for the CSFSF personnel are the following:

- electrocution;
- falling from height;
- increased noise level;
- increased temperature of the equipment surface;
- increased level of ionizing radiation in buildings and structures.

To protect the workers from negative impact of the above-listed external and internal factors, the following primary electrical means are provided for at Rivne NPP SUs, in accordance with par.5.2.7 of NPAOP 40.1-1.01-97 [34]:

- insulating rods;
- insulating tongs;
- personal shielding bundle, screens;
- tong-test instruments;
- voltage detectors;
- insulating gloves (up to 1000 V);
- tools with insulating coating (up to 1000 V).

Additional electrical means (determined in the job order as required):

- nonconducting footwear;
- dielectric mats;
- insulating pads and patches;
- voltage alarm devices;
- protective fencing;
- portable grounding, posters and safety signs.

Connection of the electric equipment shall be carried out by the personnel having at least IIIrd qualification group by electrical safety.

Protective means to prevent falling from height, in accordance with par 4.1.12 of NPAOP 00.0-1.15-07 [33]:

- safety belts;
- hardhats;
- lifelines;
- safety climbing gears;
- traps with vertical rope;
- fencing, safety meshes etc.

Personal protective equipment for protection from falling from height are ensured by a system of belts for their attachment to the worker's body and a system to fasten to a reliable support. Before performance of the high altitude works, it is necessary to ensure strengh of supports to which the worker(-s) will be fastened by the safety belt sling, as well as that of climbing gear elements. They have to reliably withstand force that may appear at falling of the people.

Means to protect workers from increased noise level (determined in the job order depending on the measured noise level):

- ear protection;
- ear plugs;
- antinoise ear plugs.

When in premises with the working power engineering equipment and in the repair area, all workers shall wear protective masks and hearing protection means.

For handling of decontamination solutions and dust control means, the personnel shall have a set of the following PPE:

- cotton fabric clothing;
- underwear;
- cap, socks, protective footwear;
- rubber gloves in bundle with cotton fabric gloves;
- appropriate personal respiratory protective equipment (PRPE) (to be indicated by the qualified specialist depending on a nature of a dangerous factor);
- flexible PVC apron and protective sleeves;
- flexible PVC overshoes or rubber boots;
- full-facial shield and glasses;
- hardhat;
- suit for protection from the used chemicals;

Type of the needed PPE is determined by the Safety Instruction specific for use of each individual chemical substance.

For protection from the impact of increased temperature, the personnel, when handling the HI-STAR and HI-STORM casks, shall use protective means determined in par.2.7 of DSN 3.3.6.042-99 [11], in particular:

- for continuous work - felted safety suit;
- for feet protection from heat radiation - special leather footwear;
- for hands protection - woolen, canvas gloves, combinated, with leather palm pads;

- for head protection - felted caps, protective hardhats with liners, textolite or polycarbonate helmets;
- for eyes and face protection - protective masks with transparent shield, heatproof shields.

Protective clothing shall have protective properties excluding heating of its inner surfaces at any area to the temperature of 40°C IAW GOST 12.4.176-89 [36], GOST 12.4.016-87 [37].

Primary and additional packages of PPE shall be used to ensure personnel safety against radiation impact. In accordance with par.12.5.4 of the Principal Sanitary Safety Rules of Ukraine [12], primary PPE package includes:

- overall or suit;
- cap;
- underwear and socks;
- footwear;
- gloves;
- respiratory protection equipment depending on possible radiation contamination of the air.

Additional PPE package includes:

- open or closed type glasses;
- arm and head pads, full-face shields;
- protective gloves, aprons, sleeves, shields for hands and body protection, protective footwear etc.

Additional PPE are selected at preparation of the joint job order and determined by the type of works and radiation conditions of these work performance sites.

Medical aid to the personnel has to be rendered at a first-aid station located in the administrative building.

For public catering a provision is made for a buffet designed for 50 visitors, in the administrative building, and in the guard building - mess room.

In the acceptance building, on the 1st floor it is anticipated to locate sanitary facilities and amenities (locker room, showers, wash hand basins etc.) and sanitary control post for operational and attracted personnel of the controlled access zone.

Structure of the sanitary facilities and amenities is determined depending on the number of the placed production personnel, its classification by appropriate groups of the production process, and their characteristics in accordance with requirements set in DBN V.2.2-28:2010 [35].

8.9 Information on benefits, permissibility of women's and teenagers' work

At the CSFSF it is provided for provision of benefits and compensations for work in hazardous working conditions as per the valid laws, in particular:

- right for preferential pension coverage per List 1 and 2 (decree no.10 of 26 January 1991);
- free healthful and dietary meals;
- reduced working day and working week;
- increased duration vacation;
- free personal protective equipment;
- sanitary and hygienic breaks.

Exact list of benefits will be established after the facility is commission and after attesting and hygienic classification of the labor by harmful exposure and

danger of production environment factors at workplaces are performed in accordance with the Decree no.442 of the Cabinet of Ministers of Ukraine dated 01 August 1998 *On the Procedure of Workplace Evaluation with Respect to Working Conditions* and the Document *Hygienic Classification of Labor by Hazard and Danger of Production Environment Factors, and Working Process Difficulty and Intensity* [38] approved by the Order of the Ministry of Public Health of Ukraine no.248 of 08 April 2014.

Permissibility of women's labor - in accordance with the valid laws. Attaction of persons under 18 as well as handicapped persons to the work is not anticipated.

9. PERSONNEL NEEDS

In accordance with the Customer-provided data (letter from PC Atomproectenginiring, ref.no.03-46/260 of 17 February 2016), core activities at the CSFSF site will take place on a single-shift basis, five days a week, 220 days per year. The shift duration is eight hours.

Manpower of the personnel with indication of a group of production processes per DBN V.2.2-28:2010 [35] is provided in Table 9.1.

Table 9.1 **Manpower of the personnel with indication of a group of production processes**

Position	Number per staffing plan	Maximum shift	Group of production processes per DBN V.2.2-28:2010 [35] (Tab.4)	Location of sanitary facilities and amenities
ADMINISTRATION				
Director	1	1	1a	AAB
Principal Engineer	1	1	1a	AAB
Deputy Director for Physical Security (Service Chief)	1	1	1a	AAB
Deputy Principal Engineer - Chief Mechanic	1	1	1a	AAB
Chief Accountant	1	1	1a	AAB
Inspector for NRS, OS&H	1	1	1a	AAB
Inspector for Fire Safety	1	1	1a	AAB
Inspector for NM accounting and	1	1	1a	AAB
HR Inspector	1	1	1a	AAB
Total	**9**	**9**		
ADMINISTRATION GROUP				
Group Manager	1	1	1a	AAB
Engineer	2	1	1a	AAB
Documentation Clerk	2	1	1a	AAB
Counsel	2	1	1a	AAB
PR Manager	1	1	1a	AAB
Total by the Group	**8**	**5**		
FINANCE AND ECONOMY UNIT				
Head of the Unit	1	1	1a	AAB
Accountant	1	1	1a	AAB
Cost Controller	1	1	1a	AAB
Total by the Unit	***3***	***3***		
PRODUCTION AND TECHNICAL UNIT				
Head of the Unit	1	1	1a	AAB
Environment Protection	1	1	1a	AAB
Civil Engineer	1	1	1a	AAB

Position	Number per staffing plan	Maximum shift	Group of production processes per DBN V.2.2-28:2010 [35] (Tab.4)	Location of sanitary facilities and amenities
Human Resource Training Engineer	1	1	1a	AAB
Process Engineer	2	2	1a	AAB
Total by the Unit	**6**	**6**		
PHYSICAL SAFETY UNIT				
Head of the Unit	1	1	1a	AAB
Specialists, Engineers	17	6	1a	AAB, Guardhouse, Checkpoint 1
Total by the Unit	**18**	**7**		
THERMAL				
Head of the Shop	1	1	1a	AAB
TE Area				
Foreman	1	1	1a	Acceptance Building
Engineer	1	1	1a	Acceptance Building
Harness and Finished Products Warehouse Fitter	3*	1	1b	Acceptance Building, Train Crew
Crane Operator	2	2	2g	Acceptance Building
Slingsman	3*	1	2g	Acceptance Building, Train Crew
Welding Area				
Foreman	3*	1	1a	Acceptance Building, Train Crew
Engineer	1	1	1a	Acceptance Building
Fitter	3*	1	1b	Acceptance Building, Train Crew
Welder	3*	1	1b	Acceptance Building, Train Crew
Total by the Shop	**21**	**12**		
RADIATION SAFETY				
Head	1	1	1a	AAB
Dosimetrist	6	2	1c	Acceptance Building
Personal Dosimetry	2	1	1c	Acceptance Building
Total by the Shop	**9**	**4**		
AUXILIARY SYSTEMS SHOP				
Head	1	1	1a	AAB
Ventilation, Sewage and Heat Supply Area				
Foreman	1	1	1a	Acceptance Building
Engineer	1	1	1a	Acceptance Building
Maintenance Fitter	2	1	1b	Acceptance Building
Instrumentation Power Supply Area				
Foreman	1	1	1a	Acceptance Building

Position	Number per staffing plan	Maximum shift	Group of production processes per DBN V.2.2-28:2010 [35] (Tab.4)	Location of sanitary facilities and amenities
Engineer	1	1	1a	Acceptance Building
Electrical Fitter	1	1	2d	Acceptance Building
Communication Operator	1	1	1a	Acceptance Building
Programming Engineer	1	1	1a	Acceptance Building
Maintenance Electrician	6	2	1b	Acceptance Building
Instrumentation Technician	3	1	2d	Acceptance Building
DPP Operator	1	1	1a	Acceptance Building
Repair and Mechnical Works Area				
Foreman	1	1	1a	Acceptance Building
Engineer	1	1	1a	Acceptance Building
Fitter	7	7	1b	Acceptance Building
Machine Operator	1	1	1a	Acceptance Building
Technician	1	1	1b	Acceptance Building
Rail and Motor Transport Area				
Foreman	1	1	1a	Acceptance Building
Motor Vehicle Driver	4	3	1a	Acceptance Building
Cargo Carrier Operator	2	1	1a	Acceptance Building
Rairoad Engineer	2	1	1a	Acceptance Building
Rolling Stock Repair Fitter	4	2	1b	Acceptance Building
Technician	2	1	1a	Acceptance Building
Total by the Shop	**42**	**33**		
OPERATING PERSONNEL				
Shift Supervisor	6	1	1b	Acceptance Building
Engineer	6	1	1b	Acceptance Building
Lineman	20**	4	2d	Acceptance Building
Total operating personnel	**32**	**6**		
ADMINISTRATIVE AND MAINTENANCE UNIT				
Head of the Unit	1	1	1a	AAB
Production Area Cleaner	5	5	1a	AAB
Storekeeper	1	1	1a	AAB
Medical Nurse	2	1	1a	AAB
Total by the Unit	**9**	**8**		
LABORATORY				
Head	1	1	1a	Acceptance Building
Laboratory Assistant	2	1	1a	Acceptance Building
Total by the Laboratory	**3**	**2**		

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Signature, Date

Size A4

Position	Number per staffing plan	Maximum shift	Group of production processes per DBN V.2.2-28:2010 [35] (Tab.4)	Location of sanitary facilities and amenities
TOTAL CSFSF	**161**	**95**		
* the number is determined by non-exceedance of the individual yearly radiation exposure dose and clarified under precommissioning works results ** the number is determined by non-exceedance of the individual yearly radiation personnel exposure dose with consideration of the designed capacity of the storage; number of the personnel increases incrementally with filling of the storage				

Personnel numbers indicated in the table is subject to confirmation and adjustment prior to putting the facility into operation.

In addition to the CSFSF personnel, in accordance with the National Guard of Ukraine, at the facility there may be up to 58 servicemen of the National Guard of Ukraine at the regular mode of service, and up to 68 servicemen in case of enhanced service mode. The National Guard personnel shall be deployed in the guardhouse and checkpoint 1 buildings.

10. NUCLEAR AND RADIATION SAFETY

CSFSF designing, construction and operation activity shall be carried out in accordance with the laws of Ukraine and other statutory acts regulating relations in the area of the use of nuclear energy, spent nuclear fuel and radioactive waste handling.

Requirements of the following documents were accounted at development of the CSFSF design:

- International Treaties, ratified in Ukraine;
- laws of Ukraine;
- Presidential decrees and Resolutions/Decrees of the Verkhovna Rada and the Cabinet of Ministers of Ukraine;
- regulatory documents of Ukraine on nuclear and radiation safety;
- hygienic normatives applied in the Chernobyl NPP exclusion zone.

ICRP and IAEA recommendations are used in that of their extent which do not contradict with the requirements of the above documents and are aimed at reduction of radiation impact on the personnel, population and natural environment.

10.1 Safety Assurance Principles

Main regulatory technical document that establishes principles and criteria of the CSFSF safety, classification of the CSFSF systems and elements, and requirements to assurance of the safety at all stages of the CSFSF life cycle (choice of the site, construction, commissioning, operation and decommissioning) is *The Main Provisions on Assurance of the Safety of Intermediate Storages for the Spent Dry Type Nuclear Fuel*. (NP 306.2.105-2004) [39].

Pursuant to NP 306.2.105-2004 [39], the CSFSF satisfies the safety requirements if at normal operation, operational occurrences and design basis accidents individual exposure doses do not exceed dose limits established by the valid norms in respect to the personnel and the dose limit quota for the population, and emissions and discharges of radioactive substances into the environment at all stages of the CSFSF life cycle don't exceed permissible levels established by the valid norms.

According to NP 306.2.105-2004 [39], the CSFSF safety is ensured by implementation of the principle of the defense-in-depth, which is based upon the use of the system of successive physical barriers on the route of proliferation of radioactive substances and ionizing radiation into production premises and environment, as well as of the system of technical and organizational measures to protect the barriers and preserve their efficiency in case of radiation accidents.

SNF storage system shall provide for at least 2 barriers on the route of proliferation of radioactive materials and 1 barrier on the route of proliferation of ionizing radiation [39] (permissible is to combine radiactive material localization barrier with biological protection, and in this case fuel matrix of the SNF may not be considered as a barrier for localization of radioactive materials).

For ensuring the CSFSF safety, the system of technical and organizational measures forms 4 tiers of the defense-in-depth.

Tier 1 - creation of conditions, which prevent operational occurrences:

- assessment and selection of the site suitable for CSFSF placement;
- development of the design on the basis of conservative approach;
- quality assurance for the CSFSF systems and elements, and the performed works;

- CSFSF operation in accordance with the requirements of the regulatory documents, technical specifications, and operation manuals;
- maintenance of safety-critical systems and elements in good working order;
- selection of the CSFSF personnel and assurance of its necessary qualification level for normal operations, operational occurrences, accidental situations, and accidents;
- buildup of the safety culture.

Tier 2 - prevention of design-basis accoidents, development of the design-basis accidents and their transformation into beyond design basis via:

- timely localization of deviations from the design-established limits and normal operation conditions, and elimination of these deviations;
- efficient management of the system of technical and organizational measures in order to eliminate causes, which led to operational occurrences;

Tier 3 - management of beyond design basis accidents via:

- prevention of the uncontrolled development of beyond design basis accidents and mitigation of their effects;
- protection of physical barriers against destruction and maintenance of their operability in case of beyond design basis accidents;
- recovery of the CSFSF into the controlled state at which permanent cooling of the SNF and retention of radioactive substances by protective barriers are ensured

Tier 4 - planning of the personnel and population protection measures and actions via:

- establishment of the protected zone and surveillance zone around the CSFSF;
- preparation and implementation, as required, of the actions plan for personnel and population protection in case of radiation accidents.

Requirements to radiation safety and radiation protection of the personnel and population during practical activity at the CSFSF and in case of critical events are built upon principles of justifiability, non-exceedance and optimization in accordance with NRBU-97 [101] and NRBU-97/D-2000 [102].

Technical and organizational solutions on ensuring the CSFSF safety at the designing, operation, retrofitting and upgrade of the systems and equipment shall be proved by past experience or tests, appropriate research, positive practice of operation of prototypes or pilot installations, and comply with the valid norms, rules and standards on nuclear and radiation safety.

At the CSFSF there shall be provided system for accounting and control of nuclear materials in accordance with the Treaty between Ukraine and IAEA on the Guarantees in relation with the Nuclear Non-Proliferation Treaty, Regulation on the State Nuclear Materials Accounting and Control System, and Rules of Accounting and Control of Nuclear Materials at the Facility.

The CSFSF shall have efficient physical protection system in accordance with requirements of the Law of Ukraine on Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Wastes, Other Sources of Ionizing Radiation and the Rules of Physical Protection of Nuclear Materials and Nuclear Installations.

At the CSFSF there shall be ensured collection, processing and storage in the electronic database of the information on conditions of the use of nuclear fuel in the reactor and storage of the SNF in the spent fuel pools, which is transmitted from the NPP, from which the SNF is transported to the CSFSF for the long-term storage.

Pursuant to NP 306.2.105-2004 [39], the CSFSF systems and elements are broken down to the following classes, depending on their impact on the safety:

- safety-critical systems and elements - systems and elements, which failure, with consideration of a single error/fault of the personnel, may lead to the accident;
- systems and elements not affecting the safety.

10.2 General Design Safety Criteria and Requirements

Pursuant to NP 306.2.105-2004 [39]:

- the CSFSF project shall utilize the defense-in-depth principle;
- during designing of the CSFSF it is necessary to provide for sanitary and hygienic and organizational and technical measures to ensure radiation protection of the personnel and population;
- during designing of the CSFSF values of the parameters and characteristics of the CSFSF systems and elements and their states for normal operations, operational occurrences, accidental situations, and accidents are established;
- compliance of the designed CSFSF with the requirements and norms of the nuclear and radiation safety for normal operation and accidents is justified in PSAR.
- the design provides for technical and organizational measures and actions aimed at prevention of the personnel faults and mitigation of their affects during operation and maintenance of the CSFSF systems and elements;
- when designing the CSFSF systems and elements it is necessary to prefer systems and elements which functioning is based on passive action principle;
- it is necessary to provide for in the CSFSF design technical and organizational measures and actions aimed at prevention of design basis accidents and mitigation of their effects, in particular - at non-exceedance of the permissible levels of the personnel and population radiation exposure and levels of discharges and emissions into the environment;
- it is necessary to provide for in the CSFSF design technical and organizational measures and actions aimed at safe transportation of the SNF within the CSFSF site;
- it is necessary to provide for in the CSFSF design measures and actions on decommissioning of the facility.

10.3 Design Basis

10.3.1 SNF Characteristics

Characteristics of the nuclear fuel, which after its use in active zones of VVER reactors and storage in the NPP spent fuel pools, is subject to long-term storage at the CSFSF are given in Tables 10.1 - 10.4.

VVER-1000 reactors of the Ukraine's NPPs have used and provide for the use of fuel assemblies (FA) of the following modifications: FA-M и FAA (manufactured by TVEL OJSC), FA-W (LTA), FA-W and FA-WR (manufactured by Westinghouse). Main characteristics of these FAs and absorber rods of the control and protection system (CPSAR) are given in Tables 10.1 - 10.3.

Generation 1 and 2 fuel assemblies are used in the active zones of VVER-440 reactors of the Rivne NPP Units 1 and 2. Fuel assemblies

VVER-440 consist of assemblies of 2 types: FA and working cartridges (WC). Number of the control and protection system cartridges (CPSC) consisting of the FA and follower is 37 pcs. Adjusting rod (follower) is the absorbing part of the CPS cartridge. Adjusting rod (follower) is an assembly consisting of the head, casing, bottom nozzle, internal cylinder tube and hexagon-shaped inserts. Insert material is borated stainless steel. Material of all remaining parts of the follower is stainless steel. Their main characteristics are given in Table 10.4.

Table 10.1**- Main design parameters of VVER-1000 reactor FA subject to storage at the CSFSF [140, 145]**

Description	FAM	FAA	FA-W, FA-WR	FA-W (LTA)
Size of the turnkey FA, mm	234	234	234	234
Fuel elements qty, pcs	312	303/306/312	306	312 (48 pellet-integrated burnable absorbers (PIBA)*)
FAG qty, pcs	-	9/6/0	6	-
FA height, mm	4570	4570	4583	4583
FA element height, mm	3830; 3837	3837; 3842	3898,13	3898,13
Height of new fuel column in cold state, mm	3530	3530	3530 (central zone 3225.3 and 2 blankets 152.4 each	3530 (central zone 3225.3 and 2 blankets 152.4 each
FA weight, kg	670	710-714	755/760	743
Weight of UO_2in FA, kg	455,52±4.50	491,4±4.5 494,5±4.5	550,4±5	536±5
Mass content of uranium isotope mix in FA elements, %	87.9	87.9	87.9	87.9
Mass content of ^{235}U in uranium isotope mix in FA elements (fuel enrichment), %	1.6÷4.4	1.3-4.4	2.0 – 4.2 (central zone), 0.71 (blanket)	3.0 – 4.4 (central zone), 0.71 (blanket)
Mass content of gadolinium oxide in FAG, %	-	5	5	-
Mass content of ^{235}U in uranium isotope mix in FAG (fuel enrichment), %	-	2.4 – 3.6	2.0 – 3.6	3.65
Fuel density (UO_2), g/cm	10.4 – 10.7	10.4 – 10.7	10.96	10.96
Burnable absorber rod used	yes	-	-	-
Max. permissible average depth of fuel/FA element/FAG burning, MW*day/kgU	49/-/-	55/59.1/-	-/62/-	-/62/-
Average depth of unloaded fuel burning, MW*day/kgU	42 (44 after introduction of FAA)	51	Expected - 50	43.69
Pressure of FA element filler gas, at 20ºC, MPa	2	2	1.896	1.896 (0.689 – in FA elements with PIBA)

Description	FAM	FAA	FA-W, FA-WR	FA-W (LTA)
Spacing between FA elements, mm	12.75	12.75	12.75	12.75
Fuel element cladding diameter (inner/outer), mm	9.1/7.72	9.1/7.73	9.144/8.001	9.14/8.00
Filling gas	Helium	Helium	Helium	Helium
Fuel used in fuel elements	UO_2	UO_2	UO_2	UO_2
Fuel used in FAG	-	$UO_2+Gd_2O_3$	$UO_2+Gd_2O_3$	UO_2+ZrB_2
Fuel pellet diameter, mm	7.57	7.57	7.844	7.84
Diameter of the center hole in a FE/FAG fuel pellet, mm	2.35 and 1.5	1.5 and 1.4	-	-
Diameter of the guide channel (GC), outer/inner, mm	12.6/11	12.6/10.9	12.6/11.0	12.6/11.0
Diameter of the central core (CC), outer/inner, mm	11.2/10.6	13.0/11.0	12.6/11.0	12.6/11.0
Qty of the spacer grid (SG)	15	15	16	16
Material of FE/FAG cladding	Alloy E110	Alloy E110	Alloy ZIRLO™	Alloy ZIRLO™
Structural materials: - Head and bottom nozzle parts	Steel 08X18H10T 12X18H10T	Steel 08X18H10T	Steel CF3, 304, 304L	Steel 304
- Guide channels	Steel 08X18H10T 12X18H10T	Alloy E635	Alloy ZIRLO™	Alloy ZIRLO™
- Central core	Alloy Zr-1%Nb	Alloy E635	Alloy ZIRLO™	Alloy ZIRLO™
- Spacer grids (SG)	Steel 08X18H10T 12X18H10T	Alloy E110	(13 pcs. - Zr-1%Nb 3 pcs. – Alloy 718)	1 - Zr-1%Nb 14 – Alloy 718
- Framework angle elements	-	Alloy E635	-	-
- Tension clips	XH77TЮР	EK 173-ID, XH77TЮР	Alloy 718	Alloy 718
Permissible FE cladding temperature, ºC - at storage - at short-term transient modes (total of up to 8 hours)	 350 450	 350 450	At At burnup ≤45 GW*day/tU 400 570	At At burnup ≤45 GW*day/tU 400 570
Note: *Test FA-W (LTA) manufactured by Westinghouse consists of 312 fuel elements, of which 48 FEs are with PIBA, filled in as				

Description	FAM	FAA	FA-W, FA-WR	FA-W (LTA)
with standard fuel pellets and with pellets with absorber (ZrB_2). Fuel pellets with coating of such absorber are similar to pellets of enriching uranium dioxide with the exclusion that cylindrical surface of the pellets is additionally coated with a thin layer of zirconium boride (ZrB_2) with a thickness of less than 0.025 mm. Pellets with this coating are in the central part of the fuel pellet column. Total length of the active (fuel) part of the fuel element is 3550 mm. Fuel elements with PIBA contain in the central part the column of pellets with ZrB_2 coating and length of 2905 mm. Between the central column and blankets there are two columns of standard (uncoated) pellets with the length of 160.1 mm each				

Table 10.2 **- Main technical characteristics of VVER-1000 reactor burnable absorber rods [140, 145]**

Parameter or characteristic	Value
BAR qty, pcs	18
Absorbing material	Chromium diboride in aluminum matrix (CrB2+Al)
Density of the absorbing material by boron (nominal), g/cm	0.020 – 0.065
Height of the absorbing material column (nominal), mm	3550
Nominal weight, kg	21
BAR height, mm	4250
Cladding material	Zr-1%Nb
BAR outer diameter, mm	9.1

Table 10.3 - **Main technical characteristics of VVER-1000 reactor control and protection system absorber rods (CPSAR) [140, 145]**

Parameter or characteristic	Value
1 AE qty, pcs	18
2 Absorbing material	
2.1 Mark (AE upper part)	Boron carbide (B_4C)
2.1.1 Density, g/cm3, at least	1.7
2.1.2 Height of the boron carbide column in cold state, nominal, mm	3200
2.2 Mark (AE lower part)	Dysprosium titanate ($Dy_2O_3 \cdot TiO_2$)
2.2.1 Density, g/cm3, at least	4.9
2.2.2 Height of the dysprosium titanate column in cold state, nominal, mm	300
2.3 Total height of the absorbing material column in cold state, nominal, mm	3500
3 AE cladding material:	
- in CPSAR 0401.12.04.000 496.00.070	Steel 06X18H10T
- in CPSAR 0401.12.04.000-01;-03 496.00.070-01.02	Alloy 42XHM
4 Outer diameter of AE cladding, mm	8.2
5 Thickness of AE cladding, mm - of steel 06X18H10T	0.6

- of alloy 42XHM	0.5 or 0.55
6 Weight, kg:	
- CPSAR 0401.12.04.000;-03 496.00.070;-02	18.5 ± 0.5
- CPSAR 0401.12.04.000-01 496.00.070-01	18.5-1.1
7 Max. service life, eff.hours	
- CPSAR 0401.12.04.0001), 496.00.0701) in the	15150
- CPSAR 0401.12.04.000, 496.00.070 in the group	52750
- CPSAR 0401.12.04.000-1; -032), 496.00.070-01;-02)	75600
Notes: 1) Operation of CPSAR 0401.12.04.000, 496.00.070 in the NR group after their use in the AZ group and vice versa is not permitted. 2) Including, in the NR group - not more than 25,500 eff.hours. Regulation on relocation of CPSAR 0401.12.04.001-01; -03, 496.00.070-01; -02 from the NR group to AZ group and vice versa is determined by the Consumer. It is allowed to calculate operating time in the NR group by actual duration of CPSAR location below the upper terminal disconnect switch.	

Table 10.4- **Main technical characteristics of VVER-440 reactor FA subject to storage at the CSFSF [140, 145]**

Description	**FA**		**2nd Gen FA**	
	WC	**FA**	**WC**	**FA**
Size of the turnkey FA, mm	145	144	145	
FA qty in reactor, pcs.	276 (Rivne NPP-1) 312 (Rivne NPP-2)	37	276 (Rivne NPP-1) 312 (Rivne NPP-2)	37
FE qty in FA, pcs.	126	126	120	
Qty of FE with gadolinium	-		6	
FA height, mm	3217	3200	3217	3200
FE/FAG height, mm	2536 / -		2601.5 / 2540	
Height of new fuel column in cold state, mm	2420 / -	2320 / -	2480 / 2360	
FA weight, kg	215	220	219	220
Fuel type	UO2		UO2/UO2+5%Gd2O3	
Weight of UO2 in FA, kg	136.96	131.17	143.8	136.7
Mass content of uranium isotope mix in fuel, %	87.9		87.9	
Uranium (isotope mixture) weight	120.2±2.5	115.2±2.5	126.3±1.9	120.3±1.
Mass content of uranium-235 in the uranium isotope mix (enrichment), %	1.6 – 4.4		1.6 – 4.6	
Mass content of gadolinium oxide in fuel, %	-		3.35	
Mass content of uranium-235 in the uranium isotope mix in FE with gadolinium (enrichment), %	-		4	
Fuel density	10.4 – 10.7		10.4 – 10.7	
Cartridge-average designed burnout of fuel in max.burnt	53.5	42	58	57.5

Description	FA		2nd Gen FA	
	WC	FA	WC	FA
cartridge, MW*day/kgU				
Average depth of unloaded fuel burning, MW*day/kgU	39		No data	
Pressure of FE filling gas, MPa	0.5 – 0.7		0.5 – 0.7	
Spacing between FE in FA, mm	12.2 – 12.3		12.3	
Thickness of FA, WC case, mm	1.5	2.0	1.5	
Fuel element cladding diameter (inner/outer), mm	9.1 / 7.73		9.1 / 7.73	
Fuel pellet diameter, mm	7.54 - 7.57		7.57 – 7.60	
Diameter of the center hole in a fuel pellet, mm	1.4 and 1.5		1.2	
Qty of the spacer grids	10		12	
Central core	1		1	
Diameter of the central core (outer/inner), mm	10.3 / 8.8		10.3 / 8.8	
FE cladding material	Alloy E110 (Zr-1%Nb)		Alloy E110 (Zr-1%Nb)	
Structural materials: - Head and bottom nozzle parts - Central core (CC) - Spacer grids (SG) - Case	Stainless Steel 12X18H10T Alloy E110 Zirconium alloy H1 Alloy E125		Stainless Steel 12X18H10T 08X18H10T Alloy E110 Alloy E110 Alloy E125	
Permissible FE cladding temperature: - at storage - at short-term transient modes (up to 8 hrs in total), ºC	350 450		350 450	

10.3.2 Design Features of the CSFSF

The CSFSF is intended for the long-term storage of the SNF from units Nos. 1 and 2 of Khmelnitskyi NPP, units Nos. 1 to 4 of Rivne NPP, and units Nos. 1 to 3 of Yuzhoukrayinska NPP.

The CSFSF operation period shall be 100 years

The capacity of the CSFSF is 16,529 SFA, including 12,010 SFA from VVER-1000 reactors and 4,519 SFA from VVER-440 reactors

The CSFSF is based on the technology by Holtec International (hereinafter — Holtec). Main elements of the technology:

- MPC — multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT);
- car transporter for the HI-STAR.

The project provides for the reception of HI-STARs with an MPCs, concrete-casting of the HI-STORMs' shells, transfer of the MPCs from the HI-STARs to HI-STORMs, and the storage of the HI-STORMs, filled with spent nuclear fuel on the territory of the CSFSF.

10.3.3 Criteria conditioned by the environment, natural phenomena and man-induced impacts

CSFSF is to be located on the site between the villages of Stara Krasnytsia, Buryakivka, Chystogalivka and Stechanka in Kyiv Region within the exclusion zone with radioactive contamination after the Chernobyl disaster

In accordance with NP 306.2.105-2004 [39] and PiN AE-5.6 [7], safety-critical CSFSF systems and elements shall be designed with consideration of potential accident events occurring under special external natural and man-induced impacts.

Loads and impacts on the buildings and structures referring to safety non-critical systems and elements (SNCS) are adopted by the loads regulated by the general construction norms and rules, and in the part of seismic impacts - by DBN V.1.1-12:2014 [167].

Table 10.5 displays classification of buildings and structures by their impact on the safety.

Table 10.5 - Classification of the buildings and structures

Loc. on the Master Plan	Description of the building/structure	Safety specification IAW NP 306.2.105-2004 [39]	Object category by liability for radiation and nuclear safety IAW PiN AE-5.6 [7]	Seismic stability IAW PNAE G-5-006-87 [124]
1	Acceptance Building	SCS	I	I
2	Cask storage area	SCS	I	I
3	Maintenance building with an MPC warehouse	SNCS	III	III
4	Office building (subject to civil protection)	SNCS	III	III
5	Electrical equipment building	SCS	III	I
6	Garage	SNCS	III	III
7	Filling station	SNCS	III	III
8.1	Fire water supply pump	SNCS	III	III

Loc. on the Master Plan	Description of the building/structure	Safety specification IAW NP 306.2.105-2004 [39]	Object category by liability for radiation and nuclear safety IAW PiN AE-5.6 [7]	Seismic stability IAW PNAE G-5-006-87 [124]
	water supply			
8.2	Fire water tanks	SNCS	III	III
9.1	Guardhouse (subject to civil protection)	SNCS	III	III
10.1	CHECKPOINT 1	SNCS	III	III
10.2	CHECKPOINT 2	SNCS	III	III
11.1	Accumulating tanks for the polluted storm water	SNCS	III	III
11.2	Accumulating tanks for the clean storm water	SNCS	III	III
11.3	Storm water treatment facilities	SNCS	III	III
12	Household wastewater pump station	SNCS	III	III
14	Telecommunication tower with a modular building	SNCS	III	III
15	Automated radiation monitoring system post	SNCS	III	III

External natural processes, phenomena and factors which impacts on the buildings and structures of the facility are the initial events for accident situations and their consequences are referred to special ones.

10.3.3.1 Special natural impacts

List of the special natural processes and their impacts with consideration of which safety critical structures are designed is determined pursuant to the regulatory requirements of NP 306.2.105-2004 [39] and PiN AE-5.6 [7]. Parameters of the special impacts, as well as their loads on the structures in accordance with which the safety critical systems and elements are designed, are determined under the regulatory requirements of DSTU-N B.V.1-1-27 [168], DBN V.1.2-2:2006 [166] and under PiN AE-5.6 [7] in a conservative manner, as well as in accordance with the engineering survey data.

Extreme wind

Pursuant to DBN V.1.2-2:2006 [166] and PiN AE-5.6 [7], extreme designed wind load is: $W_0 \times K_П = 0.45 \times 2.5 = 1.125$ kPa.

Extreme snowfall

Pursuant to DBN V.1.2-2:2006 [166] and PiN AE-5.6 [7], extreme designed snow load is: $S_0 \times K_П = 1.59 \times 2 = 3.18$ kPa.

Extreme Air Temperature

Pursuant to DSTU-N B V.1.1-27-2010 [168]

- absolute minimum of the air temperature is minus 40°C
- absolute maximum of the air temperature is 40°C

Tornadoes and tsunamis

Pursuant to the Main Regulatory Requirements and Design Characteristics of Tornadoes for the Chernobyl NPP Site [169], Class 3 tornado will be taken as a basis for the design criteria at the CSFSF construction site.

Design characteristics of tornadoes with the indicated reliability of $1x10_6$ are specified in Table 10.6.

Table 10.6

Design characteristics of tornadoes	**Value for the tornado with reliability of $1 \cdot 10^{-6}$**
Design tornado probability class, k_p	3.0
Exceedance probability (event/year)	$1 \cdot 10^{-6}$
Maximum rotational speed of the funnel, V_p, m/s	81
Tornado progressive motion speed, U_p (m/s)	20.3
Pressure difference between the center and the periphery of the tornado funnel, ΔPp (hPa)	81
Length of the tornado path, L_p (km)	28.6
Width of the tornado path, W_p (km)	0.29

There is no such natural phenomenon as tsunami encountered at the site.

Maximum design earthquake (MDE)

Earthquake intensity for the CSFSF site is adopted in accordance with the Main Regulatory Requirements and Design Characteristics of Earthquakes for the Chernobyl NPP Site. Letter of the State Construction Committee of Ukraine no.3/19-19 of 08.07.05, Annex C [170].

Pursuant to DBN V.1.1-12:2014 [167], intensity of earthquakes in the Chernobyl NPP and CSFSF region is characterized by:

5 intensity (OSR-2004-A map, recurrence - every 500 yrs);

intensity 5 (OSR-2004-B map, recurrence - every 1000 yrs);

6 intensity (OSR-2004-C map, recurrence - every 5000 yrs).

Soil characteristic by seismic properties IAW DBN V.1.1-12:2014 [167]:

Chernobyl NPP and SFSF-2 sites - class III;

CSFSF site - class II.

Design characteristics of earthquakes for application in assessment of seismic resistance of the buildings and structures at the Chernobyl NPP site are given in [170]. Development [170] bases upon results of seismic microzoning (Order no.10 of 21 January 1998 by the State Committee of Ukraine for Construction and Architecture: On Approval of the Map of Seismic Microzoning of the Chernobyl Nuclear Power Plant Production Site) and is performed with consideration of requirements set in the regulatory documents SNiP II-7-81*, PN AE G-5-006-87, PiN AE-5.6, and IAEA recommendations (## NS-G-1.6 and SSG-9) on the need to account the value of peak acceleration of the accelerogram (PGA) of MDE earthquake not less than 0.1g. Data [170] for MDE

are characterized by PGA=0.127g, which exceeds I=intensity 7. The document accounts for increase of the intensity in δI=1 for class III soils by seismic properties.

Increase of intensity for the CSFSF site for seismic class II soils is not required.

Therefore, application of the design characteristics of earthquakes mentioned in [170] for the CSFSF complies with requirements of the valid regulations of Ukraine and IAEA recommendations, and application of such characteristics for CSFSF is conservative.

Flooding and underflooding

There are no external natural phenomena such as floods and underflooding at the CSFSF construction site.

10.3.3.2 Special external man-induced events

List of external man-induced initial events is determined pursuant to the regulatory requirements set in NP 306.2.105-2004 [39] and based upon the conservative approach under PiN AE-5.6 [7].

Special man-induced events at the construction site are conditioned both by technological processes at the facility and by human activity at the site and outside the construction site on the neighboring objects.

Parameters of the special man-induced impacts are determined by the technological requirements, and conservatively - by requirements set in the regulatory documents PiN AE-5.6 [7] and the Recommendations on Assessment and Mitigation of Consequences of External Accidents Impacts on the Nuclear Power Plants [171], and by the original data obtained from Ukraine's state Authorities (Annexes A, B, Volume 4.2.1).

Design-basis accident

There are no external man-induced initial events for calculation of consequences of design basis accidents, which may occur during technological operations, on the site.

Air blast

The need for accounting the impact of explosions on the buildings and structure may appear if there are potential sources of explosion hazard on the construction site or around it. They are divided into:

- stationary (explosion hazardous productions, warehouses etc.);
- mobile (all types of transport).

On the CSFSF site.

Pursuant to the technological process, on the CSFSF site there are no objects that may be potential sources of explosion hazard.

Outside the CSFSF site.

In accordance with [171], preliminary criterion for selection of potential sources of explosion hazard is safety radius under table 3 [171]. Safety radius for the class of our objects is R_s = 0.39 km. At such distunce, potential excessive pressure in the airblast front does not exceed 10 kPa.

According to the initial data obtained from the State Agency of Ukraine for the Exclusion Zone Control with letter no.01-2429/1.4.2 of 04 Nov 2015 (Annex A, Volume 4.2.1):

- all stationary objects, which may be potential sources of explosion hazard, are located in the town of Chernobyl and in the town of Pripyat at the distance of about 10 km. This distance is by 2 magnitude orders larger than the safety radius, which makes up R_s = 0.39 km < 10 km. Due to this, load of the air blast from the stationary

potential sources is low as compared with the loads in case of tornado, so it is not considered in the calculation justifications.

- mobile potential sources of explosion hazard, in particular roads, which may be used for transportation of explosion hazardous cargoes, are located at the distance of more than 10 km from the CSFSF site, and the roads located within the safety radius are not used for transportation of the explosion hazardous cargoes. So, the nearest road to Vektor complex, which is located at the distance of 0.27 m from the site, is used for RW transportation only.

Airplane fall

Pursuant to NP 306.2.105-2004 [39], it is necessary, for the CSFSF, to consider as the initial accident event - airplane fall on the facility.

In accordance with the data received from the State Enteprise for Servicing of the Air Traffic of Ukraine - letter no.5.18-844 of 21 September 2015 (Annex B, Volume 4.2.1):

- there are no airfields within the radius of 40 km from the CSFSF site;
- within the radius of 10 km from the CSFSF construction site there are sections of the air traffic routes of airplanes of various types (Table 10.7);
- average daily frequency of the flights is up to 12 airplanes per day;
- main characteristics of the aircrafts are given in Table 10.7.

Table 10.7

Aircraft type	Takeoff weight (max), t
Airbus A320	77
Boeing 767-300	159
Boeing 737-500	52
Boeing 737-300	56
Bombardier Dash 8 Q400	26
Bombardier Canadair Regional Jet 100	22
Bombardier Canadair Regional Jet 200	24
Bombardier Canadair Regional Jet 900	37
Bombardier Challenger 300	18
Bombardier Global Express	42
Embraer ERJ 145	21
Embraer ERJ 190	48

10.3.4 Design criteria of mechanical loads

10.3.4.1 Loads and impacts on building structures

Design criteria of mechanical loads and impacts of the building structures are determined:

- by the structural failure consequence class IAW DBN V.1.2-14-2009 [49];
- by the class of responsibility for nuclear and radiation safety IAW PiN AE-5.6 [7].

For buildings with the consequence class SS3 and class I responsibility under PiN AE-5.6 [7], limit values of the design criteria are given in Table 10.8.
For buildings with the consequence class SS3 and class II responsibility under PiN AE-5.6 [7], limit values of the design criteria are given in Table 10.9.

Table 10.8 - Limit values of the criteria for the Acceptance Building

Criterion	Limit value
Limitation of vertical motion of the foundation $S_{\max,U}$	100 mm IAW PiN AE-5,6 [7]
Limitation of the relative difference of vertical motion of the foundation $\left(\Delta S/L\right)_U$, where L = distance between two points of the motion difference ΔS	< 0.003
Restriction of vertical stress in the basis σ_z with the value of the design soil resistance R	DBN A.2.2-10-2009 [6]
Strength	DBN A.2.6-98:2009 [177]
Limitation of the crack opening width	W_{max} = 0.4 mm; W_{max} = 0.3 mm DBN V.2.6-98:2009 [177], DSTU B.V.2.6-156:2010 Tab. 5.1 [178]

Table 10.9 - Limit values of the criteria for the Cask Storage Area

Criterion	Limit value
Limitation of vertical motions of the foundation $S_{\max,U}$	150 mm IAW PiN AE-5,6 [7]
Limitation of the relative difference of vertical motions of the foundation $\left(\Delta S/L\right)_U$, L – distance between the foundations	< 0.003 (Annex I, DBN V.2.1-10-2009 [6])
Restriction of the design pressure σ_z, by the design soil resistance R	DBN V.2.1-10-2009 [6]
Foundation strength	DBN V.2.6-98:2009 [177]
Limitation of the crack opening width	W_{max} = 0.4 mm; W_{max} = 0.3 mm DBN V.2.6-98:2009 [177], DSTU B.V.2.6-156:2010 Tab. 5.1 [178]

In accordance with DBN V.1.2-14-2009 [49], the established and accident design situation shall be considered.

In the established design situation loads shall be determined in accordance with recommendations of DBN V.1.2-2:2006 [166]. The following loads are taken into account: weight of the structures, weight of the equipment; snow; wind; crane; climate temperature. In the established design situation accounted are loads with the characteristic duration of the implementation of the same order as the established service life of the facility - Tef=100 years. Limit states of group 1 and 2 are studied with consideration of the responsibility coefficient γ_n=1.25 for group I limit states and 1.05 - for group II states.

In the design accident events it is necessary to consider group 1 limit states with accounting of the loads with typically low probability and duration of the implementation but which are important from the standpoint of potential failure consequences, responsibility coefficient γ_n=1.05.

Joint action of the loads:

- main for checking the structures in the established situation;
- emergency for checking the structures in the design accident events.

For checking the group I ultimate states used are main combinations, which include permanent loads with limit values, limit design values of variable impacts.

For checking the group II ultimate states used are main combinations, which include permanent impacts with with operational values, operational design values of variable impacts.

The accident combination, in addition to permanent and variable impacts, may include only one accident (special) load.

For main combinations, which include permanent and at least 2 variable loads, variables are adopted with the combinations coefficient ψ=0.95 for long-term loads and ψ=0.90 for short-term loads.

For accident combinations, which include permanent and at least 2 variable loads, variables are adopted with the combinations coefficient ψ=0.95 for long-term loads and ψ=0.90 for short-term loads, and the accident load is adopted with the combination coefficient ψ=1.00.

At calculation of the distributed control system the existing logical links between individual loads are taken to account - mutual exclusion, associated and simultaneous loads. The load may also be characterized as the alternate load.

Permanent loads are considered in all combinations.

10.3.4.2 Cask strength criteria

During the analysis the following has been reviewed in [139] for the normal conditions of HI-STAR-190 operation:

- Loads during transportation and technological operations. For hoisting gear HI-STAR 190 cask has stress limits anticipated by NUREG-0612 [172] document, which requires that total stress in the lifting point shall be less than 1/10th of the material strength limit, provided that the lifted cargo is under additional dynamic load. These ultimate values are applicable to the lifting pins of the container and threaded joints in the covers. Intensity of the stresses of the cask bottom forging during HI-STAR 190 lifting operation was also taken into account. The loads on the bottom forging being reviewed represent own weight of this bottom forging, as well as weight of MPC canister, fuel basket and fuel. For assessment of eligibility 15% strengthening of the load and ultimate values of the stress intensity were utilized.

Loads during transportation under normal conditions. Loads during transportation under normal conditions, which serve as a basis for the strength analysis, are determined in [123, 172], and include:

- reduced external pressure 60 kPa;
- increased external pressure 150 kPa;
- free falling from height of 0.3 m onto a hard horizontal surface at most vulnerable positioning of the cask;

- standard vibration loads typical for transportation;
- standard operation conditions (pressure and temperature).

Loads referring to the accident conditions of HI-STAR 190 operation are determined in [123, 172]. Such conditions, which are considered in [139], are:

- Free fallng from height of 9 m (30 feet);
- Perforation. Performation is divided into 2 potential extreme scenarios, in particular:

  - lateral perforation: this event includes free falling (shock absorbers are neglected) from the height of 1 m onto a fixed vertically installed rod of soft steel with the diameter of 15 cm with the edge radius (upper edge) of 6 mm. It is anticipated that the rod is of such length that will lead to maximum damage to the cask. The cask is believed to be falling in a horizontal position, and the point of penetrating force is located in the middle of the cask length;

  - top perforation: this event is similar to the previous one, except for the point that penetrating force is supposedly acting on the center of the cask cover. Due to the vicinity of bolted joints this case is considered as the extreme for the butt end penetration.
- Fire at the temperature of 800ºC;
- Submersion at the height of the water head at least 15 m;
- Deep water submersion under 200-meter head.

HI-STORM 190 system is designed for on-site storage throughout the entire design service life. Respectively, the cask system is designed to withstand normal and accident conditions of storage, as well as environmental conditions.

During the analysis the following has been reviewed in [139] for the normal conditions of HI-STORM 190 operation:

- Dead weight of the structure. HI-STORM 190 shall withstand static loads conditioned by weights of all of its components.
- Loads caused by transportation and technological operations. HI-STORM 190 shall withstand loads appearing during the normal transportation and technological operations. Pursuant to standard [176], in order to include any dynamic effects for account of the lifting operations, loads shall be increased by 15%.
- Pressure. HI-STORM 190 cask is uncapable of preserving the internal pressure due to its open design and, respectively, pressure of the environment and hydrostatic pressure are the only pressures it may sustain. External design pressure at normal conditions is established for the standard ambient pressure minus 1 atmosphere.
- Temperature. Design temperatures of HI-STORM 190 components are given in Table 10.10.
- Snow loads. Design snow loads are given in Table 10.11.

During the analysis the following has been reviewed in [139] for the abnormal conditions of HI-STORM 190 operation:

- Tripping. Free standing HI-STORM 190 maintains kinematic stability at the design environmental phenomena (tornado, earthquake etc.).
- Fire.
- Tornado. HI-STORM 190 shall withstand pressure, wind loads and impact of the flying objects, which appeared as a result of tornado. Characteristics of the tornado and flying objects are given in tables 10.12 and 10.13.

- Flooding. HI-STORM 190 system shall withstand flooding-associated pressure and hydrostatic forces. In case of the flooding, loads on HI-STORM 190 system include buoyancy effects, static pressure loads, and dynamic pressure due to the water speed. It is anticipated that in case of flooding HI-STORM 190 system will submerge deeply under water. Maximum depth of water submersion and water flow rate are given in table 10.11.
- Earthquake.

During justification of preservation of integrity of the auxiliary equipment under normal operating conditions, the following types of loads were determined - dead weight, loads during transportation and technological operations, temperature:

- Dead weight. Auxiliary element shall withstand static load appearing in the assembled system.
- Loads during transportation and technological operations. Hoisting gear shall withstand loads, which appear during performance of transportation and technological operations in the normal mode. In this case loads are skewed upward by 15% in order to account for possible dynamic effects, which appear during cargo lifting operations.
- Temperature. Values of mechanical parameters, which are taken into consideration during analyzing the strength of auxiliary equipment, shall correspond to the maximum average temperature by thickness of the metal under normal operating conditions.

Table 10.10 - **Design temperatures of HI-STORM 190 components**

HI-STORM 190 components	Design ultimate values of long-term temperatures under normal conditions (lasting events), °C	Ultimate temperature values under accident conditions (short-term events), °C
Outer protective container concrete	149	343
Outer protective container cover	232	371
Remaining part of the steel structure of the outer protective container	177	371

Table 10.11 - **Design temperatures of HI-STORM 190 components**

Object	Conditions	Value
Snow load, kPa	Normal	4.8
Maximum water submersion depth at flooding, m	Accident	38.1
Water flow rate, m/s	Accident	4.572
External pressure on outer protective container, kPa	Accident	68.95 (pressure drop max for 1 s) 34.47 (pressure drop in a steady state)

Table 10.12 - **Characteristics of the tornado**

Conditio	Value
Horizontal wind speed, m/s	101
Tornado progression speed, m/s	20.3
Route length, km	28.6
Route width, km	0.29
Pressure difference, hPa	10411

Table 10.13 - **Flying objects tha appeared as a result of tornado**

Description of the flying object	Weight,	Speed, m/s
Vehicle	1800	203
Hard solid steel cylinder with 200mm diameter	125	203
Hard sphere with 25mm diameter	0.22	203

10.3.4.3 Protective barriers tightness criteria

Confinement, which prevents release of the radioactive content of the MPC, is its completely welded design. Localizing MPC casing has no bolted joints or mechanical sealings.

Localizing MPC casing consists of the following components:

- MPC shell (internal and external)
- MPC bottom (internal and external)
- MPC cover (internal and external)
- MPC drain and ventilation opening covers (internal)
- Appropriate welds

MPC is built tight [140] in accordance with the ANSI N14.5 [163] definition: “tightness is defined as the degree of package containment assured by a shell that practically rules out any substantial leakage of the radioactive material. The attainment of this degree of containment must be demonstrated by the leakage velocity that equals, or is less than, 1×10^{-7} cm^3/s, in terms of air, with a pressure of 1 atm within the shell and a pressure of 0.01 atm or lower outside the shell”. Thus, the design of the MPC makes sure that leakage velocity never exceeds 1×10^{-7} cm^3/s with the pressure differential of 100 atm between the inner space of the MPC and the environment. MPC compliance with the structural requirements was shown in the course of analytical studies described in the document [139].

MPC is the localizing vessel of the HI-STORM 190 system. MPC design provides for ensuring the confinement for all radionuclides under normal operating conditions, at operational occurrences, and under conditions of the accident. Three main components of the MPC casing are shell, internal bottom and cover. Welding of the shell and its welding to the bottom is carried out a the manufacturing plant. The remaining welded joints of the localizing casing are executed at the NPP power units.

MPC cover consists of two sections welded together (referred to as the upper and lower sections). Only the upper part of the cover is considered as the localizing casing. The cover is intentionally made thick-walled by adding the lower part of the cover in order to minimize radioactive irradiation of the workers during MPC closing operations.

10.3.5 Heat criteria

HI-STAR 190 and HI-STORM 190 are significantly different in respect to the geometry, structural materials, design loads and design criteria, as well as requirements of the regulatory documents applicable to them.

General requirement to HI-STAR 190 and HI-STORM 190 casks is the requirement not to exceed maximum permissible temperatures of FE casings at normal operating conditions, opperational occurrences and design basis accidents. The following design criteria are established:

- Maximum permissible FE cladding temperature for the normal operating conditions is:
  - for FAM and FAA - 350°C;
  - for FA-W, FA-W, FA-WR, FA-W(LTA) - 400°C;
- For short-term transient and accident modes (up to 8 hrs), maximum permissible FE cladding temperature is:
  - for FAM and FAA - 450°C;
  - for FA-W, FA-W, FA-WR, FA-W(LTA) - 570°C;

In this case, maximum design basis residual heat emission of the cask is:

- 38 kW for MPC-31;
- 33 kW for MPC-85;

Pursuant to the design, transport package HI-STAR 190 (consists of HI-STAR 190 cask, MPC-31 or MPC-85 multipurpose cask and shock absorbing devices) in type B (U) package under PBTRM-2006 [123]. The following design requirements are set for HI-STAR 190 in accordance with [123]:

- HI-STAR 190 shall be designed for the range of ambient temperatures from -40°C t0 +38°C (normal operating conditions), with consideration of exposure to sunlight;
- HI-STAR shall be designed for a fire with duration of 30 min at the flame temperature equal to 800°C (accident conditions);
- HI-STAR shall be designed in such a way that the temperature on accessible surfaces of the package at the ambient temperature of 38°C and with no exposure to sunlight is not exceeding 85°C;

Design thresholds of the temperatures and pressures for HI-STAR 190 in accordance with [137] are given in tables 10.14 – 10.16.

Table 10.14 - **Design thresholds of HI-STAR 190 elements temperatures**

Description of the element	**Material**	**Design temperature limit for normal operating conditions,** °C	**Design temperature limit for abnormal operating conditions, °C**
Fuel basket	Metamic-HT	400	50
Support structures and solid plates	Aluminum alloy	400	50 0
MPC shell	Stainless steel.	316	42
MPC cover	Stainless steel	316	42

Description of the element	Material	Design temperature limit for normal operating conditions, °C	Design temperature limit for abnormal operating conditions, °C
MPC bottom	Stainless steel	316	427
Internal MPC shell	Cryogenic steel	232	371
Flange, bottom forging	Cryogenic steel	232	371 (accidents affecting the strength properties) 788 (fire)
Cask cover	Cryogenic steel	232	371 (accidents affecting the strength properties) 788 (fire)
Steel of the remaining elements of the cask	Carbon steel	232	371 (accidents affecting the strength properties) 788 (fire)

Table 10.15 - Design thresholds of HI-STAR 190 elements temperatures

Element	Material	Temperature limit for normal operating conditions, °C	Temperature limit for abnormal operating conditions, °C
Cover sealings	Stainless steel / Elastic sealing	120	≤ 20 h: 170 ≤ 3 h: 210
Neutron protection	Holtite-B	204	Preservation of the integrity of the neutron protection material in the inflammation scenario is not considered. During the fire it is conservatively anticipated that there is no reduction of Holtite-B material heat conductivity coefficient, and after the fire it is conservatively anticipated to replace Holtite-B with air
Gamma	Lead	316 (600)	316
Shock absorbers	Crumple aluminum	127 (260)	Strength properties of the crumple material are not calculated at or after the accident associated with fire.

Table 10.16 - **Design thresholds of the pressure for HI-STAR 190**

Conditis	Threshold pressure values, kPa
Normal transportation conditions	690 for MPC 345 for
Hypothetic accidents	1379 for MPC 690 for

In accordance with the design for HI-STORM 190 storage system (consists of HI-STORM 190 cask and MPC-31 or MPC-85 multipurpose cask) the following design requirements are set:

- not to exceed maximum permissible temperatures of FE casings at normal operating conditions, opperational occurrences and design basis accidents;
- pressure in MPC shall not exceed 690 kPa for normal operating conditions (long-term storage) and 1379 kPa for short-term transient and accident conditions [137];

Design thresholds of the temperatures of HI-STORM 190, in accordance with [137], are given in Table 10.17.

Table 10.17 - **Design thresholds of HI-STORM 190 temperatures**

HI-STORM 190 element	**Temperature thresholds for long-term storage conditions, °C**	**Temperature thresholds for abnormal operating conditions, °C**
Storage container concrete	149, Concrete section average temperature value	343, Local concrete (bioprotection) temperature, except for fire
Upper and lower plates of the storage container cover	232	371
Remaining parts of the steel structure	177	371
MPC shell	316	427
MPC basket	400	500
MPC basket support structures	400	500
MPC cover	316	427
MPC lock ring	260	427
MPC bottom	316	427

10.3.6 Nuclear safety assurance criteria

Main requirements valid in Ukraine as to assurance of the nuclear safety at all stages of the CSFSF life cycle are set in the regulatory and technical documents [39, 69, 146, 147, 123, 134]:

- NP 306.2.105-2004. Principal Dry-type Spent Nuclear Fuel Interim Storage Facilities Safety Guidelines;
- PNAE H-14-029-91. Safety Rules for Nuclear Fuel Storage and Transfer at Nuclear Energy Sites;

- PBYa-06-08-77. Nuclear Safety Rules at Transportation of the Spent Nuclear Fuel;
- PBYa-06-00-88. Main Nuclear Safety Rules at Processing, Storage and Transportation of Nuclear Hazardous Fissionable Materials;
- NP 306.6.124-2006. Nuclear and Radiation Safety Rules at Transportation of Radioactive Materials (PBPRM-2006);
- RD 306.8.02/2.067-2003. Recommendations on Structure and Contents of Spent Nuclear Fuel Storage Facility Safety Analysis Reports.

Main requirements of the Ukrainian RD [39, 69, 146] on nuclear safety applicable to the CSFSF systems:

- at SNF storage subcriticality of the systems and elements which contain fissionable materials shall be mainly ensured by the geometry of SNF location;
- for the systems and elements which contain fissionable materials, effective coeffic of neutron breeding K_{eff} at normal operating conditions, operational occurrences and at design basis accidents shall not exceed 0.95 ($K_{eff} \leq 0,95$);
- if $K_{eff} \leq 0.95$ conditions cannot be fulfilled only due to the SNF location geometry, additional means and measures are provided for in the design to ensure subcriticality, in particular fixed neutron absorbers or fuel burnout accounting;
- when analyzing the nuclear safety it is necessary to neglect the presence of the absorbing elements in SFA or SFA case structures, if such are not fixed, their absorbing properties cannot be determined or if their efficiency deteriorates due to the initial events;
- analysis of the nuclear safety shall be carried out with the account for the factors at which the SNF storage and handling system has maximum K_{eff} at normal operating conditions, operational occurrences and design basis accidents;
- it is necessary to consider errors in the methods of calculation of K_{eff} , concentration and isotope composition of neutron absorbers, as well as tolerances for the manufacture;
- if there is nuclear fuel with different enrichment degrees, it is necessary to consider the fuel with maximum degree of enrichment;
- spent nuclear fuel shall be considered as new if K_{eff} at burning reduces, except for the cases when the burnout depth is used as a nuclear safety parameter and is controlled by means of special devices;
- when analyzing the subcriticality assurance, it is necessary to consider presence of the neutron reflector;
- subcriticality assurance analysis shall be performed for the maximum design capacity of the system;
- equipment for the spent nuclear fuel storage shall be designed in such a manner that effective coefficient of neutron breeding does not exceed 0.95 even if the storage is filled with water, and at such volume, distribution and density of the water as a result of the initial events, which lead to the maximum K_{eff} ;
- in case of the temperature change at normal operating conditions and at initial events of the accidents it is necessary to consider such SNF state, which leads to the maximum K_{eff} .

10.3.7 Radiation safety and protection criteria

Main requirements valid in Ukraine as to assurance of the nuclear safety at all stages of the VVER CSFSF life cycle are set in the regulatory and technical documents [39, 123, 110]:

- NP 306.2.105-2004. Principal Dry-type Spent Nuclear Fuel Interim Storage Facilities Safety Guidelines;
- DHN 6.6.1-6.5.001-98. Ukrainian Radiation Safety Standards. NRBU-97;
- DHN 6.6.1-6.5.001-98. Radiation Protection Against Potential Irradiation Sources. NRBU-97/D-2000;
- DSP 6.177-2005-09-02. State Sanitary Rules “Main Ukrainian Radiation Protection Sanitary Rules”. OSPU;
- NP 306.6.124-2006. Nuclear and Radiation Safety Rules at Transportation of Radioactive Materials (PBPRM-2006);
- RD 306.8.02/2.067-2003. Recommendations on Structure and Contents of Spent Nuclear Fuel Storage Facility Safety Analysis Reports;
- Core Reference Levels, Release Levels, and Action Levels with Regard to Radioactive Contamination of the Exclusion Zone and the Compulsory Evacuation Zone. DAZV of Ukraine no.800/53-13.

Radiation safety (RS) and radiation protection with respect to practical activity, in conditions of the current and potential exposure to radiation, in accordance with requirements set in NRBU-97, NRBU-97/D-2000 and OSPU-2005 [101, 102, 110] are ensured with use of the following principles:

- justifiability principle, in accordance with which any practical activity that is accompanied by the people exposure shall not be carried out if it is not a major asset for the exposed individuals or the society in general if compared with the harm it causes;
- optimization principle, in accordance with which individual dose levels and/or number of radiation-exposed individuals with respect to each source of the radiation mush be as low as practically possible with consideration of economic and social factors.
- non-exceedance principle, in accordance with which levels of radiation exposure from all significant types of practical activity shall not exceed the established limits of the doses.

In accordance with NRBU-97 [101], the following categories of radiation-exposed individuals are established:

- category A (personnel) - persons who permanently or temporary work in direct vicinity of the ionizing radiation sources;
- category B (personnel) - persons who directly are not dealing with the ionizing radiation sources but in relation with their workplaces location in the premises and on production sites of the facilities with radiation and nuclear technologies may be exposed to additional radiation;
- category C - all population.

Values of effective and equivalent dose limits for category A and B personnel and values of permissible levels of yearly entry of significant radionuclides via respiratory organs, as well as permissible concentration of radionuclides in the working zone air for category A personnel, are regulated by NRBU-97.

Numerical values of dose limits are established at levels, which exclude the possibility of appearance of determinated radiation exposure factors and, at the same time, guarantee so low probability of appearance of stochastic effects

of the exposure that it is acceptable both for individuals and for the society in general.

For category A and B persons, dose limits are established in terms of individual yearly effective dose, external and internal radiation exposure, and equivalent doses of external exposure (limit of the yearly effective dose and limits of the equivalent dose of external exposure). Limitation of radiation exposure for category C persons (population) is ensured by introduction of limits of yearly effective and equivalent doses in the critical group of category C persons. The latter means that values of the yearly radiation exposure of persons which are on the critical group shall not exceed the dose limit established for category C.

Dose limits are given in table 10.18.

Table 10.18– **Dose limits [101]**

Organs or tissues	**Categories of exposed persons**		
	A[1), 2)]	B[1)]	C[1)]
D_{LE} (effective dose limit), mSv/year	20[3)]	2	1
Limits of the equivalent dose of external exposure:			
DL_{lens} (for crystalline lens), mSv/year	150	15	15
DL_{skin} (for skin), mSv/year	500	50	50
DL_{extrim} (for hands and feet), mSv/year	500	50	-

Note:
Distribution of the radiation exposure dose during the calendar year is not regulated;
For women of child-bearing age (until 45 years old) and for pregnant women there are restrictions in force in accordance with par.5.6 of NRBU;
On average for any 5 successive years but not over 50 mSv for an individual year (DL_{max})

Design total dose of the external and internal current exposure of the personnel shall not exceed the dose limit established for the personnel, and for the population - quota of the dose limit established for this company/facility [110].

Quota of the dose limit for the CSFSF, in accordance with [101], is 40 mcSv/year for account of emissions, 10 mcSv/year for account of the critical type of water use, and 80 mcSv/year - total quota for account of the air and water ways of the dose buildup.

Also, for category A personnel NRBU [101] establishes permissible levels of skin exposure to beta particles (permissible density of the flow and specific maximum equivalent dose), as well as permissible levels of radioactive contamination of the work surfaces, skin (during the work shift), special clothing and PPE by alpha- and beta-emitting nuclides.

Values of the reference risks of potential exposure not exceeding the admissibility level are established in [102] and are 2×10^{-4} $year^{-1}$ for personnel and 5×10^{-5} $year^{-1}$ for population. Value of 'neglectibly low' risk is 5×10^{-7} $year^{-1}$.

According to [101], personnel protection from the radiation exposure shall be designed with 2-time reserve for the design by yearly effective and equivalent doses of the current and potential exposure

Pursuant to requirements set in [110], the CSFSF design shall establish design reference levels of the personnel exposure. With that said, RL values shall not exceed 70% [110] of the values of permissible levels established in NRBU [101].

The CSFSF will be built within the Chernobyl NPP exclusion zone contaminated with radionuclides after the accident of 26 April 1986. In this area valid are reference levels [112], which shall be considered when planning the measures related with the CSFSF construction and operation.

According to the document [112], category A personnel is all persons permanently working within the exclusion zone, regardless of the nature of the performed works. Based on this, all personnel performing works on the CSFSF site refers to category A under NRBU-97 [101].

Category C is the population living outside the Chernobyl NPP exclusion zone and compulsory evacuation zone.

Considering the above and with consideration of requirements set in [110, 112], the design establishes the following design reference levels of the personnel exposure (effective dose):

- 11.0 mSv/year for account of external exposure;
- 3.0 mSv/year for account of internal exposure.

Additionally, for works performed at the construction stage, established is the design reference level of the single-time (shift) effective dose - 0.08 mSv/shift. According to the Customer's data, during the CSFSF construction works shift duration is 10 hours.

In addition of the above criteria, the document [123] establishes design criteria of biological protection assurance during SNF transportation for HI-STAR 190 transport and storage container, which is classified under PBPRM-2006 [123] norms as a type B(U) package. According to these requirements, dose rate for HI-STAR 190 shall not exceed:

- 2 mSv/hour at any point of the package surface at normal operating conditions;
- 0.1 mSv/hour at any point at the distance of 2 m from the package surface at normal operating conditions;
- at accident conditions radiation rate at the distance of 1 m from the package surface shall not exceed 10 mSv if there is maximum radioactive content.

10.3.8 Fire and explosion protection

According to GOST 12.1.004-91 [179], fire safety of the facility is ensured by fire prevention and fire protection systems, to include organizational and technical actions and measures. Fire safety systems shall exclude fire breakout and ensure fire safety of the people.

Fire prevention is ensured by prevention of formation of combustible medium and/or prevention of formation of (or introduction) ignition sources in the combustible medium.

Prevention of the combustible medium formation is achieved through:

- maximum possible use of non-combustible and fire resistant substances and materials;
- maximum possible limitation of the weight and/or volume of combustible substances and materials and maximum safe method of their positioning;
- isolation of the combustible medium, maintenance of the safe concentration, temperature and pressure of the combustible medium, at which flame propagation is excluded;

- maximum automation of the technological processes associated with combustible substances handling;
- installation of fire-safe equipment in isolated premises and at open areas;
- use of protective devices to safeguard the production equipment with combustible substances from damages and accidents, installation of tripping/disconnecting devices.

Prevention of formation of ignition sources in the combustible medium is achieved by application of one of the following methods or their combination:

- use of machinery, mechanisms, equipment and devices which operation does not causes formation of the ignition sources;
- use of electric equipment in accordance with its fire hazard and explosion hazard rating
- use fast-action protective tripping devices for potential ignition sources in the design;
- use of the technological process and equipment satisfying the requirements on electrostatic intrinsic spark safety;
- arrangement of lightning protection for buildings, structures, and equipment;
- maintenance of the temperature of heating of the surfaces of machinery, mechanisms, equipment, devices, substances, and materials which may come in contact with the combustible medium at a leve lower than maximum permissible which is 80% of the lowest temperature of the fuel self-ignition;
- elimination of conditions for thermal and chemical self-combustion of the circulating substances and materials;
- use of non-sparking tools when working with easily combustible liquids and combustible gases;
- reduction of the determining size of the combustible medium below the maximum permissible value in terms of combustibility;
- observance of the valid building norms, rules, and standards.

Limitation of the weight/volume of combustible substances and materials, as well as the safest method of their placement is achieved by application of one of the following methods or their combination:

- reduction of the weight/volume of combustible substances and materials which are simultaneously kept in premises and at open sites;
- arrangement of the emergency drainage system for fire hazardous fluids from the machinery;
- periodic cleaning of the site, premises, utilities, equipment from combustible wastes, deposits, dust etc.;
- removal of fire hazardous wastes generated during operation of the facility;
- maximum possible replacement of easily combustible and combustible liquids with non-combustible ones.

Fire protection is achieved by application of one of the following methods or their combination:

- use of fire suppression means and appropriate types of fire protection machinery;
- use of fire alarm and automatic fire suppression (AFSS) system;
- use of main building structures and materials, to include those used for cladding of the structures, wit the rated values of fire hazard;
- application of fire protection paints (compounds) on the surfaces of building structures;
- appliances which ensure limitation of the fire development;
- organization, with use of technical means including automatic ones, of the timely warning and evacuation of people;

- use of collective and personal protective means to safeguard people from dangerous fire factors;
- use of smoke protection means.

Limitation of the fire development is achieved by application of one of the following methods or their combination:

- arrangement of fire protection barriers;
- establishment of standard-permitted areas for fire safety compartments (sections), number of floors in the buildings and structures;
- arrangement of emergency tripping and switching of installations and utilities;
- use of the means preventing or restricting spoilage and spreading of combustible fluids at fire;
- use of fire-stop assemblies on the equipment. Organizational and technical measures include:
- organization of fire guard;
- organization of the workers' training on the fire safety rules,
- development and implementation of fire safety rules and norms, manuals on handling of fire hazardous substances and materials, on observance of fire safety regime and actions of people in case of a fire;
- manufacture and use of visual aids on assurance of the fire safety;
- norming of the number of people at the site in accordance with their safety conditions in case of fire;
- development of measures on the management and personnel actions in case of a fire and organization of evacuation of people;
- equippage of the facility with fire fighting machiner that ensures efficient fire (inflammation) fighting.

According to par.2.15 of DBN V.1.1-7-2002 [17], buildings and premises of the production and storage purpose are classified in accordance with their explosion and fire hazard rating.

Determination of the categories of buildings, premises, structures and outdoor installations is performed on the basis of methods and requirements laid down in NAPB B.03.002-2007 [14].

10.3.9 Control criteria

The design provides for the CSFSF control and management system (CMS) that ensures comprehensive control and management of the technological processes on receipt and storage of casks with the spent nuclear fuel, as well as control and management of auxiliary systems.

CMS integrates separate primary systems into a single system thus allowing to perform comprehensive processing, display and storage of information in a single place - at the central control and monitor panel (CCMP).

CMS ensures maintenance of radiation and general technical safety at receipt of SFA and their storage. CMS executes the function of the information support for the personnel in a form convenient for perception and analysis in order to determine negative trends in a change of the state of hazard sources at the CSFSF and arrange measures to prevent development of these trends.

The following design criteria were used as the basis for the control and management system:

- reliability (to be achieved through the use of high-reliability components and optimal system structure, and hardware-based fault detection capabilities);

- openness of the system (to be achieved by means of additional components and subsystems as well as by means of integration with other information systems).

The design shall set up control over the safety barriers in case of long term SNF storage at the CSFSF. One of the control types shall provide for control over heat removal process. Heat removal process control during the SNF storage in HI-STORM is ensured by the system for remote control of the cask storage process, which structurally is a part of the CMS.

10.3.10 Criteria of the SNF extraction from the CSFSF

Criteria of the SNF extraction from the CSFSF:

- Normal operation - after expiry of the design period of the SNF storage at the CSFSF, i.e. in 100 years;
- Abnormal conditions - failure of the safety barriers during the storage. According to the results of the storage process control in case safe operation limits are exceeded.

The SFA management technology in the CSFSF is not anticipated. At normal operation, accident events and accidents anticipated is handling of the MPC that contains SFA.

10.3.11 Criteria or Guarantees and Physical Protection Assurance

The nuclear materials (NM) are subject to national and international control (IAEA) and inspections.

The CSFSF shall have a system to control and account nuclear materials in accordance with NP 306.7.122-2006 [180].

Nuclear Material Recordkeeping and Control Rules:

- nuclear materials shall be subject to the state recordkeeping and control starting from their minimum quantity established by the Rules [180];
- nuclear materials shall be classified according to their categories in order to ensure differential approach to determination of the recordkeeping and control procedures and methods;
- licensee shall coordinate with the SNRIU material balance areas (MBA) within the nuclear plant or nuclear material storage site;
- in each MBA determined should be reference measurement points (RMP) for nuclear materials;
- nuclear materials are covered by construction and design documents which confirms reliability of previous measurements of quantitative properties and attributes of the nuclear materials;
- recordkeeping of the nuclear materials shall base upon the results of measurements of nuclear materials quantitative properties.

Nuclear materials recordkeeping and control criteria at the CSFSF are assurance of the ongoing control of the available quantity of nuclear materials, facilitation in localization of potential losses, prevention of unauthorized use or theft of these materials.

Main principle for the recordkeeping and control is timely recording of every relocation of a nuclear material and every change in the NM inventoried quantity.

Unit of measurement for the recordkeeping purposes is a batch of fissionable nuclear material.

In the CSFSF recordkeeping system, unit of measurement of NM is a batch of nuclear material contained in one MPC.

In accordance with the Law of Ukraine on Physical Protection of Nuclear Materials, Nuclear Installations, Radioactive Wastes, and Other Sources of Ionizing Radiation (hereinafter - Law on Physical Protection) [181] and the Law of Ukraine no.638-15 on Anti-Terrorism [182], CSFSF physical security system (PSS) is created at the CSFSF.

The following principles were accounted during the PSS design process:

- physical security actions shall not impede observance of the process regulations of the CSFSF;
- physical security actions shall not deteriorate nuclear, radiation, fire and other types of the CSFSF security.

PSS is designed for detection of attempts and prevention of unuauthorized entry to the CSFSF site, which may lead to willful actions aimed at incapacitation of the PSS engineering and technical means and, especially, critical CSFSF technical elements, as well as prevention of unuauthorized relocation outside the facility of any radioactive substances and nuclear materials, to include prevention of sabotage acts, in accordance with the IAEA requirements INFCIRC/225/Rev.5 [183] and INFCIRC/274/Rev.4 [184], to include Convention of Physical Security of Nuclear Materials and Nuclear Plants, as amended in accordance with the Law of Ukraine no.356-VI of 03.09.2008 [185].

10.4 Nuclear Safety

10.4.1 Technical solutions on assurance of the nuclear safety

Nuclear and radiation safety during transportation and technological operations on the SNF is ensured by the structural solutions of the equipment and presence on the site of the system for monitoring of the state of HI-STORM with MPC.

Detailed description of the SNF handing operations is given in Part 1, Volume 3 of this design.

To confirm fulfillment of the requirements of Ukraine's regulatory documents (RD) with respect to nuclear safety assurance, Holtec International has performed necessary calculations [134-142].

Detailed justification of nuclear safety at normal operating conditions, opperational occurrences and accidents is given in the PSAR.

According to requirements of the regulatory documents [36, 69, 146], nuclear safety of the CSFSF is ensured by:

- limitation of the spacing between FAs in the MPC;
- limitation of the weight of fissionable materials in one MPC;
- use of heterogenic absorbers of thermal neutrons (installation and attachment of Metamic-HT neutron absorber in the MPC);
- control of technological parameters of the complex of nuclear fuel storage and handling systems.

Technical solutions associated with the design and materials of the MPC, HI-STAR and HI-STORM

SNF handling technology presented by Holtec anticipates that SNF is directly kept in multipurpose casks (MPC). MPC is double-walled tight welded cases made of stainless steel and filled with helium.

MPC is built tight [140] in accordance with the ANSI N14.5 [163] definition: “tightness is defined as the degree of package containment assured by a shell that practically rules out any substantial leakage of the radioactive material. The attainment of this degree of containment must be demonstrated by the leakage velocity that equals, or is less than, 1×10^{-7} cm^3/s, in terms of air, with a pressure of 1 atm within the shell and a pressure of 0.01 atm or lower outside the shell”. Thus, the design of the MPC makes sure that leakage velocity never exceeds 1×10^{-7} cm^3/s with the pressure differential of 100 atm between the inner space of the MPC and the environment. MPC compliance with the structural requirements was shown in the course of analytical studies described in the document [139].

Inside the MPC there is a basket for installation of FA, made of aluminum and structural material which is a neutron absorber (Metamic material).

Metamic is a compound metal matrix made of 99.5% pure aluminum reinforced with boron carbide. Minimum content of B_4C in the material is 9%. Burnout of neutron absorber ^{10}B during 100-year storage is neglectibly low and Metamic preserves its properties during the design CSFSF operation period, what is justified in the documents [137, 140].

MPC basket materials are aluminum and Metamic and ensure the required heat removal from the SNF. Presence of the inert atmosphere in the MPC (helium filling) ensures protection against corrosion of FE cases, what preserves their integrity during long-term storage. Inert atmosphere inside the MPC is maintained due to the reliability of tight and sealed MPC barriers. Tightness of the MPC within the design service life, at all design modes, is justified in the document [140].

HI-STAR and HI-STORM casks execute the function of MPC protection against external impacts [139, 143] and also radiation protection function [141, 143]. HI-STAR cask is made primarily of steel and Holtite material which contains 2% B_4C and serves, among other, as a neutron absorber. HI-STORM cask is made primarily of steel and concrete. Design and materials of HI-STAR and HI-STORM casks ensure MPC protection against external impacts [139, 143] and sufficient conditions of the SNF cooling in the MPC [138] at normal operating conditions, operational occurrences and at design basis accidents.

Technical solutions in the CSFSF acceptance building

In the acceptance building, technical solutions associated with assurance of the nuclear safety are aimed at reduction of the probability of mechanical damage to the MPC and exclusion of water access to SFA in case of accident MPC containment failure. It is related with the point that nuclear safety is primarily ensured by the MPC design.

To reduce the probability of mechanical damage to the MPC, it is anticipated to use in the acceptance building equipment of the seismic resistant design with enhanced reliability rating. Moreover, the design solutions ensures that handling with the MPC will occur only within the cask transfer facility (CTF) with use of the cask transfer equipment (CTE) what excludes MPC falling with destruction of barriers. The design also provides for ensuring the integrity and stability of the acceptance building as the object/facility

referring to class I of responsibility for nuclear and radiation safety IAW PiN AE-5.6 [7].

For excluding the possibility of SFA contact with water in case of a hypothetic event with malfunction of the tightness barriers, there are no water supply in the acceptance building and the CTF.

No water is used in these premises when the fire safety systems are designed.

Throughout the entire process chain in the acceptance building ensures are at least 2 engineering barriers which prevent from water penetration to the SFA - tight casing of the MPC, cask casing or HI-STAR or HI-STORM.

Ensured is remote surveillance of all process operations and control of neutron radiation in that part of the acceptance building where MPC acceptance and transfer operations are performed.

HI-STAR used in the CSFSF is designed for falling from 9-m height without damaging its content. Maximum height of HI-STAR cask lifting in the acceptance building is 7 m.

Detailed description of the SNF handing operations and equipment in the acceptance building is given in Volume 3.1 of this design.

10.4.1.3 Technical solutions during on-site transportations

On-site transportation of HI-STORM which contains MPC with SFA inside is carried out by the on-site wheeled vehicles (OWV). Main element that ensures nuclear safety at transportation of SNF by the transporter is HI-STORM. Main technical solutions on assurance of the nuclear safety at on-site transportation are aimed at ensuring the protection of HI-STORM from mechanical damages during transportation.

The following technical solutions are implemented to ensure nuclear safety during on-site transportation of the spent nuclear fuel:

- transporter carries only one HI-STORM container with MPC during one trip, i.e. quantity of the transported nuclear material is limited by the design of the used equipment;
- transporter design and transporter route has no provisions for the use of water, what excludes hypothetic possibility of water contact with SFA;
- transporter design ensures lifting of the cask at the height of not more than 28 cm, what excludes damaging of HI-STORM in case of falling down during the transportation (HI-STORM is designed for falling from the height of 30 cm without any damage to the container and the contents);
- master plan of the site is developed in such a manner as to reduce the route of the transporter travel with HI-STORM from the acceptance building to the storage area and exclude crossing of the routes of the loaded transporter and other cargo transporters within the CSFSF site, what reduces the probability of accidents during transportation;
- transporter design excludes high-speed motion what excludes possiible personnel's faults in relation to the transporter traffic regulations and, respectively, reduces the probability of the container falling during transportation.

Detailed description of the equipment and technological process of the SNF transportation to the storage area is given in Volume 3.1 of this design.

10.4.1.4 Engineering solutions at the storage area in the CSFSF

The following technical solutions are implemented to ensure nuclear safety during the storage of the spent nuclear fuel:

- for MPC storage used in HI-STORM Protective container which design is rated for extreme impacts up to the aircraft fall. Even in this case the container and, respectively, MPC remain undamaged;
- to exclude flooding of the storage area the provision is made for the storm water drainage system intended for removal of water from the maximum daily precipitation rate in the CSFSF area;
- permanent uninterrupted control of the temperature at the entry and exit of HI-STORM ventilation channels, which reflect the state of the MPC heat release and, respectively, state of the MPC;
- selected area for construction of the CSFSF has low level and amplitude of groundwater level fluctuations what excludes initial accident event with flooding of the site and, respectively, water penetration to the MPC via HI-STORM ventilation channels;
- selected area for construction of the CSFSF is located far from water basins and rivers what excludes initial accident event with flooding of the site and, respectively, water penetration to the MPC via HI-STORM ventilation channels;
- the storage area is located inside of the secured CSFSF perimeter and is separated into an extremely important zone which prevents access of unauthorized personnel;
- the provision is made for the scheduled patroling of the storage area by the CSFSF personnel for detecting any possible clogging of HI-STORM ventilation channels and their timely cleaning;
- materials used during designing of the storage area are such non-combustible materials which exclude such initial event as fire.

Detailed description of the HI-STORM container servicing operations in the storage area is given in this design, Volume 3.1 “Technological Part. Part 1. Spent Fuel Handling Description of the CSFSF Master Plan is given in Volume 2. Detailed description of the control and management system (control of the temperature at the entry and exit of HI-STORM ventilation channels) is given in Volume 6 of the design.

10.4.2 Subcriticality assessment

Holtec International has performed calculations [136] which assess subcriticality of HI-STORM 190 and HI-STAR 190 systems for the spent nuclear fuel storage and transportation for the CSFSF (the copy is attached in Volume 1.2.2). These calculations confirms non-exceedance of the maximum value of the effective coefficient of neutron breeding $_{eff}$ 0.95 for HI-STAR 190 casks and HI-STORM 190 storage module with MPC-31 and MPC-85 for transportation and storage of the undamaged VVER-1000 and VVER-440 spent nuclear fuel at normal operating conditions, operational occurrences and at design basis accidents.

The document [136] provides assessment of subcriticality of the spent nuclear fuel in the following types of the casks:

- HI-STAR 190 - transport cask, type B(U)F, made of steel, lead and Holtite material;
- HI-STORM 190 - storage cask, made of steel and concrete;

- HI-TRAC 190 - transfer cask, made of steel and lead, also contains water in the water jacket.

The above casks may be loaded with the following modifications of the multipurpose cask (MPC):

- MPC-31 with 31 storage cells built with consideration for VVER-1000 undamaged spent fuel (fuel material - UO2) with the rated maximum enrichment for ^{235}U;
- MPC-85 with 85 storage cells built with consideration for VVER-440 undamaged spent fuel (fuel material - UO2) with the rated maximum enrichment for ^{235}U;

Assessment of subcriticality of the casks in the paper [136] was performed with use of MCNP5 computer code - 3D-code of general purpose based on Monte-Carlo method developed by Los Alamos National Laboratory in the USA.

10.4.2.1 Methods

HI-STAR 190 - hereinafter HI-STAR - is the main element of the transport package designed for transportation of multipurpose casks loaded with VVER-1000 and VVER-440 SNF. HI-STORM 190 - hereinafter HI-STORM - is a thick-walled cask, partially made of concrete, for long-term storage of the SNF at the CSFSF. HI-TRAC 190 - hereinafter HI-TRAC - is a transfer cask used for loading of SNF into MPC (MPC is filled with water inside HI-TRAC) as well as for transferring the dry MPC into HI-STAR. MPC fuel basket is built in such a way that fixed neutron absorber in its structure preserves its efficiency during the storage over 100 years, and it should be mentioned that there are no reliable mechanisms which could reduce or deteriorate its efficiency. Respectively, there is no need for actions to monitor and control long term efficiency of the neutron absorber. Three used casks (HI-STAR, HI-STORM, and HI-TRAC) differ only by the external reflector material, what insignificantly affects the breeding properties. Respectively, analysis results for the cask of one type are applicable to other types as well. Therefore, most calculations for justification of the nuclear safety during transportation and storage of the spent nuclear fuel were carried out only for one of three containers, namely for HI-STAR. Nevertheless, calculations for assessment of the nuclear safety was also performed for HI-TRAC and HI-STORM what is mentioned in Chapter 7.4.

HI-STAR localization system is represented by 2-walled multipurpose cask (MPC) with flat bottoms and flat welded covers (internal barrier) and metal package cask with bolted cover (external barrier). Therefore, multibarrier tight localization system is ensured, in which the metal package cask with bolted cover ensures only the external barrier. Inside the MPC the SFA are located in the basket cells which ensure their permanent position. At normal and accident conditions of transportation HI-STAR transport cask is in dry state (without moderator) due to which breeding capability of the system is very low (Keff < 0.50).

Nuclear safety during transportation and storage depends on the following main design parameters:

1. Geometry of the fuel baske inside MPC;

2. Permanent fixed neutron absorber in the composition of the fuel basket. The basket is completely made of Metamic-HT - composite material consisting of

aluminum and B_4C. Therefore, all SFAs are completely surrounded by neutron absorbing material;

3. Specified limit for the maximum fuel enrichment;

4. Capability of the system to prevent water penetration at accident conditions.

Due to this capability of the system any possible modification of the fuel configuration at accident conditions will have no consequences from the standpoint of nuclear safety.

For identification of the degree of the impact of tolerances and deviations during manufacture of the fuel and MPC basket on K_{eff} of the system, sensitivity analysis was carried out in the paper [136]. For calculations used was the worst combination of tolerances and alignments, i.e. such combination that leads to increase of the system's breeding properties.

Assessment of subcriticality of the casks in the paper [136] was performed with the following conservative assumptions, which comply with the criteria [39]:

- considered were systems with maximum design capacity of SFA loading;
- MPC basket is completely loaded with the fuel with maximum breeding properties;
- formed was the combination of the worst conditions from the point of tolerances and alignments;
- performed were analysis for cases of absence and presence of the water as the moderator and external reflector. Varied were water density inside the cask, water level inside the cask at vertical and horizontal flooding, water density outside the cask, presence or absence of the neighbor casks, as well as distance to the neighbor casks. As a result, the conditions, which lead to maximum breeding properties of the system, were taken as the final ones;
- analysis was performed for loading of the new fuel with maximum enrichment;
- in the new fuel presence of ^{234}U and ^{236}U, which are additional neutron absorbers, was not considered;
- presence of the burnable absorbers was not considered;
- calculations of the flooding with the moderation used water which temperature matches the maximum breeding capability of the system;
- absorbing properties of the FA structural elements were neglected;
- during creation of the design diagram of HI-STAR casks and HI-STORM storage module materials absorbing the neutrons, such as Holtite and steel beyond Holtite, were not considered.

10.4.2.2 Calculation Results

Max K_{eff} values calculated with 95% confidence level are provided in Table 10.19 for all casks used during SNF storage and transportation. Results of additional calculations for HI-STAR cask are given Table 10.20. Generally, the results confirm that neutron breeding coefficient (K_{eff}), with consideration of all calculation errors and uncertainties, with 95% confidence level, does not exceed 0.95 value at all conditions of normal operation, operational occurrences and accidents.

Results of the performed analysis of the nuclear safety of HI-STAR 190 transport systems and HI-STORM 190 storage systems for the spent nuclear fuel demonstrated provision of the subcriticality state at all normal conditions, operational occurrences and accident conditions. Analysis of the endless array of HI- STAR casks with various parameters of external and internal moderation demonstrates that maximum value of K_{eff} is significantly less than the established standard limit of 0.95.

Table 10.19 - **Max K_{eff} values for all casks used during SNF storage and transportation [136]**

FA	Enrichment, mass % ^{235}U	Maximum value $k_{эф}$ [1]		
		HI-STAR	HI-TRAC	HI-STORM
MPC-31				
VVER-1000, FA-A	4.45	0.9449	0.9448	0.9434
VVER-1000, FA-M	4.45	0.9428	0.9435	0.9415
VVER-1000, FA-W	4.25	0.9387	0.9390	0.9378
VVER-1000, FA-W (LTA)	4.45	0.9420	0.9426	0.9409
MPC-85				
VVER-440, WC	4.45	0.8918	0.8924	0.8917
VVER-440, WC (2nd Gen)	4.65	0.9007	0.9007	0.8998

[1] "Maximum K_{eff} value" means the maximum possible effective neutron breeding coefficient with consideratio of the error, uncertainty and rated statistics, which is determined for most unfavorable combination of manufacture tolerances. Mean square deviation (σ) of the calculations is about 0.0003

Table 10.20 **- Results of additional K_{eff} calculations for HI-STAR [136]**

Configuration	% density of the internal moderator	% density of the external moderator	Max. Keff value
MPC-31			
Separate cask without reflector	100%	%	0.9449
Separate cask, full reflector	100%	100%	0.9447
Localizing shell, full reflector	100%	100%	0.9440
Separate cask with damages	0%	100%	0.4093
MPC-85			
Separate cask without reflector	100%	0%	0.9007
Separate cask, full reflector	100%	100%	0.9006
Localizing shell, full reflector	100%	100%	0.9000
Separate cask with damages	0%	100%	0.4071

More detailed justification of the subcriticality at normal operating conditions, operational occurrences and accidents is provided in PSAR.

10.5 Analysis of Thermal Conditions

According to requirements [39], Holtec International has performed thermal analysis [137] of HI-STAR 190 package and HI-STORM 190 storage system, which contain MPC with VVER SNF (the copy is enclosed in Volume 1.2.2).

10.5.1 Methods

During thermal analysis of HI-STAR 190 the document [137] made the following conservative assumptions:

- Absence of the contact between MPC fuel basket and shell as well as between the MPC shell and the cask, i.e. fuel basket and MPC are in a suspended state (have no contact).
- Convective heat transfer in the cask cavity was not considered.
- It was assumed that external surfaces absorb 100% of the solar energy falling onto them.
- Values of the heat conductivity of the materials of the shield protecting from neutron radiation, Metamic-HT and shock absorbing assemblies were significantly lowered.
- Heat transfer in axial direction via fuel pellets was not considered.
- Maximum design heat release was assumed in all SFA storage cells.
- Effect of the dust, fog, tilt angle and latitude, reducing impact of the sun heat flow was not considered.
- Conservative provision was that residual heat release of the SNF is unevenly distributed along the entire SFA length with maximum value in the middle of the active part length.
- Heat dissolution via the SFA spacer grids was not considered.

During thermal analysis of HI-STORM 190 the document [137] made the following conservative assumptions:

- Absence of the contact between MPC fuel basket and shell as well as between the MPC shell and the cask, i.e. fuel basket and MPC are in a suspended state (have no contact).
- It was assumed that external surfaces of the cask absorb 100% of the solar energy falling onto them. Shadowing of the cask surface by other neighboring casks was not considered.
- The assumption was that the bottom part of the cask is isolated.
- Heat transfer in axial direction via fuel pellets was not considered.
- Maximum design heat release was assumed in all SFA storage cells.

- Maximum hydraulic resistance was conservatively adopted during simulation of the flow via MPC.
- Conservative provision was that residual heat release of the SNF is unevenly distributed along the entire SFA length with maximum value in the middle of the active part length.
- Heat dissolution via the spacer grids and joining parts in the upper and lower parts of the cask was not considered.

10.5.2 Analysis Results

Analysis Results [137] for HI-STAR 190 are given in tables 10.21 – 10.25.

Table 10.21 - **Maximum temperature of the fuel shell for normal conditions of HI-STAR 190 transportation**

Cask	Temperature, °C	Temperature limit for normal operating conditions, °C
MPC-31	340	350
MPC-85	337	350

Table 10.22 - **Maximum values of the temperature for normal conditions of HI-STAR 190UA transportation for MPC-31 and MPC-85**

Material/Element	MPC-31 temperature, °C	MPC-85 temperature, °C
Fuel element cladding	340	337
Fuel basket	327	316
MPC shell	214	229
Neutron protection	151	156
Internal TPC shell	158	165
External TPC shell	126	130
Cover sealings	91	112
TPC cover	93	116
Shock absorber	83	72

Table 10.23 - **Maximum working pressure of HI-STAR 190**

Conditions	Excessive pressure, kPa.	
	MPC-31	MPC-85
Maximum working pressure in the MPC internal cavity		
Normal Operating Conditions	640.3	645.9
3% damage of FE	654.1	653.4
Ring gap between MPC and HI-STAR 190		
Normal Operating Conditions	190.2	173.0

Table 10.24 - **Maximum values of HI-STAR 190 elements temperature at a fire-associated hypothetic accident**

Material/Element	Initial condition, °C	Fire, °C
Fuel element cladding	340	340
Fuel basket	327	327

Material/Element	Initial condition, °C	Fire, °C
MPC shell	214	214
Internal TPC shell	158	172
Neutron protection	151	Not indicated as the neutron protection material integrity during or after the fire is not guaranteed
Cover sealings	91	106
TPC cover	93	102
External TPC shell	126	788

Table 10.25 - **Maximum pressure of HI-STAR 190UA transport cask at a fire-associated hypothetic accident**

Description	Excessive pressure, kPa.
Maximum working pressure in the MPC internal cavity	
Without FE damaging	683.1
100% damage of FE	1162.8
Ring gap between MPC and HI-STAR 190	
Pressure in the cavity	214.4

The document [137], for HI-STAR 190, with consideration of conservative assumptions, justifies non-exceedance of the maximum permissible temperatures of FE casings at normal operating conditions, opperational occurrences and design basis accidents. The same document proves non-exceedance of the design pressure limits and non-exceedance of the permissible temperature on external surfaces of HI-STAR 190.

Analysis Results [137] for HI-STORM 190 are given in tables 10.26 – 10.34.

Table 10.26 - **Maximum values of SFA FE casing temperature in HI-STORM 190 cask during storage**

Storage scenario	Temperature, °C	Temperature limits, °C
MPC-31	314	350
MPC-85	333	350

Table 10.27 - **Maximum temperatures in the MPC at long-term storage**

Element	Temperature, °C	
	MPC-31	MPC-85
Fuel cladding	314	333
Fuel basket	292	313
Basket support structures	241	269
MPC cover – average by section	231	225
Internal MPC shell	218	245
External MPC shell	203	224
MPC bottom – average by section	158	174

Table 10.28 - **Maximum HI-STORM 190 temperatures at long-term storage**

Element	Temperature, °C	
	MPC-31	**MPC-85**
Internal shell of the storage cask	147	163
External shell of the storage cask	81	81
Storage cask housing concrete:		
– Average by section	103	121
- Maximum	146	163
Storage cask cover concrete:		
– Average by section	108	121
- Maximum	121	141
Lower plate of the storage cask cover	121	142
Upper plate of the storage cask cover	83	83
Storage cask bottom – average by section	153	49

Table 10.29 - **Maximum HI-STORM 190 storage cask temperatures at the increased ambient temperatures**

Element	Temperature, °C	
	MPC-31	**MPC-85**
Fuel cladding	325	344
Fuel basket	303	324
Basket support structures	252	280
MPC cover – average by section	242	236
Internal MPC shell	229	256
External MPC shell	214	235
MPC bottom – average by section	169	185
Internal shell of the storage cask	158	174
External shell of the storage cask	92	92
Storage cask housing concrete	157	174
Storage cask cover concrete	132	152
Lower plate of the storage cask cover	132	153
Upper plate of the storage cask cover	94	96
Storage cask bottom – average by section	164	60

Table 10.30 - **Maximum HI-STORM 190 storage cask temperatures at the extreme ambient temperatures**

Element	Temperature, °C	
	MPC-31	**MPC-85**
Fuel cladding	326	345
Fuel basket	304	325
Basket support structures	253	281
MPC cover – average by section	243	237
Internal MPC shell	230	257
External MPC shell	215	236
MPC bottom – average by section	170	186
Internal shell of the storage cask	159	175

Element	Temperature, °C	
	MPC-31	MPC-85
External shell of the storage cask	93	93
Storage cask housing concrete	158	175
Storage cask cover concrete	133	153
Lower plate of the storage cask cover	133	153
Upper plate of the storage cask cover	95	97
Storage cask bottom – average by section	165	61

Table 10.31 - **Maximum HI-STORM 190 storage cask temperatures at 50% clogging of the vent inlets**

Element	Temperature, °C	
	MPC-31	MPC-85
Fuel cladding	319	338
Fuel basket	298	319
Basket support structures	247	275
MPC cover – average by section	237	231
Internal MPC shell	224	251
External MPC shell	210	231
MPC bottom – average by section	163	179
Internal shell of the storage cask	155	171
External shell of the storage cask	83	83
Storage cask housing concrete	154	171
Storage cask cover concrete	129	149
Lower plate of the storage cask cover	129	150
Upper plate of the storage cask cover	85	87
Storage cask bottom – average by section	159	55

Table 10.32 - **Maximum HI-STORM 190 storage cask temperatures at 100% clogging of the vent inlets**

Element	Temperature, °C	
	MPC-31	MPC-85
Fuel cladding	440	440
Fuel basket	428	429
Basket support structures	380	389
MPC cover – average by section	338	313
Internal MPC shell	359	368
External MPC shell	344	350
MPC bottom – average by section	298	293
Internal shell of the storage cask	307	307
External shell of the storage cask	158	142
Storage cask housing concrete	306	307
Storage cask cover concrete	210	215
Lower plate of the storage cask cover	211	218
Upper plate of the storage cask cover	112	104
Storage cask bottom – average by section	296	172

Table 10.33 - **Time of achievemen of the temperature limit for FE shell after beginning of the complete clogging of the vent inlets and outlets**

MPC type	Temperature, °C	Time of achievement of the temperature limit,
MPC-31	350	18.1
	440	82.0
MPC-85	350	9.0
	440	56.5

Table 10.34- **Pressure in the MPC at operational conditions**

Condition	Average temperature across the MPC cavity volume, °C		Excessive pressure of the MPC cavity, kPa	
	MPC-31	MPC-85	MPC-31	MPC-85
Long-term storage conditions: - Without FE damaging - At 1% damage of FE	 245 245	 259 259	 629.3 633.4	 648.6 651.4
Increased ambient temperature	256	270	644.4	664.5
Extreme ambient temperature	257	271	645.8	665.9
50% clogging of the vent inlets	251	266	637.6	659.0
Accident - 100% clogging of the vent inlets and outlets	380	375	819.6	812.7
Accident - 100% damage of FE	245	259	1076.0	891.9

The document [137] for HI-STORM 190 shows that calculated values of FE shell temperature values and the respective internal pressure in the MPC at normal operating conditions and at abnormal (50% clogging of the vent inlets) and accident conditions (100% clogging of the vent inlets) are below the permissible limits for temperature and pressure.

Mode detailed justification of the thermal conditions at normal operating conditions, operational occurrences and accidents is provided in PSAR.

10.6 Strength Analysis

Holtec has performed calculations to determine strength properties of HI-STAR 190 UA, HI-STORM 190 systems and auxiliary equipment utilized for transportation, storage and handling of the spent nuclear fuel at the CSFSF. Strength analysis outcomes are provided in the document [138] (the copy is enclosed in Volume 1.2.2).

The document [138] displays the following justifications:

- Assessment of the compliance of HI-STAR 190 package with the requirements of the documents [39, 123, 164] in terms of strength properties for normal transportation conditions and for hypothetic accident situations.
- Assessment of the preservation of the integrity of HI-STORM 190 storage cask (which determines tightness of the shell localizing the radioactive contents, assurance of the nuclear safety and radiation protection, as well as preservation of the possibility of the SNF extraction) under impact of all probable loads at normal operating conditions, operational occurrences and design basis accidents and extreme natural phenomena in accordance with the requirements of the documents [39, 123, 165].

- Assessment of preservation of integrity of the auxiliary equipment under normal operating conditions.

10.6.1 Methods

Analysis of HI-STAR 190 strength under PBPRM-2006, SSR-6 and Regulatory Guide 7.6 [123, 172, 174] was performed for normal accident operating conditions.

ANSYS Mechanical and LS-DYNA computer applications were used to perform strength and mechanical numerical calculations.

When analysing the strength of HI-STAR 190 UA and HI-STORM 190, the following main issues are considered:

- Determination of the strength characteristics of the casks and elements of the systems.
- Identification of materials used in the systems
- Determination of loads on the system elements during transportation and technological operations, at normal operating conditions, operational occurrences, accident situations and accidents. Determination of parameters of most unfavorable design conditions such as fire or water submersion.
- Determination of the criteria of permissibility of the systems behavior under impact of the specified various operating conditions on the basis of ASME standard criteria and criteria of other regulatory documents.
- Determination of the margin of strength and safety of the systems under impact of the loads at various operating conditions.

When analysing the strength of safety critical auxiliary equipment, the following main issues are considered:

- Strength properties of the auxiliary equipment.
- Determination of loads acting on auxiliary equipment under normal operating conditions.
- Determination of the criteria of acceptability of operation of the auxiliary equipment at normal conditions in accordance with ASME standard and other standards.
- Analysis to determine the margin of strength of the auxiliary equipment at normal operating conditions.

10.6.2 Analysis Results

Performed analyses [139] resulted in justification that equipment used at the SNF handling will preserve its functionality throughout the entire design service life, at all design modes.

Results provided in [139] show that HI-STAR 190 UA complies with requirements of par.659, 727 and 729 of SSR-6 and PBRM-2006 standard. Results of the simulation of falling from 9-meter height are performed with the use of the upper limit value of the production tolerance for aluminum material of the cellular structure (i.e. 110% of the nominal value), to ensure maximum value of braking during the impact. During assessment, values of the shock absorbers collapse strength were reduced to 90% of the respective nominal values in order to check that lower limit value of the production tolerance will not result in ‘failure’ of the shock absorber due to extensive displacements at the collapse. Considered were also 2 penetration events and determined consequences.

For conditions of hypothetic accident at transportation all reliability coefficients are over 1.0, tightness function was preserved for all postulated events. Respectively, at hypothetic accident conditions of transportation HI-STAR 190 UA has sufficient strength to satisfy requirements SSR-6 and PBRM-2006 documents as to subcriticality, tightness, protection and temperature.

HI-STAR 190 UA and MPC containments are preserved tight and sealed in case of submersion in accordance with par.733 of SSR-6 and PBRM-2006, which follows the free falling, perforation and fire.

Opening between the cover and flange will be sealed by 2 sealings in completely pressed state.

Average warping of the basket panel in the fuel zone is less than the standard limit.

Local plastic deformation in case of penetrating concentrated impact from a soft steel rod will lead to a surface dent and not to a deep penetration, and will not be a cause of the loss of integrity of the protective shell.

More detailed description of the strength analysis at normal operating conditions, opperational occurrences and accidents is provided in PSAR.

10.7 Radiation Safety

Actions to ensure radiation safety at all stages of the CSFSF operation come down to assurance of the safety at normal operation and at accidents.

Observance of the RS principles is achieved through selection of optimal technical solutions and performance at all stages of the CSFSF life cycle (construction, commissioning, operation and decommissioning) of the set of actions on radiation protection. These actions can be conditionally divided into the following groups:

- technical (shielding, dust suppression, decontamination, active ventilation and active gas treatment, use of remotedly controlled mechanisms, CCTV etc.);
- radiation and hygienic (establishment of the sanitary and protection zone and surveillance zone, establishment of the reference levels, assessment of personnel exposure doses, premises and territory planning, airlocks, use of PPE and PRPE, radiation control etc.);
- organizational (preparation of workplaces, permit to perform works, control and supervision of teh activity, organization of medical aid etc.).

The list of exact actions/measures is developed and regulated for each stage of the CSFSF life cycle:

- by the design documentation to include construction design, instructions and provisions of the Exclusion Zone - CSFSF construction phase;
- program of putting into operation, commissioning program, instructions and provisions of the Exclusion Zone - CSFSF commissioning phase;
- operation and technical documents and technological regulation of the CSFSF, as well as the Manual on the RW Handling of the Exclusion Zone - operation phase;
- by the CSFSF decommissioning program, instructions and provisions of the Exclusion Zone - decommissioning phase.

Further, in the following sections there is detailed description of the actions to ensure radiation safety adopted in the design for all stages of the CSFSF life cycle.

Detailed justification of the radiation safety is provided in PSAR.

10.7.1 Radiation Safety at Construction

The CSFSF construction will be carried out on the territory of the exclusion zone and compulsory evacuation zone (Exclusion zone) which is characterized by the radioactive pollution caused by the consequences of the Chernobyl accident in 1986. In this area valid are reference levels [112], which shall be considered when planning the measures related with the CSFSF construction and operation.

In order to improve the radiation safety in accordance with [112], the exclusion zone is divided into three radiation-regime zones, namely:

- Zone I (the 10-kilometer zone) — the area within a 10-km radius around the Chernobyl Nuclear Power Plant. In this area, the radiation-hazardous works are carried out on the basis of programs agreed with the regulatory authorities in accordance with the requirements of the current normative-legal acts on radiation safety in Ukraine. The strict radiation monitoring procedures are implemented in this zone.
- Zone II (the buffer zone) — the territory from the border of the 10-kilometer zone to the outer edge of the exclusion zone (except the city of Chernobyl). In this area, constant radiation monitoring is implemented.
- Zone III (the residential zone) — this zone comprises a part of the territory of Chernobyl and the surrounding sites where there are dormitories and administrative building of the State Agency of Ukraine for the Exclusion Zone Management, the public catering facilities and retail outlets, the social, cultural, health-care institutions, and the access roads.

The CSFSF construction site is located in Zone I, its territory is almost completely occupied by the pine forest (forest occupies 17.2 hectares out of 18.2 ha).

During construction of the CSFSF, radiation exposure of the personnel are primarily related with the preliminary preparation of the construction site which area refers to the radiation contaminated lands. The following works are provided for during preparation of the construction site:

- arrangement of fire protection lines along the perimeter of the construction site occupied by the forest;
- removal of the forest plantation to include removal of trees and underwood, logging of the cut timber, stump extraction and removal of the remaining roots (area - 17.2 ha);
- removal of the upper soil layer with organic inclusions to a depth of 0.2 m, with further transportation to the storage site (area - 18.2 ha);
- planning of the territory with consideration of the soil mass balance and removal of the excessive soil to backfill the basis of the access railroad;
- planning of the territory for construction of the access motor road to the construction site)
- construction of the access railroad from Shepelichi station to the construction site;
- arrangement of the fencing along the perimeter of the site and construction of the checkpoint.

The site area is currently slightly slopy from north to south and is characterized by altitudes from 142.00 to 139.00 m in the northern part and from 138.50 to 137.00 m in the south.

Organization of the relief anticipates for the entire leveling of the territory.
Estimated grade elevation of the site is 138.50 m.

Forest cut down during the preparation of the site territory does not refer to radioactive wastes, requires no burial and will be transferred to a specialized organization for the use within the 10-km zone.

During preparation of the CSFSF site territory the works, which by its complexity are divided into characteristic groups, are performed. List of the works is given in tables in Table 10.35.

Table 10.35 – **List of the performed works with breakdown to typical groups [148]**

Groups of works	List of performed works
Works performed in the contaminated territory of the CSFSF site, which do not anticipate active impact on radiactively contaminated soil.	• removal of the forest plantation to include removal of trees and underwood; • arrangement of the fencing along the perimeter of the site; • erection of temporary contractor's buildings.
Works performed in the contaminated territory of the CSFSF site, which do anticipate active impact on radiactively contaminated soil	• arrangement of fire protection lines along the perimeter of the construction site occupied by the forest; • logging of the cut timber, and stump extraction; • removal of the upper soil layer with organic inclusions to a depth of 0.2 m, with further transportation; • planning of the territory with consideration of the soil mass balance (to include removal of the excessive soil to backfill the base of the access railroad); • planning of the territory for construction of the access motor road to the construction site; • planning of the territory for construction of the on-site railway tracks; • planning of the territory of the access railroad from Shepelichi station to the construction site; • installation of poles/supports for the fencing along the perimeter of the site; • construction of the checkpoint.

Division of the works into typical groups enables differentiated approach to selection of measures aimed at protection of the personnel and environment.

So, for works with active impact on radioactively contaminated soil, use of additional PPE is required (protection from the personnel inhalation exposure), measures on dust suppression (protection of the personnel and environment) and control of radioactive contamination of the air on the construction site borders (environmental protection).

According to [149], hygienic classification of labor by working process complexity values at performance of preparatory works on the CSFSF construction site will be classified as Class 2 (admissible labor conditions).

During performance of these works possible is short-term increase of the volume concentration of radionuclides in the near-surface layer of the atmosphere for account of dust lifting, what will lead to the building personnel radiation exposure and additional surface contamination of adjacent areas, to include motor roads and neighboring facilities, first of all - Vektor CPS. Considering the fact that the entire adjacent territory is radioactively contaminated in the same extent as the earthwork sites, no significant additional contamination of this territory will occur.

Since the main scope of construction works will be performed on already decontaminated construction site, no further radiation exposure during construction is assumed. Decontamination of the construction site before the main scope of the construction works means the entire scope of works on preparation of the site, which also anticipate removal of the soil for the purpose of creation of the grade elevation of the CSFSF site.

Detailed description of the organization of works during construction is provided in Volume 11 (Organization of Construction) of the present design.

10.7.1.1 Radiation situation and radiation exposure sources

Main source of the personnel radiation exposure during construction of the CSFSF is radioactive contamination of the construction site which is determined by gamma radiation dose rate, radioactive contamination of the soil cover and plantations, as well as the near-surface layer of the atmosphere.

Gamma radiation dose rate

Gamma radiation dose rate on the CSFSF construction site and adjacent territory is primarily generated by the radioactively contaminated soil and determined by the ^{137}Cs radiation. Contribution of ^{137}Cs that has migrated into other environments (air, water, biological objects) is insignificant [148, 150] мигрировавшего в другие среды (воздух, вода, биологические объекты), незначителен [148, 150].

The document [148] provides results of gamma radiation dose rate measurements on the CSFSF construction site. Gamma radiation dose rate measurement was performed by the grid of 25x25 m at the height of 1m and 0.1m with use of MKS-07 “Poisk” dose rate meter.

Gamma surveying revealed areas with increased (abnormal) values of the dose rates. In this areas gamma radiation dose rate was measured by the grid of 10x10 m at the height of 1m and 0.1m. Figure 10.1 shows the map of the EDR distribution at 1-m height (left) and 0.1-m height (right).

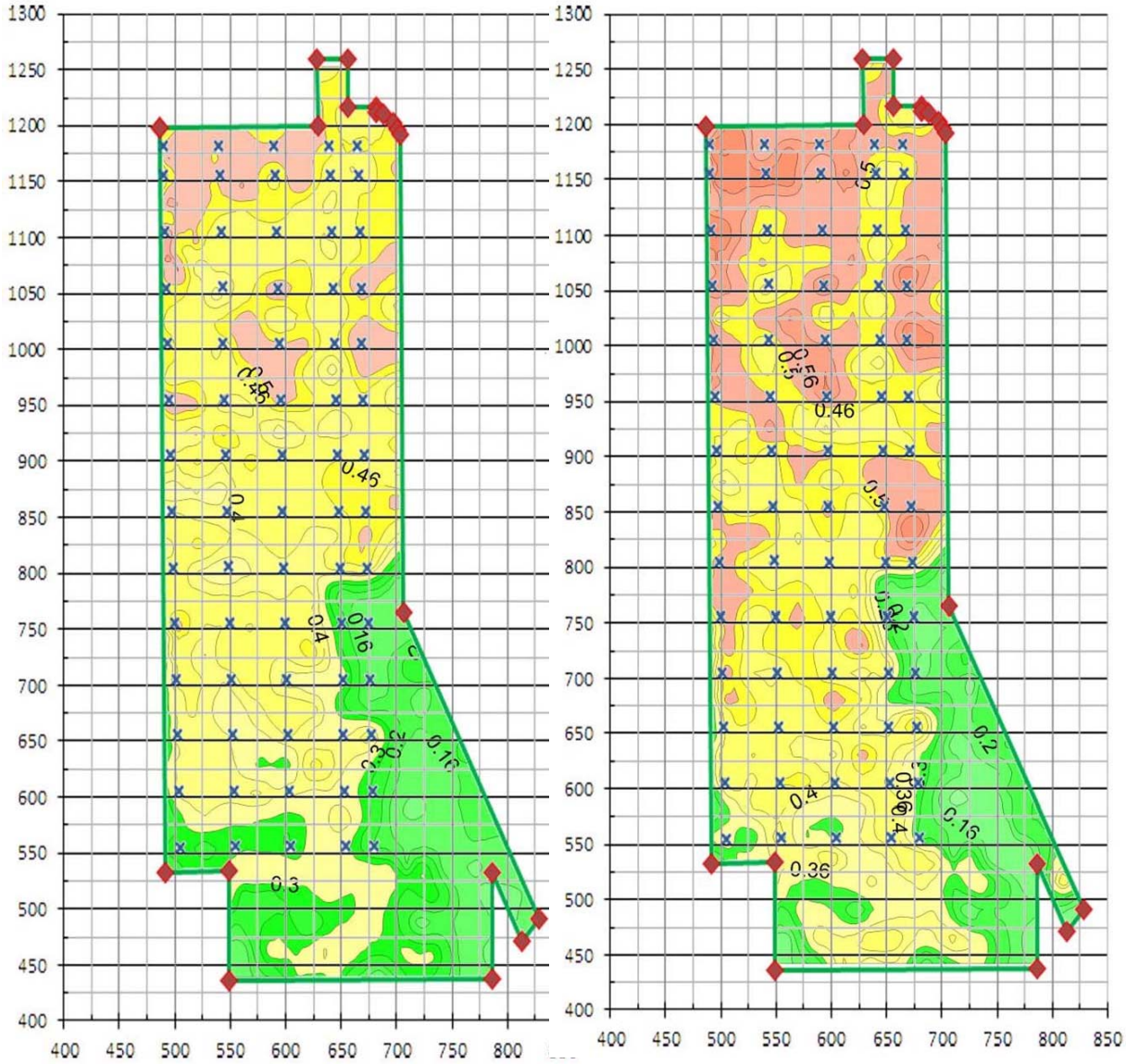

Figure 10.1 - Interpretative map of EDR distribution at the height of 1 m (left) and 0.1 m (right) on the CSFSF construction site

After analyzing the map data, the following conclusions can be made [148]:

- EDR decreases with increase of the distance from the soil;
- Maximum EDR value equals to 0.70 mcSv/h at the height of 0.1 m and 0.66 mcSv/h at the height of 1 m;
- Average EDR value on the site equals to 0.41 mcSv/h at the height of 0.1 m and 0.37 mcSv/h at the height of 1 m;
- area of the site with the EDR exceeding 0.5 mcSv/h is relatively small and concentrated mainly near the northern border of the site.

Radiation contamination of the soil cover

Emergency radioactive contamination of soils in the exclusion zone is represented by the mix of radionuclides ^{90}Sr, ^{137}Cs, ^{154}Eu, $^{238\text{-}241}Pu$ and ^{241}Am, which are in various physical and chemical forms and relations [148].

Currently, in most landscape conditions 90 to 95% of the total activity of accidental contamination is concentrated at the depth of 5-10 cm from the soil surface [148].

The document [148] provides results of contamination density measurements of the soil cover on the CSFSF construction site.

According to the data [148] shown in Figures 10.2 and 10.3, density of ^{90}Sr contamination in the entire area of the construction site does not exceed 40 kBq/m2, and density of ^{137}Cs contamination near three borders of the site exceeds 80 kBq/m2. Distribution of the density of the surface contamination of TUE in the area of the CSFSF construction site is displayed in Figure 10.2

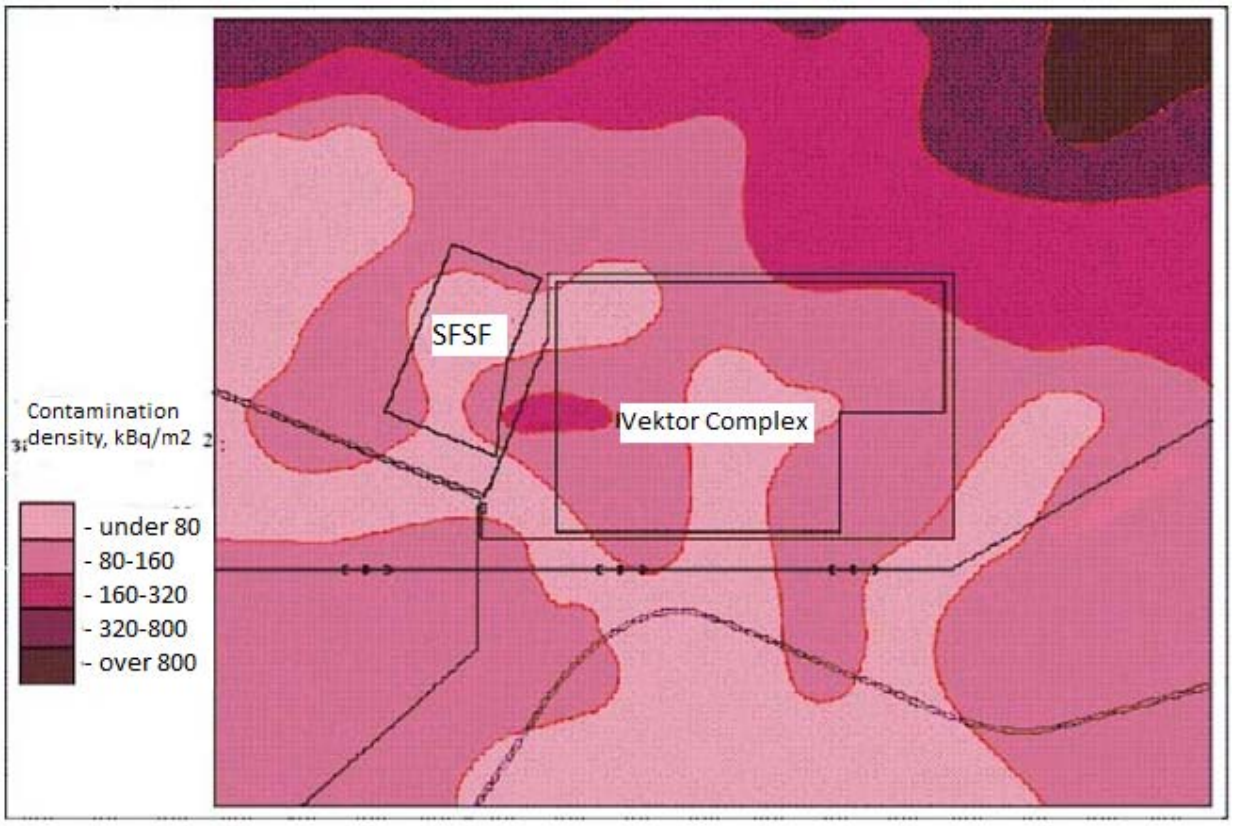

Figure 10.2 - **Density of the surface ^{137}Cs contamination**

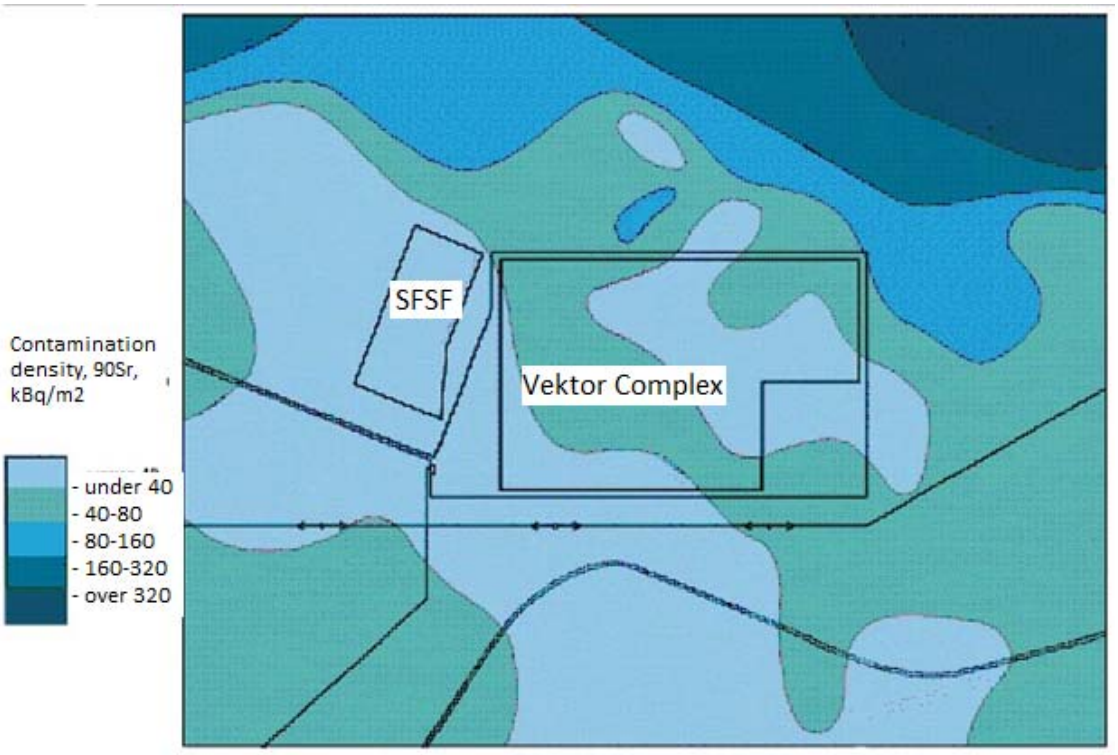

Figure 10.3 - **Density of the surface ^{90}Sr contamination**

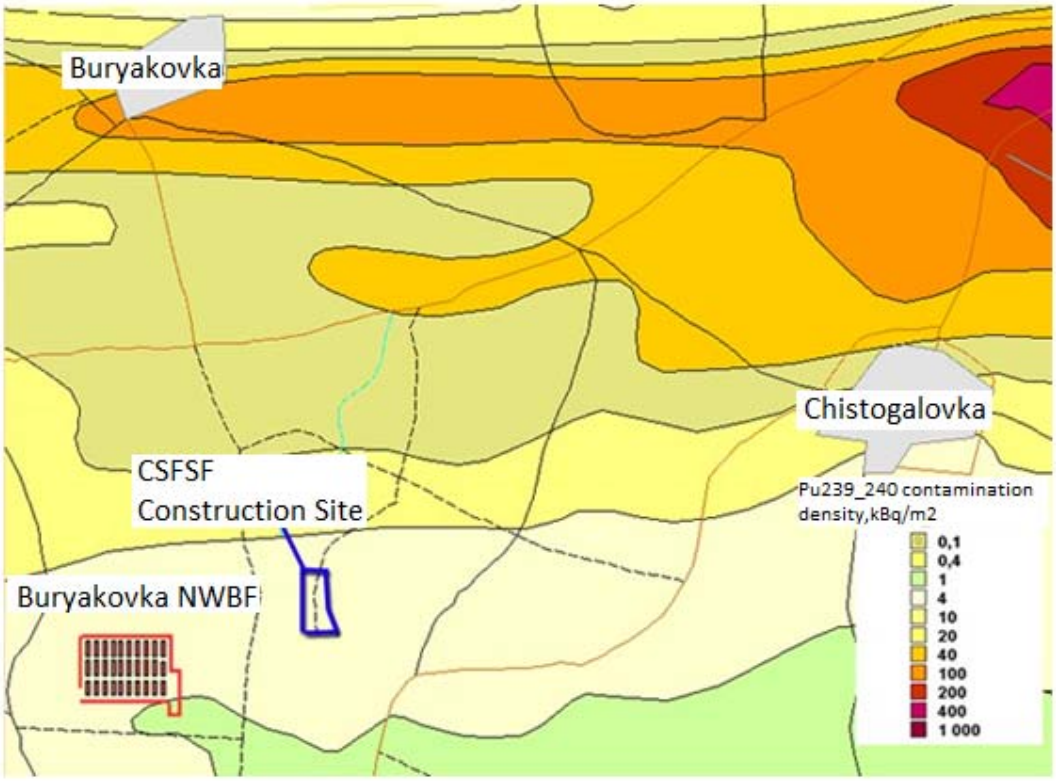

Figure 10.4 - **Density of the surface $^{239, 240}$Pu contamination of the CSFSF construction site area**

According to the results of the measurements [148], the beta-particles flux density on the territory of the site does not exceed 120 ppm cm^{-2} min^{-1}. Most often values are within the scope of 50 – 80 ppm·cm^{-2}·min^{-1}.

The average specific activity of ^{137}Cs and ^{90}Sr in the survey area, in accordance with the results of determination of the specific activity of these radionuclides, for the 20-centiimeter soil layer does not exceed 2.35 kBq/kg and 1.36 kBq/kg respectively. In the most contaminated area, the values are around 3 kBq/kg and 2 kBq/kg respectively.

According to the document [148], values of the specific activity of beta-, gamma emitting radionuclides do not exceed the level of extraction - 10 kBq/kg, and values of the specific activity of transuranium alpha-emitting radionuclides do not exceed the level of extaction - 0.1 kBq/kg, which are established by the state sanitary rules [110]. Therefore, at 20-cm thickness of the removed soil the wastes formed as a result are not radioactive.

Radioactive pollution of the boundary layer of the atmosphere

The existing radioactive pollution of the atmosphere [148] within the exclusion zone is formed due to the secondary air migration of radioactive accidental precipitations of 1986, which are deposited in various natural and man-made objects. In this case value of the volume-specific activity of the boundary layer of the atmosphere is formed under impact of multiple factors, having natural or natural and man-made origin. Most significant of them are the following influencing factors:

- current weather (wind speed, precipitations) and season;
- man-induced activity causing the dust lifting;
- density of the surface contamination of the soil cover in the area;
- radionuclide, physical and chemical and dispersion composition of the primary accidental radioactive fallout;
- relief of the neighboring terrain;
- properties and current state of the soil cover;
- dangerous natural and natural and man-induced phenomena (forest fires, turf deposit combustion, dust storms etc.).

In each certain situation, significance of any of the above factors for formation of the magnitude of the air pollution may vary significantly, what leads to a high dynamics of the values of radioactive pollution of the air in time and space.

At the present time [148], the main factor facilitating the increase of the level of radioactive pollution of the air is man-induced activity within the exclusion zone.

According to the data provided in [148] under results of the research conducted on the CSFSF site, the following concentrations of long-lived radionuclides of the Chernobyl origin (^{137}Cs, ^{90}Sr+^{90}Y) in the boundary layer of the atmosphere:

- $2.3 \cdot 10^{-5} \pm 5.3 \cdot 10^{-5}$ Bq/m^3 (measurements of 28.10.2014);
- $4.5 \cdot 10^{-5} \pm 1.2 \cdot 10^{-5}$ Bq/m^3 (measurements of 4.11.2014).

Obtained results do not exceed the reference levels established by appropriate regulation [112].

Radioactive contamination of the vegetation

The CSFSF construction area is almost completely occupied by the pine forest. The document [148] provides results of radioactive contamination of timber on the CSFSF construction site. According to the data[148], surface contamination does not exceed: bark - 118 beta-particles/cm^2 min, debarked timber – 25 beta-particles/cm^2 min, trunk section – 38 beta-particles/cm^2 min. Specific activity of the timber does not exceed 1.2 Bq/kg.

According to the criteria laid down in the document [110], unbarked timber on the CSFSF construction site does not refer to the radioactive waste by the exemption level for beta- and gamma-emitting radionuclides of Group 3 (10 kBq/kg).

According to the criteria laid down in the regulatory document [112], timber to be obtained after removal of the forest on the CSFSF construction site does not exceed the reference levels of radioactive contamination for their limited release and use in the industry.

10.7.1.2 Normal conditions of the construction

Calculation of the personnel exposure doses was performed in accordance with the document [151] approved by the Ministry of Public Health of Ukraine in 2004.

Choice of this method for assessment of the personnel dose loads during preparatory works on the CSFSF construction site is conditioned by the point that nature of this site contamination almost doesn't differ from the similar characteristics for the materials localized near the Shelter Facility and on the adjacent territory.

The following information (for each operation) was used as initial data for calculation of the personnel dose loads:

- labor costs (manhours quantity);
- activity type;
- radiation situation in the WA;
- category of the performed works by physical load;
- calculated values, IAW regulatory documents (geometry of external exposure, coefficient of transition from expositional dose of the external exposure to the effective dose of the external exposure, type of the used PRPE and their corresponding value of the effective protection coefficient - kEP);
- coefficient "effective dose rate per unit of total concentration of beta-nuclides in the air".

Data on the radiation situation in the work performance areas are shown in Chapter 10.7.1.1.

Description of the parameters used at calculations, and their values, are given in Table 10.36.

The calculation used averaged value of the dose rate for operations which labor efforts were evenly distributed in the work performance areas. In this case more sophisticated detalization of the work episodes will not lead to significant change of the results of calculation of collective and individual exposure doses of the personnel.

Averaged EDR values for specific types of works are given in Table 10.37.

The design collective effective dose of the personnel external exposure was determined by the formula:

$$SP = K_{DM} \times K_E \times EDR \times T_{RHC}, \text{ man.-mSv}, \quad (10.1)$$

where K_{DM} – design margin coefficient;

K_E - coefficient of transition from expositional dose of the external exposure to the effective dose of the external exposure, mSv/R;

EDR - design value of expositional dose rate of the external exposure in the work area, R/h;

T_{RHC} – labor efforts for performance of a certain type of works in radiation hazardous conditions, man-hours.

The design collective effective dose of the personnel internal exposure was determined by the formula:

$$S_{inhal} = (K_{DM} \times g_{E\beta} \times C_\beta \times T_{RHC})/K_{EP}, \text{ man-mSv}, \quad (10.2)$$

where K_{DM} and T_{RHC} – see formula 10.1;

K_{EP} - effective protection coefficient if PRPE is used;

C_β – averaged value of the total concentration of beta-emitting radionuclides in the work area zone, Bq/m3;

$g_{E\beta}$ - coefficient “effective dose rate per unit of total concentration of beta-nuclides in the air”, $mSv*h^{-1}\cdot Bq^{-1}\cdot m^3$. Values of this coefficient are adopted IAW the methodology approved by the Ministry of Public Health of Ukraine, for typical characteristics of the Shelter Facility aerosols [151] determined depending on the category of works. Choice of the category of works under the design depends on the degree of physical load and is made in accordance with the Order of the Ministry of Public Health of Ukraine no.248 of 08.04.2014 [149].

Table 10.36 **– Values of the parameters adopted during calculation of the current exposure doses**

Parameters considered at calculation of doses	Adopted values
Design margin coefficient, K_{DM};	2
Coefficient of the labor effors at increase of PRPE use, K_{IT}	1.1 - at the use of semi-facial filtering respiratory mask (earthworks and for the personnel in cabines of the building machinery)
Coefficient of transition from expositional dose of the external exposure to the effective dose of the external exposure, mSv/R	11 - for all activity
Averaged value of the total concentration of beta-emitting radionuclides in the work area zone (according to Chapter 4 hereof)	0.0011 Bq/m3 1)
Effective protection coefficient of PRPE, K_{EP}	K_{EP} = 20
Complexity category 2) of the performed works (by complexity)	Cat II
Coefficient “effective dose rate per unit of total concentration of beta-nuclides in the air”, $(mSv\cdot m^3)/(m\cdot Bq)$	$1.4\cdot10^{-3}$ – for Cat II works and ‘typical’ characteristics of aerosols
Reference level of the single-time (shift) individual dose , RL_S, mSv/shift	under 0.08 mSv - for all works 3)

1) According to data [“Reference on the Radiation Condition of the Environment in the Exclusion Zone in December 2012”, Chernobyl Spetskombinat SE”], the maximum value of the volumic activity of ^{137}Cs in the boundary layer of the atmosphere at ARMS checkpoint no.38 in the territory of NWBF “Buryakovka”.

2) Cat II works (physical works of medium complexity) are works associated with walking, relocation or carriage of loads under 10 kg in the standing or sitting position, and accompanied by moderate physical stress (reference energy costs of a man are within 175-290 W).

3) Shift is 10 hours

Labor efforts for performance of a certain type of works in radiation hazardous conditions (T_{RHC}) were determined by formula:

$T_{RHC} = T \times K_{UT}$, man.-h, (10.3)

where T - labor efforts for performance of a certain type of works (without considering the specifics of the works in radioactive contamination conditions);

K_{UT} – coefficient that accounts increase of labor efforts in case PRPE is used.

Duration of the work performance (tP) was determined by formula:

$t_P = T_{RHC} / N_{TM}$, h, (10.4)

where N_{TM} - number of workers in one team.

Total number of workers' teams (n) necessary for performance of a certain work is determined based on the values of reference levels of the shift exposure dose with rounding to the higher side:

$n = (S_P + S_{inhal})/(RL_S \times N_{TM})$, (10.5)

where RL_S – reference level of the shift exposure dose.

Total number of the workers participation for performance of a certain work (NTOT) was determined according to formula:

$N_{TOT} = N_{TM} \times n$, man.-part. (10.6)

Actual duration of one team work (t_{TM}) was determined by formula: $t_{TM} = t_P / n$, h (10.7)

Collective effective dose of the personnel exposure at performance of a certain work was determined by the formula:

$S_{TOT} = S_P + S_{inhal}$, man.-mSv. (10.8)

Planned individual single-time (shift) dose of one worker exposure at performance of a certain work with consideration of the dose received on the way to the workplace and back (E_0) was determined by formula:

$E_0 = S_{TOT} / N_{TOT}$, mSv. (10.9)

Assessment of the collective and individual doses of the personnel internal and external exposure was performed on the basis of the methodology [151].

Results of assessment of the personnel dose loads at performance of works on preparation of the site to the CSFSF construction are given in table 10.37.

As a result of the performed calculation on the labor efforts and collective effective exposure dose of the personnel participating in the CSFSF construction site preparatory works the following final data were obtained:

- number of man.- participations over the entire period of works – 10167;
- total labor input - 84282 man-hours;
- total collective effective dose of the personnel exposure was about 146 men-mSv of which inhalation component (internal exposure) is less than 1%.

Analysis of the performed calculations displays that reference levels of the personnel exposure will not be exceeded during works on preparation of the CSFSF construction site.

132

Table 10.37 - **Results of assessment of the personnel dose loads at performance of preparatory works on the CSFSF construction site**

Description of works	Scope of works		T, man-hours	KUT	Trhc, man-hours	Ntm persons	tR, hours	EDR on RM, R/h	SR, man-mSv	n, particip	ttm, hours	Ntot man-particip	Sinhal, man-mSv	T, days	Ttot, man-hours	Stot, man-mSv	Eo, mSv	RL ind., mSv
	UoM	Qty																
Forest clearing with stump extraction	pcs/ha	23492/18.7	28747	1.1	31621.7	30	1054	4E-05	27.8	106	10	3180	1E-01	105.4	31621,7	27.924	0.009	0.08
Removal of the technogenic soil layer, 0.2m thick	ha/m3	18.7/34516	1540	1.1	1694.0	4	424	4E-05	1.5	43	10	172	3E-04	42.4	1694.0	1.491	0.009	0.08
Planning of the territory with backfilling, soil compaction in the fill, and strengthening of slopes	m3/m2	91893 / 175750	5928	1.1	6520.8	8	815	4E-05	5.7	82	10	656	1E-03	81.5	6520.8	5.739	0.009	0.08
Arrangement of reinforced concrete fencing of the territory	m	1950	7552	1.1	8307.2	7	1187	4E-05	7.3	119	10	833	1E-03	118.7	8307.2	7.312	0.009	0.08
Construction of access onsite and temporary onsite motor roads, walkways	km	3	7983	1.1	8781.3	8	1098	4E-05	14.539	110	10	880	1E-03	109.8	8781.3	14.541	0.017	0.08
Laying of temporary water supply systems of steel pipes	m	1271	5906	1.1	6496.6	11	591	4E-05	1.454	60	10	660	2E-02	59.1	6496.6	1.474	0.002	0.08
Arrangement of temporary domestic sewage system utilities and construction of the septic tank (V=15m3)	m	139	1199	1.1	1318.9	7	188	4E-05	15.993	77	2	539	4E-03	18.8	1318.9	15.997	0.030	0.08
Arrangement of temporary onsite networks of fire water supply systems and construction of fire water reservoirs (V=3x80 m3)	m	228	2129	1.1	2341.9	7	335	4E-05	17.45	84	4	588	7E-03	33.5	2341.9	17.454	0.030	0.08
Arrangement of temporary off- and onsite power supply networks and installation of transformer substation	km	1.3	1846	1.1	2030.6	11	185	4E-05	33.44	102	2	1122	6E-03	18.5	2030.6	33.447	0.030	0.08
Arrangement of temporary networks of outdoor lighting of motor roads and security lighting of the site	km	7.5	9717	1.1	10688.7	11	972	4E-05	9.4	98	10	1078	3E-02	97.2	10688.7	9.439	0.009	0.08
Assembly of the module unit of the checkpoint, 3.0 t weight, pcs, with arrangement of foundations of concrete slabs (12 pcs)	pcs.	1	143	1.1	157.3	5	31	4E-05	0.1	4	8	20	5E-04	3.1	157.3	0.139	0.007	0.08
Assembly of the sanitary and amenities buildings (4 pcs) of module units, 4.5 t weight, with arrangement of foundations of concrete slabs (100 pcs)	pcs.	24	1189	1.1	1307.9	7	187	4E-05	1.2	19	10	133	4E-03	18.7	1307.9	1.155	0.009	0.08
Construction of warehouse premises	m2	288	2741	1.1	3015.1	9	335	4E-05	2.7	34	10	306	9E-03	33.5	3015.1	2.663	0.009	0.08
Sub-total			76620		84282				139			10167	0.186		84282	138.8		
Control and supervision, 5%			3831.0		4214.1				6.9			508.4	0.009		4214.1	6.9		
Total:			80451		88496				145.5			10675	0.195		88496	145.7		

10.7.1.3 Measures to Ensure Radiation Safety While Building CSFSF

Radiation protection of the personnel during performance of works on preparation of the CSFSF construction site is ensured by a set of organizational, radiation-sanitary and technical measures.

Organizational Arrangements

To ensure the proper level of radiation safety, the following arrangements are planned the project:

- human resource training;
- providing for safety of work;
- monitoring and supervision during performance of works.

The personnel performing the works on the territory of the exclusion zone is subject to high external and internal exposure due accidental radioactive contamination of the surrounding environment, and in accordance with [112] is classified as Category A staff.

In accordance with the requirements of [152], the following persons are permitted to work within RZ&CRZ:

- persons aged 18 and older who do not have medical contraindications for wok in contact with the ionizing radiation sources (IRS) or causation of disease and disability to the previously performed works on liquidation of consequences of the Chernobyl accident;
- the personnel who have received instruction, training and passed testing of knowledge of RS, OS and FS within the scope of their job descriptions and qualifications.

Specific arrangements providing for radiation safety during works are as follows:

- appointment of persons responsible for the safety of operations;
- briefings on RB, OS and FS;
- organization and monitoring of the use of PPE (including RPE);
- issuing permits for works and supervision of safety of works;
- registering breaks and end of work;
- maintenance and timely repair of equipment involved in the implementation of the project.

It should be noted that production of permit to perform works on the CSFSF construction site is not necessary, because the radiation conditions in the WA do not meet the established criteria of particularly dangerous works as regards the radiation dose rate (DR) (MD does not exceed 12 mSv/h) [152].

The monitoring and supervision of compliance with the RS, FS and OS regulations are carried out by the Customer's and Contractor's compliance supervision services, within their competences, in accordance with the laws of Ukraine and applicable regulations.

Radiation-Hygienic And Technical Measures

To ensure the appropriate level of RS during the work on preparation of the CSFSF construction site, the following activities are planned:

- dosimetry and medical monitoring of personnel;
- use of personal protective equipment (PPE), including respiratory protective equipment (RPE);

- organization of sanitary access control;
- dust suppression and decontamination.

Radiation monitoring is an integral part of the entire system of RS in the course of project implementation.

Personal dosimetry monitoring implies:

- monitoring the radiation situation, including:
  - monitoring of DER in the WA, temporary buildings and traffic routes;
  - monitoring of radioactive contamination of the equipment, vehicles, internal surfaces of temporary structures;
  - monitoring of volume activity of radioactive substances in the air in the working areas during execution of works;
  - monitoring of the volume activity of radioactive substances in the air at the border of the CSFSF construction site during felling and earthworks;
- control of contamination of the PPE and skin;
- personal dosimetric monitoring (IDM) of the personnel, including:
  - PDM of external exposure;
  - PDM of internal exposure;
- radiation monitoring during handling of radioactively contaminated materials and structures.

Medical services and rehabilitation of the personnel involved in the works include:

- medical examinations;
- first medical aid;
- disease prevention and treatment (if necessary);
- rehabilitation procedures (if necessary).

Medical examination of personnel and first aid will be available in SOHF-126 (Chernobyl). The workers' locker rooms located on-site in the trailers must be equipped with places with first aid kits.

According to the requirements of [152], the work in the exclusion zone are permitted only with the use of appropriate personal protective equipment. The staff is dressed in overalls, while the personal clothing is stored in the on-site dormitory (Chernobyl). Working in personal working clothing is strictly prohibited.

The personnel involved in the project will be provided with basic and additional PPE, including the sets of protective clothing and footwear for work and travel.

The content of the basic set of personal protective equipment is regulated by Cl. 3.9 of [152]. The basic set of PPE includes:

- cotton coveralls;
- headdress;
- cotton underwear;
- cotton socks;
- shoes;
- sweatshirt or jacket (depending on the weather conditions).

Additional PPE include:

- plastic protective clothing (sleeves, aprons, shoe covers, splash coats, bib and brace overalls, etc.);
- gloves (rubber, vinyl chloride, cotton);
- various helmets and protective goggles;

- hearing protection equipment and RPE.

Selection of additional PPE is dependent on the type of activity.

Furthermore, according to Paragraph 3.9.5 of [152], during travel from the place of residence (city Chernobyl) to the place of execution of works the personnel will use the transport kit of PPE, which must be marked with letter "T" (transport clothes) on the left side of the upper garment. The working kit of basic PPE should be marked with letter "P".

Compliance with these requirements and proper monitoring will provide for sufficient level of protection from radiation effects on the organs of hearing, respiratory, and skin of the workers.

Felling and earthworks on the CSFSF construction site are the works with open sources of ionizing radiation that imply the providing of temporary (for the period of preparation of the CSFSF site) sanitary inspection station, which should provide for the following:

- dressing rooms for the personnel and temporary (during the work shift) storage for the transport clothes;
- storage of clean sets of working clothes and other personal protective equipment;
- place for intermediate storage of contaminated clothing and used disposable PPEs before dispatch to the laundry (for deactivation) or for disposal;
- equipped room for washing (decontamination) hands and other exposed parts of the body;
- storage for bottled drinking water.

The project provides for the organization of temporary sanitary inspection station on the basis of semi-detached residential trailers, divided into two parts — "clean" and "dirty" — with a vestibule with small a washing trailer in between. The staff will pass the temporary sanitary inspection station, leave the transport clothing in the "clean" part, and pass through the sanitary barrier to the "dirty" part to put on the working clothing and additional PPE. In the reverse direction, from the "dirty" part to the "clean" part, the staff will be provided with the opportunity to wash the open skin (hands and face) in the attached washing trailer with the water supply system and the waste water collector.

The project provides for the monitoring of radioactive contamination of clothing and the body surface of the personnel at the radiation monitoring station provided. The radiation monitoring station will be located in a separate residential trailer adapted for this purpose. If the contamination levels of personal clothing and footwear exceed the established threshold, they are subject to decontamination, and in case decontamination is impossible, they are disposed of under certificate.

Radiation monitoring of vehicles and cargoes will be carried out at the dosimetry monitoring stations (DMS) when traveling beyond the borders of the first and second zones — "Lelev" and a “Dytyatki", respectively. If necessary, pursuant to the provisions of [152], decontamination of vehicles is carried out at the sanitization station "Lelev" (SS "Lelev"). In addition, the Contractor, on a contractual basis, can perform decontamination of vehicles at the facilities of enterprises located near the CSFSF construction site (Complex "Vector" and NWBF “Buryakovka”).

Exit of vehicles from the exclusion zone is carried out with mandatory radiation monitoring on the DMS "Dityatki" and is allowed only if the the established clearance radiation level is not exceeded.

Loads transported outside the exclusion zone shall be subject to mandatory radiation monitoring and registration.

Dust suppression is the most effective measure to minimize the generation of radioactive aerosols in the air in the working areas.

The need for dust suppression in the WA, as well as its frequency and amounts are determined by the types of activity, season and current weather conditions (rain, wind, etc.). Various formulations are used, depending on the desired period of dust control.

Dust suppression is provided for in the performance of works related to high dusting — hauling cut trees, uprooting stumps, grading the surface of construction plots and other earthworks. Depending on the initial situation, the dust control may be performed prior to the commencement of works and periodically during operation.

During the works (if necessary) the decontamination of the following is to be provided for:

- open skin of the staff;
- temporary structures on the construction site;
- construction and transport equipment;
- small equipment and tools;
- PPE and work footwear.

The necessity and frequency of decontamination of the facilities mentioned above depend on the results of radiation monitoring.

Selection and equipment of the station for decontamination of the construction and transport equipment, as well as small equipment and tools, are carried out by the Contractor.

Washing the open skin of the staff will be carried out in the wash basins, located in the premises of temporary sanitary inspection station.

Washing of work shoes in trays with decontamination solution will be carried out in places where they are installed.

Measures For The Prevention Of Potential Radiation Accidents And Minimizing Their Consequences During Construction Of The CSFSF

The most important measures for the prevention of potential radiation accidents and minimization of their effects to be taken during preparation of the CSFSF construction site are as follows:

- dust suppression during performance of the works related to high dusting — hauling cut trees, uprooting stumps, other earthworks;
- fire prevention;
- prevention of failure of radiation monitoring means;
- prevention of failure of personal protective equipment (PPE);
- prevention of human errors.

Minimization Of Dusting During Performance Of Earthworks

Intense dusting is expected in the performance of works on preparation of the construction site — hauling cut trees, grubbing of stumps and planning of the surfaces.

Measures to prevent this event are:

- dust control before and during the works that can cause substantial dust rise from the surface of the ground;

- monitoring of correct and consistent implementation of technological operations;
- execution of works in the most favorable time in terms of season (spring, autumn) and weather conditions (absence of strong winds, moderate rainfall, high soil moisture, etc.);
- issuing work permits to certified and qualified staff, instruction before works, in particular, on radiation and other conditions of work, most dangerous places, etc.;
- providing for temporary (mobile) station for the monitoring of the volume activity of air on the border of the CSFSF construction site during hauling cut trees, grubbing of stumps, planning of the surfaces, and other earthworks.

Fire Prevention

Most fire hazardous works on the preparation of the CSFSF construction site are deforestation and stubbing of stumps, because there is a probability of forest fires and fires of the forest bed leading to significant additional radiation exposure to personnel and the environment.

The most effective interventions for prevention of fire when working on the preparation of the CSFSF construction site are as follows:

- exclusion techniques using fire works;
- working during the seasons of low fire risk (if possible);
- timely cleaning of the site from forest residues (after logging) and uprooted stumps;
- ensuring reliability, operability, compliance with the rules of operation of technical equipment, failure of which may cause ignition;
- strict implementation of the fire safety and electrical safety regulations by the staff;
- providing staff with primary fire extinguishing means (fire racks);
- setting up of fire-protection mineralized belts around around the construction site and temporary structures of the Contractor;
- providing for reliable communication among the staff that monitors the safety of works and is directly involved in the works;
- issue of work permits only to qualified and certified personnel, instruction before works, relevant training to extinguish local fires.

During construction works, the fire may occur in the presence of combustible materials in the WA and the possibility of fire, failure of equipment or human error, as well as in case of violation of the fire safety requirements.

The most effective measures to prevent possible fires are as follows:

- minimizing the volume of hot works;
- preparation of WAs to eliminate (reduce) the fire risk, in particular exclusion of combustible materials, their timely removal;
- monitoring of correct and consistent implementation of technological operations;
- issue of work permits only to qualified and certified personnel, instruction before works.

Prevention Of Failure Of Radiation Monitoring Means

Measures to prevent this event are:

- preparation and implementation of the rules of radiation monitoring to ensure sufficient control of potential emergency situations and accidents;
- provision with serviceable, reliable technical means of radiation monitoring (in particular, regular operability checks before works) and compliance with the rules of their operation;
- provision of the technical means of radiation monitoring with reliable power supply;
- radiation monitoring using certified and qualified personnel in compliance with the rules of radiation control.

Prevention Of Failure Of Personal Protective Equipment (PPE)

Measures to prevent this event are:

- providing the staff with additional PPE;
- compliance with the rules of use of additional personal protective equipment, in particular, in accordance with the terms and conditions of works, for which the PPE is intended;
- enforcement of monitoring of the integrity and serviceability of additional PPE;
- monitoring of contamination of basic and additional personal protective equipment;
- issue of work permits only to qualified and certified personnel, instruction before works, proper training to use the PPE.

Prevention Of Human Errors

Measures to prevent this event are:

- training of the staff to perform certain works;
- preparation for works and ensuring safety conditions in the workplaces;
- providing for reliable communication among the staff that monitors the safety of works and is directly involved in the works;
- monitoring of correct and consistent implementation of technological operations;
- creating the conditions for mandatory compliance with the rules of radiation, fire and industrial safety of the personnel;
- provision of radiation monitoring in the work areas and at the borders of zones;
- provision of personnel with reliable PPE according to the conditions of works;
- issue of work permits only to qualified and certified personnel, instruction before works, proper training.

The implementation of the above measures is expected to ensure acceptable levels of radiation safety.

10.7.1.4 Accidents During Construction

All original events during construction associated with falling of cargo or equipment failure do not lead to the exposure of personnel to radiation. As regards the possible external source of accidents on the construction site, the only critical event that can lead to significant radiation exposure to the CSFSF construction staff is forest fire in the early stages of preparatory works (prior to removal of vegetation).

This is due to the fact that the major part of construction and installation works will be carried out on an already treated area, so significant radiation exposure to personnel in such accidents as falling of cargo, cranes, etc. is not expected.

Fires are quite common in the Chernobyl exclusion zone. According to "Chernobylles" (Forestry) [153], 60-100 fires are registered annually, the vast majority of which occur in the areas not covered by forests (deposits). Given that the site preparation for the construction of CSFSF will include a set of activities to remove the stands on the construction site and building of access roads, the risk of fire and wood litter burning during such activities is quite high.

The fires in such conditions are of creeping type, when the litter, grass and shrub burns. In the process of development of such fires, the radionuclides emitted with smoke and soot and deposited on the wood and litter, will be distributed in the atmosphere leading to additional contamination of soil and increase of the concentration of radionuclides in the surface air layer. This process results in concentration of radionuclides in the ash litter and the release of radioactive aerosols into the air.

The initial data on fractional composition and biomass stock of forest vegetation on the CSFSF construction site are based on the experimental data presented in Tables 10.38 and 10.39.

Table 10.38 — **Fractional Composition Of Biomass Of Forest Stands On The CSFSF Construction Site**

Phytocenosis Component	Trunk		Branches	Leaves, Needl	Leaves Bed	
	Wood	Bark			AoL	AoF+AoH
Phytomass Stock, t/ha	111	22	23	4	7	11

Table 10.39 shows the fractional composition and biomass stock in the 30-40 year old forest stands, growing on the territory of the CSFSF construction site (in tonnes of absolutely dry substance per 1 hectare) [154].

The values of specific activity, in terms of $_{137}$Cs, of the components of forest phytocenosis have been identified on the basis of the transition coefficient presented in [155].

Table 10.12 shows the content of $_{137}$Cs in the components of the Scotch pine's biomass (Bq/kg) at the contamination density of soil (230 kBq/m$_2$), taken into account in the assessment on the CSFSF construction personnel exposure.

Table 10.39 — **Accumulation Of ^{137}Cs In The Components Of Pine Phytocenosis, Bq/kg**

Trunk		Branches	Leaves, Needl	Leaves Bed	
Wood	Bark			AoL	AoF+AoH
56	111	223	270	170	21800

The calculations use the data on the litter contamination density set out in [156] based on the results of field experiments. In [156], it was found that creeping fires in the 30-40 year old pine phytocenoses burn the upper (AoL) and enzymatic (AoF) layers of litter. The humus layer (AoH) of the litter (which contains the bulk supply of radionuclides deposited in the litter) does not burn in creeping fires, and hence the radionuclides that have been deposited in it are not involved in the processes of the secondary transfer.

Numerous observations of the flow of creeping fire show that, after the initial phase, during which the fire area grows spontaneously, there comes the state of dynamic equilibrium, where the area is preserved in time: instead of burnt forest areas, there appear new plots of equivalent size [157].

The estimates show that the greatest danger is fire, which may occur during the construction in the northern part of the site with surface contamination values of about 160 kBq/m $_2$ $_{137}$Cs, 40 kBq/m$_2$ $_{90}$Sr and 4 kBq/m$_2$ α-active TUE.

The propagation velocity of surface fire front in the direction of wind may be from 0.5 to 3 m/min (the propagation velocity in the opposite direction is 6-10 times lower). At the average wind speed in the region (3.3 m/s at 10 m), the propagation velocity of creeping fire will be about 0.7 m/min. It is conservatively assumed that the velocity of propagation of fire is 1 m/min, the wind direction — in the direction of Chernobyl, and the point of fire — on the track axis.

In this case, the 4-hour fire will burn the total area of about 72 thousand m$_2$, which will lead to the total emission of about 10.8×10$_8$ Bq of $_{137}$Cs, 2.9x10$_8$ Bq of $_{90}$Sr and 2.9x10$_8$ Bq of alpha-active TUE. Here the time, t, during which complete combustion of forest litter to the state of dynamic equilibrium occurs is about 1000 seconds [157], the area of intense burning — about 5 thousand m$_2$, the rate of release — about 3.8x10$_6$ Bq/s for ^{137}Cs, 2.0x10$_6$ Bq/s for ^{90}Sr and 4.0x10$_4$ Bq/s for alpha-active TUE.

The modeling of radionuclide transfer process during creeping fire was based on a modified Gaussian model [158]. The impurity plume rise was calculated according to [160] with regard for the ultimate fire area [159] and the flame radius [161].

The calculations showed that the highest surface contamination will be observed at the distance of about 4000 meters from the site of fire and will amount to 4 Bq/m$_2$ for $_{137}$Cs, 0.9 Bq/m$_2$ for $_{90}$Sr, and 0.1 Bq/m$_2$ for alpha-emitting TUE.

The maximum volume activity of ^{137}Cs radionuclides in the air will be observed at the distances of ~4-5 km from the site of fire, and will not exceed 0.04 Bq/m$_3$. The maximum volume activity of $_{90}$Sr in the air will not exceed 0.008 Bq/m$_3$, and the maximum value of volumetric activity of alpha-emitting TUE will not exceed 0.01 Bq/m$_3$.

The individual effective dose for the personnel at the distance of maximum surface concentration (approximately 4000 m) will be from 5 to 35 uSv, depending on the weather conditions, which does not exceed the dose limits established in NRBU-97.

It should be noted that the additional surface contamination and individual effective dose for the staff calculated using this method are conservative. The forest fire alert and suppression systems currently available in the Chernobyl exclusion zone can reduce the damage arising from forest fires.

The estimates show that the localization time for the forest fire under consideration (detection, departure of fire brigades, deployment, start extinguishing and localization of fire in the area where combustion occurs) is about 30 minutes. During this time, burn about 10% of forest plantations in the CSFSF area may burn. In addition, this approach assumes that the staff who will carry out the construction of CSFSF, will be in the zone of radioactive aerosols throughout the time of fire (about 4 hours). During the development of the construction project,

it is planned to elaborate on the measures to evacuate the personnel in case of accidents during the construction.

It should be borne in mind that the fires in the exclusion zone may not be related to the CSFSF construction as well. To reduce or eliminate the risk of fire the measures to ensure fire safety were proposed.

10.7.2 Radiation Safety During CSFSF Operation

Radiation safety during operation of the CSFSF will be ensured, if the radiation impact on the personnel, population and environment is kept within normal operating conditions of the CSFSF, in case of violation of normal operating conditions and during design basis accidents that do not result in exceeding the established dose limits of radiation for workers and the public, the standards for emissions, discharges, content of radioactive substances in the environment, and will be limited during beyond design basis accidents.

10.7.2.1 Radiation Situation In The Territory And In The Premises Of CSFSF

The radiation situation in the territory and in the premises of CSFSF is determined by the factors that can be divided into two groups:

- the factors not associated with the CSFSF operation;
- the factors caused by the operation of CSFSF.

The main factor not related to the CSFSF operation, but forming the radiation situation is the ionizing radiation from the surface contamination of the territory as a result of the accident at the Unit 4 of the Chernobyl Power Plant in 1986. The value of the background radiation during operation of CSFSF will depend on the effectiveness of decontamination activities (removal of the surface layer of soil) carried out during the construction phase. The expected radiation contribution to the total dose after construction and installation works is significantly less than today.

The main sources of radiation in the territory and in the premises of CSFSF are the factors caused by the operation of CSFSF, namely MPC SFA during cargo transfer from HI-STAR to HI-STORM, and the HI-STARs and the HI-STORMs, loaded with MPCs with SFAs.

The CSFSF site, in terms of radiation hazard, is subdivided into the following areas:

- high-security zone — the territory, buildings and separate premises where the radiation exposure of personnel is determined by both the accidental pollution and the factors caused by the operation of CSFSF;
- free regime zone — the territory, buildings and separate premises where the radiation exposure of personnel is determined only by the accidental pollution, and where the sources of ionizing radiation, caused by the operation of CSFSF, are not handled;

The ionizing radiation sources, caused by the operation of CSFSF include:

- MPCs with SFA placed in the HI-STAR cask;
- MPCs with SFA in CTD during transfer from HI-STAR to HI-STORM;
- MPCs with SFA placed in the HI-STORM;
- equipment and filters of the exhaust ventilation system;

- RW casks;
- radioactively contaminated surfaces of equipment and facilities;
- radioactively contaminated PPE, kept in the sanitary inspection station;
- radioactively contaminated additional PPE.

At the specified division of the CSFSF territory into zones depending on the possible radiation exposure of personnel, the high-security zone comprises as follows:

- reception building premises listed in Table 10.40;
- storage area for HI-STORM casks;
- Automated Radiation Monitoring System station at the entrance to the casks storage facility;
- internal railway tracks and track №6 for holding HI-STAR cask cars with SFA.

The rest of the territory, buildings and separate premises of the CSFSF belong to the free regime zone.

Table 10.40 — **Reception Building Premises Within The High Security Zone**

Room No.	Room Name
	Mark 0.000
114	Central Room (transport-technological operations)
104	Machine repair shop
105	Room for cleaning and decontamination of machinery
106	Decontamination chemicals storage facility
107	Radiochemical laboratory
108	Vestibule
109	Floor drain tanks room
110	Monitoring tank room
111	Special sewage pumps room
112	Corridor
113	Staircase
115	PPE room
119	Lavatory
120	Cargo elevator well
123	Service room
124	Lobby
125	Tools storage facility
	Mark 4.200
222	KRB room
223	Wiping room
224	Shower room
225	Male locker room for overalls (sanitary inspection station)
226	Lavatory
227	Dirty overalls room
231	KRB room
232	Wiping room
233	Shower room
234	Female locker room for overalls (sanitary inspection station)
235	Lavatory
236	Dirty overalls room

Room No.	Roon Name
238	Corridor
239	KRB with washroom
240	Room for shift dosimetrist
241	Dirty overalls room
242	PPE room
	Marks 7.800, 11.000
402	Exhaust ventilation room
405	Corridor

Detailed description of the zoning of the territory and premises of CSFSF is supplied in Part 1 “Architectural-Construction Solutions. Architectural Solutions”, Volume 4.

10.7.2.2 Characteristics Of IRS

SFA are delivered to the CSFSF in sealed multipurpose casks — MPC. The main sources of ionizing radiation source in MPC is SFA. The CSFSF is expected to keep the SNF VVER-1000 and VVER-440 units.

Company Holtec International calculated [140, 142] the radiation protection of HI-STORM 190 and HI-STAR 190 spent nuclear fuel storage and transportation systems, the doses of MPC for CSFSF under normal, violations of normal operation and design base accidents.

The analysis of biological protection can be divided into two parts. The first part is the calculation of the radiation characteristics of spent nuclear fuel with the corresponding values of burnout and holding time. The second part is modeling of penetration of particles through the biological protection to assess the dose values at various points.

The calculations of radiation protection [140, 142] were made using the following computer codes:

- SAS2H/ORIGEN-S (software modules of SCALE 4.4) — for the calculation of accumulation and decay of nuclides in the fuel assembly, the radiation characteristics of spent nuclear fuel and residual energy after discharge from the reactor assembly.
- MCNP5 version 1.40 — general purpose code based on the Monte Carlo method, used to calculate the transfer of individual particles (neutrons, photons, electrons) and the joint transfer of particles (neutron/photon/electron).

MPC is a sealed cask with two sealing barriers. Tightness of the MPC is provided by design and quality of workmanship as in [139]. Based on this, the internal exposure doses for personnel in the course of handling of spent nuclear fuel under normal operating conditions of the CSFSF are absent.

The doses of external radiation during handling of SNF on the CSFSF are determined by the gamma and neutron radiation from the spent nuclear fuel.

The gamma radiation of the spent nuclear fuel comes from three separate sources. The first is the sources of gamma radiation in the active (fuel) zone of SFA resulting from decay of fission products and actinides. The structure of this source of radiation consists of 163 main radionuclides — fission products and radionuclides — actinides present in the spent fuel. The second source is the radionuclides of ^{60}Co in the steel structural materials of the fuel assembly, which are located above and below the fuel portion of the fuel assembly. The main source of gamma radiation in the structural materials of the VVER SFA is ^{60}Co.

Inclusions of ^{59}Co contained in the stainless steel of the head and shank of the FA, under neutron radiation, are activated into radioactive ^{60}Co with half life of 5.27 years. In order to calculate the content of inclusions of ^{59}Co in the steel structural elements, it is conservatively assumed at four times the content in the stainless steel. The third is the gamma radiation as a result of (n, γ) reactions.

The neutron radiation includes spontaneous fission and (α,n) reactions of the actinides, such as ^{238}Pu, ^{242}Cm and ^{244}Cm.

[140] contains the analysis of the characteristics of VVER-1000 and VVER-440 fuel assemblies, and the selection of maximum values of the parameters in terms of radiation. In order to select the maximum (in terms of radiation characteristics) parameters, different characteristics of SFA were analyzed: UO_2 weight, diameter of the tablet, enrichment tolerances, burning, exposure time, etc., resulting in a defined set of characteristics that lead to the maximum dose values.

When calculating the radiation characteristics, the following key assumptions were considered:

- A single full fuel cycle exposure until required burnout was assumed.
- The content of ^{59}Co inclusions in the steel elements of the FA was assumed at 1 g/kg. This assumption is conservative, since the content of ^{59}Co in the steel grades used for the core structures is 0.25 g/kg.
- The temperature of the fuel cladding for VVER-1000 and VVER-440 was assumed at 607.8 K.
- For VVER-440, the fuel portion length in the "hot" state was assumed at 2500 mm, for VVER-440, the fuel portion length in the "hot" state was assumed at 3550 mm.

The calculations of maximum values of initial fuel enrichment using MCNP5 code: fuel enriched to 4.34% ^{235}U for VVER-440 with maximum depth of burn of 55000 MW*d/t(U) and FA enriched to 4.6% of ^{235}U for VVER-1000 with the maximum depth of burn of 58000 MW*d/t(U) [140].

Tables 10.41-10.44 show the parameters of MPC, HI-STAR 190 and HI-STORM 190 used in the calculations of biosecurity [140, 142].

Table 10.41 — **Features Of MPC-31 For VVER-1000 Spent Fuel Assemblies [140]**

Component and Parameter	Value
Fuel basket	
Number of cells, pcs	31
The total height of the basket, mm	4400
Inner cell diameter, mm	243.6
Hermetic casing	
Inner diameter, mm	1835
Outer diameter, mm	1924
Height of the internal cavity, mm	4618
Overall height, mm	5047

Table 10.42 — **Features Of MPC-85 For VVER-440 Spent Fuel Assemblies [140]**

Component and Parameter	Value
Fuel basket	
Number of cells, pcs	85
The total height of the basket, mm	3185
Inner cell diameter, mm	155
Hermetic casing	
Inner cavity diameter, mm	1875

Component and Parameter	Value
Outer cavity diameter, mm	1924
Height of the internal cavity, mm	3278
Overall height, mm	5074

Table 10.43 — **Features Of HI-STAR 190 Cask [140]**

Component and Parameter	Value, mm
Overall height	5657.8
Outer diameter	2708
Inner cavity diameter	1933.6
Depth of cavity	5057
Cask body	
Inner diameter of the neutron shielding	2365.4
Outer diameter of the neutron shielding	2683
Journals	
Diameter	266.7
Cap	
Total thickness	200
Outer diameter	2190.8
Damping device	
Outer diameter of the shock ring	3251

Table 10.44 — **Features Of HI-STORM 190 Cask [140]**

Component and Parameter	Value, mm
Overall height	5403.12
Outer diameter (at bottom)	3556
Cask body	
Height of the inner and outer shells	5097
Inner diameter of the inner shell	2057.4
Outer diameter of the inner shell	2095.6
Inner diameter of the outer shell	3492.6
Outer diameter of the outer shell	3530.8
Bottom and top plate	
Bottom diameter	3556
Thickness of the upper plate	25.4
Bottom thickness	76.2
Cap	
Total thickness	273.1
Outer diameter	3178.2

The radiation characteristics, assumed while calculating the doses [140, 142], are shown in Tables 10.45, 10.46 and 10.47.

Table 10.48 contains the data [140] on the isotopic composition of the fuel for the isotopes, whose contribution to the total activity is at least 0.1%.

Table 10.45 — **Range Of Gamma Radiation On The SFA [140]**

Min. energy	Max. energy	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 6 years		VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 7 years		VVER-440 SFA, burning of 53,500 MW*d/t(U), ageing — 5 years	
(MeV)	(MeV)	(MeV/s)	(photons/s)	(MeV/s)	(photons/s)	(MeV/s)	(photons/s)
4.50E-01	7.00E-01	2.21E+15	3.85E+15	1.98E+15	3.44E+15	5.94E+14	1.03E+15
7.00E-01	1.00E+00	6.85E+14	8.06E+14	5.07E+14	5.96E+14	1.83E+14	2.15E+14
1.00E+00	1.50E+00	2.32E+14	1.86E+14	1.96E+14	1.57E+14	4.98E+13	3.98E+13
1.50E+00	2.00E+00	1.25E+13	7.15E+12	1.04E+13	5.92E+12	3.35E+12	1.91E+12
2.00E+00	2.50E+00	3.00E+12	1.33E+12	1.34E+12	5.96E+11	7.15E+11	3.18E+11
2.50E+00	3.00E+00	1.61E+11	5.85E+10	8.17E+10	2.97E+10	3.93E+10	1.43E+10
Total		3.14E+15	4.85E+15	2.69E+15	4.20E+15	8.30E+14	1.29E+15

Table 10.46 — **Range Of Neutron Radiation On The SFA [140]**

Min. energy	Max. energy	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 6 years	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 7 years	VVER-440 SFA, burning of 53,500 MW*d/t(U), ageing — 5 years
(MeV)	(MeV)	(neutron/s)	(neutron/s)	(neutron/s)
1.0E-01	4.0E-01	5.25E+07	5.06E+07	1.55E+07
4.0E-01	9.0E-01	1.14E+08	1.10E+08	3.38E+07
9.0E-01	1.4	1.14E+08	1.10E+08	3.37E+07
1.4	1.85	9.12E+07	8.78E+07	2.69E+07
1.85	3.0	1.70E+08	1.64E+08	5.01E+07
3.0	6.43	1.54E+08	1.49E+08	4.55E+07
6.43	20.0	1.47E+07	1.42E+07	4.34E+06
Total	6.23E+08	7.11E+08	6.85E+08	2.10E+08

Table 10.47 - **Activity Of Construction Materials Of The SFA [140]**

Exclusion	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 6 years	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 7 years	VVER-440 SFA, burning of 53,500 MW*d/t(U), ageing — 5 years
Unit	(photons/s)	(photons/s)	(photons/s)
FA head	1.82E+13	1.60E+13	5.48E+12
Plenum	2.79E+12	2.44E+12	-
Fuel portion	1.42E+14	1.24E+14	-
FA shank	2.55E+13	2.24E+13	1.05E+13

Table 10.48 - **Isotopic Composition Of Fuel (g) In The SFA [140]**

Isotope	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 6 years	VVER-1000 SFA, burning of 55,000 MW*d/t(U), ageing — 7 years	VVER-440 SFA, burning of 53,500 MW*d/t(U), ageing — 6 years
^{241}Pu	9.13E+02	8.7E+02	2.44E+02
^{137}Cs	8.51E+02	8.31E+02	2.31E+02
^{137m}Ba	1.30E-04	1.27E-04	3.52E-05
^{90}Sr	3.40E+02	3.31E+02	9.22E+01
^{90}Y	8.83E-02	8.61E-02	2.40E-02
^{134}Cs	1.64E+01	1.17E+01	4.36E+00
^{147}Pm	2.11E+01	1.62E+01	5.39E+00
^{106}Ru	2.15E+00	1.09E+00	5.23E-01
^{144}Ce	1.04E+00	4.26E-01	2.46E-01
^{144}Pr	4.40E-05	1.81E-05	1.040E-05
^{244}Cm	6.31E+01	6.07E+01	1.82E+01
^{85}Kr	1.23E+01	1.15E+01	3.30E+00
^{154}Eu	1.77E+01	1.64E+01	4.88E+00
^{238}Pu	2.53E+02	2.51E+02	7.41E+01
^{125}Sb	1.50E+00	1.17E+00	3.47E-01
^{241}Am	3.51E+02	3.93E+02	9.56E+01

The maximum dose rates, obtained in [140], which were used in calculation of the personnel radiation exposure, are set out in Tables 10.49-10.50.

Table 10.49 shows the results of calculation of the maximum dose rates [140] for the MPC-31, from the center of the surface of the MPC-31 top cap. Table 10.50 shows the dose rates for MPC-85 with the same geometry [140].

Table 10.49 — **Maximum Dose Rate As A Function Of Distance From The Center Of The MPC-31 Cap [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Total (mSv/h)
0	0.585	4.705	0.354	0.006	5.650
1	0.197	1.280	0.048	0.002	1.527
2	0.103	0.675	0.075	0.001	0.854

Table 10.50 — **Maximum Dose Rate As A Function Of Distance From The Center Of The MPC-85 Cap [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Total (mSv/h)
0	1.257	3.412	2.313	0.010	6.991
1	0.447	0.734	1.150	0.004	2.334
2	0.211	0.501	0.570	0.002	1.284

Table 10.51, according to [140], shows the maximum dose rates of HI-STAR 190 with MPC-31 under normal operation and accident conditions. Falling and fire were assumed as two possible events leading to deterioration of the properties of biological protection of the HI-STAR 190 casks. The borderline case was analyzed for both of these situations using the configuration in which the cask has no neutron protection — material Holtite.

Table 10.52 shows the maximum dose rates of HI-STAR 190 with MPC-85 under normal operation as described for HI-STAR 190 with MPC-31 above.

Table 10.51 — **Maximum Dose Rates On The Surface Of HI-STAR 190 With MPC-31 [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Subtotal (mSv/h)
Normal Operation					
0 (at the surface)	1.027	0.067	0.050	0.015	1.159
Emergency Conditions					
1	5.985	0.030	0.071	0.016	6.102

Table 10.52 — **Maximum Dose Rates On The Surface Of HI-STAR 190 With MPC-85 [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Subtotal (mSv/h)
Normal Operation					
0 (at the surface)	0.796	<0.0001	0.038	0.081	0.914
Emergency Conditions					
1	6.318	0.026	0.077	0.014	6.435

Table 10.53 shows the maximum dose rates of HI-STORM 190 with MPC-31 (lateral surface) according to [140], and Table 10.54 shows the maximum dose rates of HI-STORM 190 with MPC-85. The dose rates stated in Tables 10.53 and 10.54 are for normal operation.

Due to highly reliable design of the storage unit in HI-STORM 190, considered in [140] in accordance with [39], the hypothetical accident (flood, fire, earthquake, hit by flying object) will not affect the biological protection performance of the cask. Accidents involving rollover of the storage unit of HI-STORM 190 are excluded by the design requirements. In some emergency situations (blockage of ventilation ducts, flooding, debris accumulation), the values of the dose rate of the cask will be lower than under normal conditions. Accordingly, the normal conditions of storage with the design fuel inside are the boundary conditions that also cover contingencies and emergency storage conditions.

Table 10.53 **— Maximum Dose Rate Of The Lateral Surface Of HI-STORM 190 Loaded With VVER-1000 Fuel (MPC-31) [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Subtotal (mSv/h)
0 (at the surface)	0.024	0.115	0.264	0.028	0.429
1	0.010	0.052	0.135	0.013	0.211
2	0.006	0.038	0.084	0.007	0.134

Table 10.54 **- Maximum Dose Rate Of The Lateral Surface HI-STORM 190, When Loading VVER-440 Fuel (MPC-85) [140]**

Distance, m	Neutron radiation (mSv/h)	^{60}Co (mSv/h)	SNF gamma (mSv/h)	N-gamma (mSv/h)	Subtotal (mSv/h)
0 (at the surface)	0.027	0.001	0.427	0.030	0.485
1	0.010	0.023	0.199	0.012	0.243
2	0.005	0.027	0.107	0.006	0.145

10.7.3 Estimated Doses Under Normal Operation

The doses received by the personnel during normal operation will be determined mainly by:

- handling of HI-STAR and HI-STORM casks in the central transfer room;
- maintenance of the storage facility.

This section provides enlarged estimate of the dose rates affecting the CSFSF personnel while performing works, as provided by Holtec. The detailed evaluation of radiation dose rates should be given in the PSAR.

10.7.3.1 Evaluation Of The Dose Rates During Handing Of MPCs In The CSFSF

The received dose rate estimate depends on the following initial conditions:

- the team that conducts works in the central room of the building and the reception team that performs works on power units is the same team;
- according to the Customer's data, the maximum expected number of HI-STAR casks with spent nuclear fuel received by the CSFSF is 16 pieces a year;
- the dose rates for the vehicle drivers are not taken into account, as drivers perform on the works related to transportation to the CSFSF;
- the specific location of personnel is not taken into account, it is believed that the personnel involved in the operation is affected by the same dose rate;
- in order to perform the works according to the data by Holtec's technology developers, the team should consist of five (operators 1-5), who can perform all the necessary operations;
- it is assumed that 50% of the allowable individual dose rate is received by the personnel while loading at the reactor units, another 50% — during transfer at the CSFSF.

The estimation of dose rates for the personnel while handling the spent fuel in the reception building is presented in Table 10.55.

Table 10.55 — **Estimated Dose Rates For The Personnel In Case Of Transfer Of MPCs At The CSFSF**

Works	Operations Duration, h	Average Dose Rate, mSv/h	Maximum Annual Dose Rate For Operation (16 Casks Per
Reception of the transporter rail car with the HI STAR transport cask, loaded with MPC with SFA			
- removal of the personnel barrier (protective cover);	0.3	1.16	5.57

Works	Operations Duration, h	Average Dose Rate, mSv/h	Maximum Annual Dose Rate For Operation (16 Casks Per Year), mSv/year
- removal of fixing ties from the HI-STAR;	0.17	1.16	3.16
- removal of the dampers.	0.17	0.31	0.84
SUBTOTAL			***9.57***
Preparation of HI-STAR for transfer of the MPC to the HI-STORM			
- tipping of the HI-STAR cask from the horizontal to vertical position and unloading of the HI-STAR cask from the rail car to a special work platform;	0.17	1.16	3.16
- sampling of the gas from the annular gap of the HI-STAR;	0.1	0.31	0.50
- HI-STAR lid removal;	0.4	0.31	1.98
- installation of the lifting device (accessory) to the MPC;	0.3	5.65	27.12
- alignment of the CTD and the HI-STAR.	0.04	0.85	0.54
SUBTOTAL			***33.30***
Transfer of the MPC to the HI-STORM			
- removal of spindles (stops), CTD;	0.04	0.85	0.54
- installing stops, CTD;	0.04	0.43	0.28
- alignment of the MPC lifting yoke;	0.04	0.43	0.28
- CTD stops extension;	0.4	0.43	2.75
- disconnecting the MPC lifting device.	0.2	5.65	18.08
SUBTOTAL			***21.93***
Transfer of the HI-STORM cask from the reception and handling building to the storage area by a special vehicle			
- installation of the cap on the HI-STORM cask;	0.33	0.4	2.11
- attaching VCT lifting lugs to the HI-STORM;	0.08	0.43	0.55
- fixing of the HI-STORM to the VCT using hydraulically tensioned hold-down belts;	0.08	0.43	0.55
- transfer of the HI STORM to the storage site;	0.5	0.21	1.68
- disconnection of HI-STORM from the VCT on the permanent	0.17	1.08	2.94

Works	Operations Duration, h	Average Dose Rate, mSv/h	Maximum Annual Dose Rate For Operation (16 Casks Per Year), mSv/year
storage site;			
oval of the lid fasteners from the HI-STORM cask;	0.08	1.08	1.39
- checking the temperature control system, replacement of the IAEA seals.	0.08	1.08	1.39
SUBTOTAL			***10.61***
annual dose, mSv/year			**75.4**

Given that the team spends most of the year at the CSFSF located in the exclusion zone, the assessment of the individual dose rates is based on the reference level of external exposure in the exclusion zone, i.e. 11 mSv/year.

Thus, for the team performing the operations set out in Table 10.28, the individual dose rate limit is estimated at 5.5 mSv/year.

In order to prevent the exceedance of the individual annual dose, the number of staff performing the transfer at the power units and at the CSFSF should be: 75.4/5.5=13.7 or 14 people. Thus, it is proposed to provide for three teams of 5 people.

10.7.3.2 Evaluation Of Doses During Maintenance Of The Cask Storage Area

The received dose rate estimate depends on the following initial conditions:

- the maintenance of storage site is performed by the following staff not involved in other radiation-hazardous operations:
  - the lineman performs inspection, physical activities, drives motor vehicles, cleans the territory;
  - the control and instrumentation technician services the temperature control system;
  - the electrician services the electrical systems.
- the dose assessments is performed for the most loaded storage site — the design capacity is 458 casks;
- when working with a HI-STORM cask, a set of works (checking ventilation ducts, external examination) is performed;
- the vehicular traffic speed on the site is limited — no more than 5 km/h;
- it is assumed that as a result of daily work around by car, in case of blockage of the duct or presence of debris near the duct, the inspector will call for additional staff to such a cask. Therefore, the dose rate during cleaning of the ventilation ducts are not considered;
- checking and calibration of the temperature control system — no more than once in three years;
- checking the grounding system — no more than once a year;
- removal of garbage, snow, leaves — no more than once a month;

- remote monitoring of the MPC state using video cameras is performed via upper air ducts during inspection of the upper air ducts — not more than once every four years;
- external inspection of the site is carried out daily by car;
- the assessing of the doses rate does not provide for the maintenance of the radiation monitoring system sensors, as they are located in the places not affected by the casks in the storage.

The estimation of dose rates for the personnel while handling the spent fuel in the reception building is presented in Table 10.56.

The following special equipment is planned for maintenance operations:

- mobile cradle for servicing output air ducts and control devices located at a height;
- snow-fighting vehicle.

Table 10.56 — **Assessment Of Doses During Maintenance Of The Cask Storage Area**

Works	**Operations Duration, h**	**Average Dose Rate, mSv/h**	**Number Of Operations Per Year**	**Maximum Annual Dose For The Operation, mSv/year**
Inspector				
Visual inspection	0.5	0.68	365	124.10
Removal of snow, garbage, leaves	1.5	0.68	12	12.24
Inspection of the outer surface of the HI-STORM and MPC	0.33	0.68	114.5	25.69
Driver for the control and instrumentation technician	0.5	0.68	153	51.91
SUBTOTAL				***213.94***
Control and instrumentation operator				
Checking and calibration of the temperature control system:				
on the HI-STORM cover	0.33	0.161	153	8.11
on the HI-STORM lateral surface	0.17	0.68	153	17.65
SUBTOTAL				***25.76***
Electrician				
Grounding check	8	0.68	1	5.44
SUBTOTAL				***5.44***

In order to meet the criterion of individual dose rate of 11 mSv/year established for the maintenance of the storage site, the following personnel is required:

- Inspector: 213.94/11=19.44 or 20 people;
- Control and instrumentation technicians: 25.76/11=2.34 or 3 people;
- Electrician: 5.44/11=0.5 or 1 person.

10.7.3.3 Measures To Ensure Radiation Safety Under Normal Operation Of The CSFSF

Radiation safety of the operating and maintenance personnel is ensured by a set of organizational, technical and radiation-hygienic arrangements.

Organizational Arrangements

Before the beginning of operation and periodically during operation, it is expected to conduct the following activities:

- preparation of workplaces;
- admission to the production of works;
- human resource training;
- monitoring and supervision;
- organization of health care.

Staff training is aimed at gaining knowledge in the field of radiation, general technical and fire safety regulations when working on the CSFSF, both in normal operation and in case of possible accidents, as well as the knowledge and practical skills in the technological processes of MPC handling during their transportation, preparation for storage and storage.

Staff training includes the study of regulatory and technical documentation on operation of the enterprise, the rules of conduct in the exclusion zone, as well as action during emergencies and accidents to the extent required by the job descriptions and assigned responsibilities. Upon completion of training, the staff will undergo testing of knowledge with the issue of certificates.

Staff training will be carried in accordance with the specially developed programs, which include the study of the following materials:

- The rules of conduct in the territory of the CSFSF, including:
  - the rights and duties of CSFSF staff;
  - the order of CSFSF site entrance and exit;
  - the procedure for obtaining and use of personal dosimeters;
  - the procedure for the passage through the radiation monitoring stations.
- The fundamentals of dosimetry, radiation hazardous of the CSFSF, the methods of protection against ionizing radiation, as well as the parameters of the radiation situation in places of works.
- The rules of use of personal protective equipment (PPE), including:
  - components of the basic set of personal protective equipment and respiratory protective equipment;
  - procedure for the use of PPE.
- Procedures for possible emergencies and accidents, including:
  - actions in the event of emergency;
  - escape routes in case of an accident;
  - first aid to the victim, etc.

Professional training is carried out according to the employee's specialization in the form of theoretical study of production schedules of works, assigned duties, and developing practical skill using simulator. After checking the knowledge gained as a result of theoretical training and work with simulators, the staff practices using empty MPCs to acquire practical skills in the production situation. Upon receipt of positive results, the employee is allowed to carry out certain manufacturing operations under the supervision of an experienced instructor with gradual extension of the scope of operations as experience is gained.

To improve the safety of works, additional targeted training is planned. The procedure for conducting targeted training of the staff is determined in accordance with the requirements of the regulatory documents.

Monitoring and supervision is carried out to improve the safety of work and to prevent violations of regulations in the performance of manufacturing operations that may lead to emergency situations and unnecessary overexposure of personnel.

Medical care is offered to the personnel by the medical station localed in he administrative building.

The organizational arrangements are set out in Section 8, “Occupational Safety”, of Volume 1.

Technical Measures

The main technological protection measures to ensure radiation safety under normal operating conditions are as follows:

- shielding;
- use of remotely controlled mechanism (described in detail in Volume “Technological Part. Spent Nuclear Fuel Handling”);
- decontamination (described in detail in Volume 3.2, “Technological Part. Waste Management During Operation”);
- special ventilation and special gas treatment (described in detail in Volume 7, “Heating, Ventilation, Air Conditioning”).

The radiation safety of the CSFSF is built on the principle of multi-barrier protection.

The MPC barrier is an obstacle to the mechanical spread of radioactive substances into the environment, which practically does not prevent the spread of ionizing radiation. The barriers that have the function of protection against radiation are cask handling unit for casks transfer, the HI-STAR cask — during transportation, the HI-STORM cask — during storage.

One of the main measures in radiation protection is shielding that reduces radiation exposure based on the ALARA principle to the level stipulated by the regulations.

The design is based on the differentiated approach to shielding with due regard for the following:

- the specifics of the technological process;
- the need for the presence of personnel during implementation of certain operations;
- the time spent by the personnel in various areas.

The ventilation of premises where the casks are processed is an additional dynamic barrier to the spread of radioactive substances into the environment.

Ventilation is arranged in such a way that the air from the dirty rooms does not get into the room where the staff stays permanently. The air removed from the technological

premises is cleaned by aerosol filters prior to release into the surrounding air.

The performance of works during SNF processing with the use of remotely controlled mechanisms and video surveillance. If necessary, decontamination of facilities and equipment is also provided for.

Radiation-Hygienic Measures

The main planned radiation-hygienic measures during normal operation are as follows:

- establishment of the sanitary protection zone and the surveillance zone;
- assessment of exposure dose rates of personnel and the establishment of reference levels;
- introduction of sanitary and access control;
- zoning of premises and territories;
- use of PPE and RPE;
- radiation monitoring.

In accordance with the requirements of [39], the CSFSF is surrounded by a sanitary protection zone and a surveillance zone.

According to NRBU-97 [101], the sanitary protection zone is understood as an area around a radiation/nuclear facility where the human exposure level under normal operating conditions can exceed the quota of the dose limit for population (1 mSv/year). Individuals are prohibited from residing within the SPZ, while productive activities not related to the radiation/nuclear facility are restricted and radiation monitoring is exercised [101, 110].

Based on the criterion of non-exceeding the dose of 1 mSv/year under normal operation of the CSFSF, the SPZ boundary is set at a distance of 100 meters from the boundaries of the CSFSF production site (when the storage is completely filled with 459 HI-STORM casks).

In accordance with NRBU-97 [101], the surveillance zone is the territory, where there is possibility of radioactive discharge and emission from the CSFSF and where radiation monitoring is carried out.

The CSFSF project provides for the establishment of the surveillance zone at a distance of 600 m from the site boundaries.

Justification of the sizes of SPZ and SA is set out in EIA.

According to [112], all the personnel permanently working in the exclusion zone, regardless of the nature of the works, belong to the Category A staff pursuant to NRBU-97 [101]. With this in mind, taking into account the requirements of [110, 112], the draft project establishes the following reference levels (RL) of exposure of the CSFSF staff (effective dose rates):

- 11.0 mSv/year from external radiation;
- 3.0 mSv/year from internal radiation.

Sanitary and access control will be implemented at the CSFSF.

The sanitary and access control is necessary for physical protection and to prevent the transfer of radioactive contamination beyond the CSFSF site, PPE and skin contamination control, overalls changing and sanitary treatment of personnel, collection and dispatch of contaminated PPE for decontamination and disposal. Detailed description of sanitary and access control is provided in Section 8 of “Occupational Health”, Volume 1.

The territory, buildings and premises of the CSFSF, in terms of degree of radiation hazards, are divided into the following areas:

- high-security zone — the territory, buildings and separate premises where the radiation exposure of personnel is determined by both the accidental pollution and the factors caused by the operation of CSFSF;
- free regime zone — the territory, buildings and separate premises where the radiation exposure of personnel is determined only by the accidental pollution, and where the sources of ionizing radiation, caused by the operation of CSFSF, are not handled; More detailed zoning of the CSFSF is set out in paragraph 10.4.1.1.

During performance of works at the CSFSF, the staff, if necessary, will use PPE and RPE [110]. The use of PPE and RPE is detailed in Section 8.

In order to monitor the the radiation exposure of personnel, population and the environment under normal operating conditions of the CSFSF, violations of conditions of normal operation and design-basis accidents at the CSFSF, the radiation monitoring system (RMS) is planned. Its operation will provide the staff with the possibility to keep pollution levels and the radiation exposure dose rates of the workers and the public reasonably below the regulated limits.

Radiation Monitoring System (RMS) consists of the following subsystems:

- technological process radiation monitoring (PRC);
- radiation dosimetric monitoring (RDM);
- individual dosimetric monitoring (IDM);
- environmental radiation monitoring (ERM);
- radiation monitoring of spread of radioactive contamination. Depending on the

nature of the work, radiation monitoring includes:

- monitoring of the dose rates of ionizing radiation, beta and alpha flux density of particles in the workplace, industrial premises and the territory of the sanitary protection zone and the surveillance zone;
- monitoring of radioactive gases and aerosols in the production and administrative premises;
- monitoring of the level of contamination of production facilities, equipment surfaces, skin and clothing of the personnel;
- monitoring of release of radioactive substances into the atmosphere;
- monitoring of collection and handling of solid and liquid radioactive waste;
- vehicles contamination monitoring.

The CSFSF radiation monitoring systems is described in detail in Volume 6, “Monitoring And Control System”.

10.7.4 Radiation Safety In Case Of Accident

In accordance with the requirements of NP 306.2.105-2004 [39], a detailed analysis of accidents at the CSFSF is set out in PSAR.

Holtec International have analyzed accidents and presented the results in “Report On The Analysis Of Accidents”. Holtec International HI-2083899 [142] (a copy is supplied in Volume 1.2.2). The accident analysis report by Holtec International contains a list of initiating accidents that were determined on the basis of the requirements of NP 306.2.105-2004 [39], PNAE G-14-029-91 [69], and RD 306.8.02/2.067-2003 [134].

The Report HI-2083899 [142] deals with the following initiating events giving rise to the disturbance of regular operating conditions and design-basis accidents corresponding to the requirements of NP 306.2.105-2004 [39]:

- natural phenomena:
  - flooding;
  - tornadoes and objects carried by tornadoes;
  - earthquake;
  - extreme snowfall;
  - extreme increase in ambient temperature;
- technology-related external events:
  - fire or explosion at a neighboring facility (a passing vehicle);
  - blackout;
  - airplane fall on a HI-STORM cask;
- technology-related internal events:
  - fire;
  - flying objects generated by other accidents;
  - human error;
  - failures of fuel management and storage systems;
  - fall of objects;
  - clogging of HI-STORM vents;
  - rollover of the storage unit of HI-STORM;
  - accident during transportation;
  - MPC jamming during transfers.

A brief description of results of the probable accident and emergency situation development analysis based on the initiator events is provided hereinbelow in Table 10.57 on the basis of materials of HI-2083899 [142].

The report of the results of analysis of accidents HI-2083899 [142] shows that all the reviewed disturbances of regular operating conditions and design-basis accidents will not exceed safe operation limits and will not give rise to the discharge of radioactive substances into the environment.

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Table 10.57 — **Analysis Of Emergencies And Accidents In Accordance With The Report [142]**

Initiator Event (IE)	IE Parameters	Reception Criteria Used for Analysis	Analysis Results
Design-basis natural IEs			
Earthquake	The spectra of seismic responses for the CSFSF site (corresponding to the spectra of ChNPP, received in the NAEC letter № 03-46/340 of March 12, 2015)	HI-STORM 190 cask should remain stable without tipping	Analysis of HI-STORM 190 stability and docking mechanism strength analysis confirmed that the acceptance criterion is amply met.
Tornadoes and objects carried by tornadoes	Tornado parameters: in accordance with the letter of NAEC No. 03-46/1440 of September 29, 2015, "Tornado parameters for the CSFSF area" Objects carried by tornado: - a 1800 kg car at a speed of 203 kph; - a 125 kg, D200 mm steel cylinder at a speed of 203 kph; - a 0.22 kg, D25 mm steel cylinder at a speed of 203 kph.	The cask should not trip. The collision with objects carried by a tornado must not result in the damage that will increase the exposure rate at the site boundary.	The analysis of the stability and the impact of flying objects confirmed that the simultaneous impact of an extreme wind and a flying object impact would not knock over a HI-STORM 190 cask and reduce efficiency of the containment shell for the MPC, and, accordingly, would not increase the exposure rate at the site boundary.
Extreme increase in ambient temperature	from –40 °C to +40 °C	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis confirmed that the temperature behavior of a HI-STORM 190 cask filled with spent nuclear fuel from VVER reactors with the design-basis heat output in a MPC-31 or MPC-85 would ensure that all the design-basis temperature limits are met at extreme values of the ambient temperature.
Extreme snowfall	Snow load: 4.8 kPa (100 lbs per square foot). Complete clogging of vents	The container system must remain structurally integral. Fuel element temperatures must not exceed limits	The snow load considered is negligible in comparison with other loads under review; for this reason no additional strength

Initiator Event (IE)	IE Parameters	Reception Criteria Used for Analysis	Analysis Results
		set for accident conditions.	analysis for the snow load is called for. The thermal analysis of the HI-STORM 190 storage system in case of the clogging of vents demonstrated that temperature values would not exceed the allowed limit even in case of the conservative overstatement of the time needed for unclogging vents.
Flooding	Water level increase velocity: 4.57 meters per second (15 feet per second). Water level increase height: 109.9 m	The cask should not trip. The fuel element shell temperature must not exceed the maximum level.	The strength analysis and the stability analysis demonstrated that flooding would not knock over or displace a HI-STORM 190 cask. Flooding would not affect thermal properties of the system negatively. The heat abstraction will improve.
Design-basis technology related initiator events (external)			
Fire or explosion at a neighboring facility, passing of a vehicle with flammable or explosive cargo	A loaded HI-STORM 190 is moved to the CSFSF storage area by a VCT. An assessment of the impact of the ignition/explosion of combustible substances available in a VCT has been carried out	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions. The event must not result in a substantial increase in the exposure rate at the site boundary	The thermal analysis demonstrated that the fire would not affect the integrity of the containment shell of the MPC and the shell of a fuel element. The stability analysis confirmed that the explosion would not knock over a HI-STORM 190 cask.
Blackout	Suspended operation of electrically driven mechanisms, such as cranes; stopped process operations	The fuel element shell temperature must not exceed the maximum level.	A blackout would not result in the development of emergency conditions or

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Initiator Event (IE)	IE Parameters	Reception Criteria Used for Analysis	Analysis Results
			design-basis accident. There would be no impact on the exposure rate at the site boundary; there is no hazard to human safety.
Airplane fall on a HI-STORM 190 cask	Airplane velocity, mass, angle of entry, and amount of fuel aboard	Preserved integrity of the containment shell of the MPC	The strength and thermal analysis for a fall of a 20-tonne airplane at an impact velocity of 215 meters per second demonstrated the lack of substantial damage to the cask and the preservation of its functional integrity.
Design-basis technology related initiator events (internal)			
Partial clogging of fresh air inlets	50% of the area of fresh air inlets are clogged	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis confirmed the conformity with the temperature and pressure limits for deviations from normal conditions
Complete clogging of vents	100% clogging of vents with debris	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits set for accident conditions.	The thermal analysis demonstrated that temperature values would not exceed the allowed limit even in case of the conservative overstatement of the time needed for unclogging vents (30 hours).
Fuel element rupture	Complete (100%) fuel element rupture	The fuel element shell temperature must not exceed the maximum level. Fuel element temperatures must not exceed limits	Thermal analysis and analysis of pressure inside the MPC confirmed that the MPC is resistant to the accident

Initiator Event (IE)	IE Parameters	Reception Criteria Used for Analysis	Analysis Results
		set for accident conditions. Preserved integrity of the containment shell of the MPC	
Flying objects generated by other accidents	Site conditions	An impact of a flying object must not result in the damage that will increase the exposure rate at the site boundary.	The impact of such an event is lower than the impact of flying objects carried by a tornado
Sticking of spent fuel assemblies	Fuel basket cell size and spent fuel assembly size	Making sure that a spent fuel assembly fits basket cells easily	Taking into account the MPC geometry and manufacturing tolerances, it can be concluded that this event is not probable.
Operator's mistake when loading spent fuel assemblies	Incorrect positioning of a spent fuel assembly in the fuel basket	The fuel element shell temperature must not exceed the maximum level.	Thermal analysis of a HI-STORM 190 cask for incorrect positioning conditions confirms that the temperature and pressure limits are met
Falling objects	Potential collapses of building structures and process equipment	The impact of the object fall must not result in the damage that will increase the exposure rate at the site boundary.	The impact of falling objects on HI-STORM 190 in case of the long-term storage is less unfavorable than the impact from flying objects carried by a tornado
Failure of load gripping mechanisms when moving spent fuel assemblies	Load lifting capacity and duplication	Assurance of the necessary load lifting capacity and duplication	No need to analyze this accident because lifting and crane equipment is protected against once-off failures
Falling of HI-STORM 190	Lifting devices and HI-STORM 190 are designed to prevent falling	Preserved integrity of the containment shell of the MPC.	Falling of HI-STORM 190 will not lead to

Orig. Inv. No.	Signature, Date	Repl. Inv. No.

Amd.	Nr.a	Sheet	Doc. N	Sig.	Date

Initiator Event (IE)	IE Parameters	Reception Criteria Used for Analysis	Analysis Results
	loaded HI-STORM 190	The event must not result in a substantial increase in the exposure rate at the site boundary	emergency conditions or a design-basis accident.

Measures For Prevention Of Emergencies And Accidents

Prevention of emergencies and accidents at the CSFSF if primarily ensured by:

- design of MPC, HI-STAR, and HI-STORM;
- design solutions for the transportation and technological operations with SNF at the CSFSF;
- selection of equipment involved in the SNF management operations, in accordance with the regulatory requirements;
- prevention of human errors;
- reliability of structures of the acceptance building and storage platforms to meet the requirements for seismic loads [124];
- implementation of regulations and instructions on the CSFSF operation.

Technical solutions relating to the design and materials of the MPCs, HI-STARs and HI-STORMs are described in para 10.4.1.1 of this Section.

All the equipment involved in the SNF management at the CSFSF is classified as important for the safety of operations. It is designs with significant reserve and/or its security functions are duplicated in order to prevent new initiating events and limit their consequences.

The design solutions for the transportation and technological operations with SNF at the CSFSF are set out in Part 1, “Technological Part. Spent Nuclear Fuel Handling”, Volume 3 of this project.

The preparation of the instructions for handling operations is based on the experience of Holtec in SNF management. In order to prevent human error, organizational measures will be taken in combination with the experience of previous situations.

Reception building is classified as Category 1 structure in terms of nuclear and radiation safety according to PiN AE 5.6 [7] and seismic Category 1 under PNAEG 5-006-87 [124]. It is designed to withstand the loads during MDE (once in 10,000 years), which corresponds to the magnitude 6 earthquake at the CSFSF site. Thus, in accordance with the definition set out in PNAEG 5-006-87, the structures of seismic Category 1 must retain their protective and containment functions after the magnitude 6 earthquake.

[142] shows that the HI-STORM storage cask can withstand the load during the magnitude 7 earthquake without tipping and loss of protective properties.

During operation of the CSFSF, in order to ensure compliance with regulations and operating instructions, certain organizational arrangements will be implemented. The organizational arrangements are set out in Section 8.

The sufficiency of measures for prevention of emergencies and accidents is substantiated in the PSAR.

Out of beyond-design-basis accidents listed as initiator events in NP 306.2.105-2004 [39], only an initiator event associated with the development of a self-sustained chain reaction is applicable to CSFSF.

The subcriticality of the spent nuclear fuel management at the CSFSF subject to all conservative assumptions stated in requirements of NP 306.2.105-2004 [39] has been demonstrated in Report On The Results Of Accidents Analysis HI-2083899 [142] and Report On The Subcriticality Analysis HI-2083899 [136]. More details on the BDBA at the CSFSF are supplied in the PSAR.

In order to limit and mitigate the consequences of the BDBA, the emergency plan for the CSFSF is implemented to meet the requirements of NRBU-97 [101].

The emergency plan should at least include measures to create the necessary emergency supplies, including:

- dosimetric and radiometric equipment;
- emergency PPE kits, respiratory protective equipment;
- emergency stock of directly indicating dosimeters;
- vehicles and supply of fuels and lubricants;
- pharmacological means of radiation protection;
- communication and management means;
- decontamination means.

To reduce the risk of BDBA, measures related to physical protection of the nuclear units, consisting of a set of organizational, legal, operational, investigative, and technical activities.

10.7.5 Radiation Safety During Decommissioning

Radiation safety during decommissioning of the CSFSF will be ensured by the following design solutions.

The dry type storage eliminates the formation of large amounts of liquid radioactive waste and, accordingly, the possibility of contamination of the premises is not expected.

The SFAs are stored in sealed MPCs, so contamination of HI-STORM and, respectively, radiation exposure of personnel during dismantling will be minimal. The use of cask storage limits the possibility of contamination of large areas even in the event of depressurization of individual MPCs.

The surfaces in the premises in the areas of MPC management will be covered with easily decontaminated materials, so periodic decontamination of the premises will effectively minimize the radiation exposure of personnel during decommissioning.

The effective special ventilation system will prevent the spread of radioactive substances in the premises of the reception building during normal operation and possible accidents.

The technological process does not involve the use of toxic and other potentially hazardous non-radioactive substances.

Due to the fact that the main impact on the staff in the operation of the CSFSF is from the external gamma-radiation, the radiation dose rates for the personnel during decommissioning (after removal of the SFA) will be significantly lower than the dose rates during operation. Basic radiation dose rates can be obtained due to decontamination of premises and equipment in the high security zone located in these areas.

After work on decontamination of the contaminated equipment and premises, the radiation dose rates will be significantly reduced.

Decommissioning concept must be included in a separate section at the design stage to adequately substantiate the design, organizational and technical solutions to ensure decommissioning of the CSFSF with lowest possible radiation exposure to personnel, population and the environment. The concept will consider the general aspects of decommissioning as defined in NP.306.1.02/1.004-98 [162], with possible detailing at the design stage.

It will include the optimization of layout of premises and arrangement of systems and components of the installation with regard for the need to remove large fragments of HI-STORMs, free remote disconnection and transfer of the MPCs, and placement of the equipment for decommissioning.

The basic equipment needed for radiation protection during decommissioning will include:

- equipment required to prevent contamination of the premises (including local ventilation and filtering systems);
- equipment for radiation dosimetric monitoring;
- equipment for monitoring the dose rates and surface contamination in the workplaces, contamination of components and materials during dismantling;
- equipment required to monitor the volume activity of aerosols in the workplaces.

11. ENGINEERING AND TECHNICAL MEASURES OF CIVIL PROTECTION (CIVIL DEFENSE)

The centralized storage of spent nuclear fuel from VVER nuclear power plants of Ukraine, in accordance with the Resolution No. 6 of the Cabinet of Ministers of Ukraine dated 09.01.2014 [51], is classified as facility, designing of which is to be carried out in view of the requirements for engineering means of civil protection.

In accordance with the requirements of paragraph 6.1 of DSTU B.A.2.2-7:2010 [52], Section ETM of CP was developed as a separate volume as part of the project documentation — Volume 10, “Engineering And Technical Measures Of Civil Protection (Civil Defense)”, consisting of Part 1 “Executive Summary” (571402.201.010-GO01) and Part 2, “Structures Of Civil Protection (Civil Defense)” (571402.202.010-GO02).

The engineering measures of CP developed based on the specification for development of ETM section on CP (hereinafter — Task) issued by GSChS of Ukraine (Annex to the letter № 16-4231/162 of 23.06.2015) taking into account the requirements of the relevant regulations and legal acts. The specified task is set out in Annex A, Volme 10.1, “Engineering And Technical Measures Of Civil Protection (Civil Defense)”. Part 1. Executive Summary.

In accordance with the task, the site under design is not classified in terms of civil protection. After the completion of the facility, the site will be considered as of Civil Protection category in accordance with the procedure No. 227dsk defined by the Cabinet of Ministers of Ukraine of 02.03.2010.

The territory, in which the designed site is located (Kiev region, Ivankiv district, zone of exclusion as a result of the Chernobyl disaster), in accordance with the Resolution No. 87-2 of Cabinet of Ministers of Ukraine of 25.02.2015 is not classified as civil defense means (Task, paragraph 2).

At a distance of 20 km from the construction site, there is SSE "Chornobyl NPP", classified as the site of the first category of civil protection in accordance with the Order No. 1dsk of the State Agency of Ukraine for the Exclusion Zone Management of 07.05.2014, which, pursuant to paragraph 1.4 of DBN V.1.2-4-2006 [53], substantiates the location of the site under design within the boundaries of the possible hazardous radiation contamination zone (Task, paragraphs 3, 4).

On the basis of the Task requirements and DSTU B.A.2.2-7:2010 [52] as part of the project documentation, a set of technical measures of CP, detailed in Volumes 10.1 and 10.2 under the design solutions in the field of civil protection (civil defense), in accordance with the requirements of DBN V.1.2-4-2006 [53], and the design solutions aimed at prevention of technological and natural emergency situations, including as follows:

- on the basis of materials of the Task, taking into account the requirements of DBN V.1.2-4-2006, the substantiation of classification of the facilities under design and the surrounding objects in terms of Civil Protection and identified of possible zones of hazard have been produced;
- based on the requirements of DBN V.1.2-4-2006 [53], the minimum acceptable degrees of fire resistance for the production, storage and office buildings of the facilities under design;

- construction of two shelters of Class A-IV with a capacity of 100 people each equipped with ventilation systems designed to operate in 1 and 2 modes for civil protection (civil defense);
- equipment of the facilities under design with a local warning system;
- measures to prevent unauthorized interference with the activities at the facility;
- blackout procedures;
- measures to prevent the accidents at potentially dangerous facilities (storage of 10 m_3 of HFL);
- measures to control the radiation situation and meteorological factors on the CSFSF site;
- the development of project documentation is based on the requirements of construction in seismic areas (MDE of magnitude 6).

In accordance with Art. 31 of the Law of Ukraine “On Regulation In Urban Planning” [54], Section of ETM CP is subject to expert examination under design documentation in accordance with the procedure established by DSTU-NB A.2.2-10:2012 [55].

12. RELIABILITY AND SECURITY PROVISIONS

12.1 General Site Security Provisions

Operational safety of buildings and structures, in accordance with paragraph 5 of DBN V.1.2.-9-2008 [56], is provided for by the implementation of measures to exclude (prevention) injuries or death of personnel resulting from:

- drop as a result of sliding, stumbling, entanglement of changes in elevation;
- injury or death as a result of contact with construction site or its parts;
- burns as a result of contact with parts of the construction site or equipment;
- electric shock as a result of lightning strikes or overvoltage of power supply systems;
- accidents related to moving vehicles.

Excluding of personal injuries as a result of falling after slipping or entanglement is achieved by:

- exclusion of elevation differences and obstacles in the passages used by the personnel;
- installation fences along the roof perimeters in accordance with paragraph 6.13 of DBN B.1.1-7-2002 [17];
- use of flooring materials that exclude sliding and slipping;
- lighting in accordance with the requirements of paragraph 6 of PUE [16];
- providing of necessary slope, size and tread of stairs in accordance with paragraph 5 of DBN B.1.1-7-2002 [17].

Prevention of injury or death by contact with the building structures is ensured through the elimination (preventing) of sharp and cutting edges and the use of appropriate protection means (GOST 12.4.059-89 [57]) during repairs.

Lightning protection is provided in accordance with DSTU B V.2.5-38:2008 [26].

Provision of levels I and II of protection with the sufficient reliability of protection against direct lightning strikes of probability 0.99 and 0.95, respectively.

For outdoor casks and refueling stations separate lightning rods (of level II protection) are planned.

Lightning protection of buildings by means of grounding metal structures of buildings or through lightning protection grid on the roofs of buildings (level II protection).

The lightning protection grid is to be made of round steel with a diameter of 8 mm, with a mesh of 10x10 m.

Current taps (round steel with a diameter of 8 mm) from the lightning protection grid are to be laid along the walls of buildings along the perimeter at a distance of no more than 15 m from each other and attached to the outer grounding contour.

Earthing devices of lightning protection are combined with protective grounding of the buildings and structures.

To protect against secondary effects of lightning (introduction of high potentials) and static electricity, all the surfaces and underground communications at the entrance to the structures are connected to earthing devices.

To ensure safe operation and maintenance of electrical installations, all metal dead parts, which are normally not energized, but which can become live in the event of insulation fault, must be grounded by attaching to the protective conductor of the mains zero.

Earthing must comply with the requirements of Chapter 1.7 of PUE [16] and SNiP 3.05.06-85 [60].

For the 0.4 kV network of power consumers, including lighting, the TN-C-S earthing system is adopted. Protective earthing of the lighting system is provided according to the requirements of PUE [16].

Protection against electric shock is provided by the protective circuit breakers in the electrical installations. The circuit breakers provide protection against electric shock in the following cases:

- decrease in electric insulation resistance below the specified limit;
- connection of the phase conductor to the appliance casing;
- person touching live parts of electrical installations.

In order to prevent accidents due to movement of transport, the following measures are implemented:

- vehicles movement is carried on strictly established routes approved by the site management;
- road pavement is expected to eliminate the possibility of slippage of the vehicles and its diversion to the footpaths;
- road signs are designed to warn about the required reduction in speed within the site;
- footpaths and roads marked by appropriate traffic signs and markings are planned for the personnel.

In the period of low temperatures, the roadways and footpaths should be cleared of snow and ice.

12.2 Ensuring Of Compliance With The Requirements Of Safe Operation Of The Facility At The Stage Of Development Of Design Documentation

Given the fact that, currently, there are no buildings, structures and facilities in operation on the site, there is no need for operation safety measures/

12.3 Reliability And Structural Safety Of Buildings And Structures

According to paragraph 4.1.3 of DBN V.1.2-14:2009 [49], the main requirement in determining the reliability of the construction site is its fitness for purpose and the ability to maintain the required performance for a set period of operation. These include:

- assurance of safety of human health and life, property and the environment;
- preserving of the integrity of the site and its major parts as well as compliance with other requirements ensuring the use of the site for its intended purpose and proper functioning of the technological processes, including the reliability of building structures and foundations, heat and sound insulation properties of enclosures, their tightness, and acoustic characteristics;
- enabling development of the site (for example, extension without reinforcement of existing structures or increase of production capacity) and its adaptation to changing technical, economic or social conditions;

- providing for the necessary level of convenience and comfort for the users and operating personnel, including the requirements for climatic conditions in the rooms (ventilation, temperature, humidity, lighting, etc.), as well as the accessibility for inspection, repairs, replacement and upgrading of separate elements;
- risk limitation by meeting the requirements of fire resistance and reliability of safety devices, life-support facilities, and engineering structures.

The compliance with these requirements is ensure by the following means:

- implementation of OSMS at the CSFSF;
- training and testing of staff on labor protection;
- providing of the working places with necessary documentation in accordance with the requirements of organizational and administrative procedures of DP NAEK Energoatom;
- development of guidelines and emergency plans, training and instruction of the staff on the actions of emergency procedures and situations;
- arrangement for systematic monitoring of technical state of structures, buildings and facilities;
- arrangement for periodic maintenance and technical inspection of equipment systems;
- certification of workplaces for compliance with the working environment's requirements according to the regulatory documentation, development (if necessary) of optimization measures.

While building a centralized storage facility for spent nuclear fuel, certain design solutions are applied to ensure safe performance of technological operations with a view to ensuring the reliability and structural safety of buildings and structures.

Reliability, including the durability and survivability, is provided by simultaneous compliance with the requirements regarding the selection of materials, design and volume-planning decisions, methods of calculation, design and quality control of the works.

12.4 Specific Features Of Enforcement Of Requirements As To Operational Safety During Design Of Structures Located In The Areas With Unfavorable Natural And Technological Phenomena

Within the CSFSF site, no physical/geological processes and phenomena that would affect the condition of the area negatively have been observed. The erosion of soil, gullies and landslides is absent due to the minor difference between absolute ground surface elevations (within 2.0 m) and dense vegetation. No swamp development and waterlogging of the area have been observed (underground waters occur at depths of 12.2 to 19.2 meters).

Since the surveyed area in geological terms consists of well permeable sandy soils, the design level of underground waters was assumed to be 1.0 m higher than the level recorded during the survey to account for seasonal fluctuations. Temporary water table of the perched water may form in the thick deposits on top of the impermeable layers of clay soils during periods of intensive rainfall or in case of leakage from water lines.

In terms of the complexity of soil conditions, the construction site is categorized as Category II in accordance with Annex Zh to DBN A.2.1-1-2008 [61].

No changes in geological conditions are expected in the course of construction and operation of the storage facility.

Compliance with the requirements of DBN V.1.1-3-97 [2] as to engineering protection of the CSFSF construction site is ensured by a number of activities, namely:

- provision for required quality of materials, structures, products and works during construction of external and internal water-bearing networks by means of initial, current and final acceptance control;
- high-quality waterproofing of foundations of buildings and structures, including underground structures;
- collection and diversion to storage tanks of rainwater and wastewater from all the areas and paved roads.

12.5 Safety Barriers And Prevention Of Accidents In Buildings And Structures

According to the requirements set out in Section 4.5.2 of DBN V.1.2-14:2009 [49], the security of the site is ensured by implementation of the principle of defence in depth based on the use of barriers that are sequentially activated and operate independently performing the following functions:

- prevention of the occurrence of overloads, failures and accidents;
- provision for emergency handling of overloads and ensuring durability and functioning (possibly with the deterioration of the quality parameters or after renovation) of the main part of the site;
- prevention of explosive ruptures and failures as well as localization of consequences of the accident.

At the design stage, the implementation of the principle of defense in depth is carried out through the following organizational and technical measures:

- site selection for the object;
- establishment of sanitary-protection zone and surveillance zone around the facility, provision of fire breaks, etc.;
- development of the project on the basis of revised data on the possibility of the emergence and nature of catastrophic impacts;
- use of special safety systems;
- provision for required quality of materials, structures, products and works by means of initial, current and final acceptance control;
- operation of the facility in accordance with the operational documentation;
- provision of good condition of important security-related elements, devices and systems by means of proper maintenance;
- timely diagnosis, assessment of technical conditions and implementation of necessary measures to eliminate the detected defects and damage;
- measures to prevent possible causes of accidents, and in the event of accidents — localization of consequences;
- preparation and implementation (if necessary) of emergency plans at the facility and beyond, including the activities involving the population;
- ensuring the required level of staff training.

According to the experience of operation in the operational phase, the maintenance of security barriers in good condition is to be provided by the following activities:

- ensuring the required quality of works by means of quality system implementation;
- operation of the facility in accordance with the operational documentation;

- provision of good condition of important security-related elements, devices and systems by means of proper maintenance maintenance and repair according to maintenance schedules approved by the enterprise management;
- timely diagnosis, assessment of technical conditions and implementation of necessary measures to eliminate the detected defects and damage;
- measures to prevent possible causes of accidents, and in the event of accidents — localization of consequences in compliance with the acting guidelines for emergency situations;
- preparation and implementation of emergency plans at the facility and beyond, including the activities involving the population, as stated in the “Emergency Plan”.

12.6 Specific Features Of Assurance Of Safe Operation Of The Architectural Object At The Stages Of Construction And Installation

Construction of the CSFSF will be performed within the perimeter of temporary fencing, which will be built during the preparatory period. To ensure safety of the construction site and to prevent possible illegal actions within the facility, the following will be provided:

- installation of temporary checkpoints with round the clock security at the entrance gate and places of passage of the construction personnel;
- security lighting on the construction site and along the perimeter fence to provide for necessary visibility of the area, perimeter zones of the building and production area at night.

To ensure security at the stage of construction and installation works in accordance with the requirements of Section 6 of NPAOP 45.1-1.12-01 [62], the following activities should be performed:

- fencing and installation of safety signs to inform the workers on the borders of the construction and installation work sites;
- establishment of routes to work places for the staff;
- definition and allocation of transportation means, establishment of traffic routes. The speed of traffic on the construction site should not exceed 10 km/h; when cornering and while moving in reverse, the speed should be no more than 5 km/h;
- compliance with health and hygiene standards in accordance with the procedures established for the existing enterprise;
- identification of premises for temporary storage and domestic purposes;
- identification of places and routes for dumping of excavated soil and debris.

All construction and installation works must be carried out strictly in accordance with the specially designed project of works in compliance with the safety regulations set out in DBN A.3.2-2-2009 [63].

12.7 Operating Safety Requirements At The Stage Of Use Of The Site For Its Intended Purpose Within The Prescribed Period Of Operation

Safety of operation of the facility during its intended use is ensured by the implementation of a system of maintenance of buildings, structures, equipment, systems, as well as systematic monitoring of the territory condition.

The purpose of maintenance and repair work is to ensure safe operation of the systems during the design service life of the CSFSF — 100 years.

The main objects of maintenance in the systems are:

- buildings and structures;
- thermal and mechanical equipment of the technological systems;
- transport and processing equipment;
- storage area and HI-STORM 190 UA storage casks;
- electrical engineering systems;
- control and monitoring systems.

The maintenance tasks are as follows:

- operational control/monitoring of the systems and their components;
- timely performance of repairs;
- timely implementation of measures to ensure the security of the CSFSF;
- development of proposals, conducting of work on improving the CSFSF technical operation, as well as the quality of all types of repairs.

At the CSFSF, it planned to implement a preventative maintenance system. The system of preventive maintenance of the CSFSF will be a set of organizational and technical measures to ensure supervision, care and all types of repairs carried out routinely. It is expected that the planned maintenance of the systems and component will take 2-3 working days a month. Once a year, the main works at the CSFSF will be suspended for maintenance and repair of the main technological equipment. It is assumed that the current repair of the equipment once a year will be combined with the terms of preventative maintenance. Current inspection rounds will be carried out once every shift.

In order to ensure adequate operational and sanitary condition of the territory, the buildings and structures, as well as the compliance with the environmental requirements of Section 6.1 of GKD 34.20.507-2003 [64], the following systems and components should be kept in good condition:

- surface and groundwater drainage system all over the site, including the building and structures;
- dust, radioactive gases and aerosols emission treatment systems;
- facilities for treatment of polluted wastewater and oily sewer;
- water-supply, sewerage, and drainage systems;
- railroad tracks and crossings, roads, fire driveways, access to fire hydrants, crosswalks and other;
- basic and operational benchmarks and station marks;
- piezometers and monitoring wells to monitor groundwater regime;

- radiation monitoring systems on the territory of the sanitary protection zone and the surveillance zone;
- set engineering and technical means of protection (fencing, lighting, security checkpoints, office premises);
- lightning protection and grounding systems.

Furthermore, landscaping and land improvement should be carried out systematically.

The industrial buildings and facilities of the CSFSF must be kept in good condition to provide for long-term reliable use for intended purposes in compliance with the requirements of sanitary norms and occupational safety regulations.

In accordance with the existing practice of DP NAEK Energoatom, the safe operation of buildings and structures is provided by the following means:

- organization and conducting daily rounds and inspections;
- organization of periodic general supervision;
- organization of planned surveys of structures;
- organization and carrying out repairs.

Twice a year (in spring and autumn), along with the systematic monitoring of the CSFSF, the specialized committee should carry out overall technical inspection of buildings and structures to detect defects and damages, and in case of disasters (hurricane winds, large showers or snowfalls, fires, earthquakes, etc.) or accidents — extraordinary inspection of the facilities should be conducted by the persons responsible for their operation.

Technical inspection in spring should specify the volumes of repair of buildings, structures and plumbing systems during summer, as well as the volumes of overhaul to be included into the plans for the next year. In autumn, the technical inspection shall verify the preparation of buildings for winter.

The monitoring of buildings, structures and foundations should involve the monitoring of the state of bearings, expansion joints, welded, riveted and bolted joints in steel structures, joints and fixings precast in concrete, rebar and concrete in the reinforced concrete structures (for corrosion or deformations), crane structures and sites subject to dynamic and thermal loads and impacts. In case of detection of cracks, fractures and other signs of damage of structures, such structures should be monitored with the use of marks and instrumental measurements. The information about detected defects should be registered in the technical condition logs of the buildings and structures with the indication of terms of elimination of defects detected.

Roofs of buildings in spring and autumn should be cleaned of debris; the rain water collection systems should be cleaned and their performance should be checked.

Building structures of the main production buildings and facilities on the list approved by the head of the CSFSF, are subject to technical inspection by a specialized organization once every five years, as provided for in paragraph 6.2.3 of GKD 34.20.507-2003 [64].

Monitoring of the condition of the foundations, in accordance with the requirements of paragraph 6.2.5 of GKD 34.20.507-2003 [64], shall be carried out as follows:

- in the first year of operation — three times a year;

- in the second year — twice a year;
- further on and until stabilization of the foundation — once a year;
- after stabilization (yield of 1 mm a year or less) — once every five years.

In spring, all the water-diversion networks and devices should be inspected and prepared for the meltwater passage; the cable and pipe ducts, ventilation ducts in the walls of buildings must be sealed, and the pumps should be ready for use.

The groundwater regime monitoring — the monitoring of water levels in the monitoring wells (piezometers) — should be carried out as follows:

- during the first year of operation — at least once a month;
- in the following years — depending on the groundwater level changes, but at least once a quarter.

The water temperature measurements and water sampling from wells for chemical analysis should be carried out in accordance with the instructions.

The groundwater radioactivity monitoring should be carried out in accordance with the instructions issued by the department (service) of radiation safety and the sanitary requirements established by the supervisory bodies. The results of observations should be entered in a special register.

Te railroad tracks must be kept in good condition and maintained in accordance with the regulations on technical operation of the railways.

The maintenance of thermal mechanical equipment involves the following procedures:

- current maintenance;
- current repairs;
- overhaul.

Current repairs and overhaul to be carried out in accordance with the requirements of RG-D.027.412-10 [65], namely:

- maintenance and current repair of equipment — once every year;
- overhaul — once every four years.

The frequency of maintenance and repair of transport and technological equipment, in accordance with the requirements of RG-D.027.412-10 [67], may be assumed as follows:

- routine maintenance — at least once a year;
- current repairs — at least once every eight years;
- overhaul — at least once every 16 years.

Hoisting machinery, equipment and accessories should pass technical inspection in the amount determined by paragraphs 7.3, 7.4 of NPAOP 0.00-1.01-07 [66].

For electrical equipment, the maintenance and repair intervals may be adopted in accordance with the requirements of RG-D.027.412-10-02 [67], namely:

- factory-assembled switch-gear (cabinets, transformers, switches):
  - current repairs — once a year;
  - overhaul — once every six years;
- cable lines:
  - routine maintenance — once a year;
  - current repairs — once every three years;

- overhaul — basing on the results of high-voltage tests, the technical condition of cable lines, and standard service life of the cables of the type;

- cable ducts and steel structures:
  - routine maintenance — once a year;
  - current repairs — once a year;
  - overhaul — once every 20 years;
- alerting devices:
  - current repairs of lighting fixtures — once a year;
  - overhaul of voltage stabilizers — basing on the results of high-voltage tests, the technical condition of cable lines, and standard service life of the equipment of the type;
- UPS devices (the periodicity is based on the current practice for the Ukrainian nuclear power plants in accordance with RG-D.027.412-10-02 [67]):
  - maintenance 1 — once a month;
  - maintenance 2 — once a year;
  - maintenance 3 — once every 15 years.

For the elements of monitoring and control systems, the following maintenance and repair periodicity (in accordance with RG-0.05-412-11-01 [68]) can be accepted:

- computing systems (servers, workstations, desktops, gateways and so on)
  - maintenance 1 — once a month;
  - maintenance 2 — once every three months;
  - maintenance 3 — twice a year;
  - maintenance 4 — once a year;
  - the need for repair of computer systems is determined based on the results of technical condition monitoring, carried out during routine maintenance or when troubleshooting failures. The recommended range of works for maintenance 1-4 for the computer systems components is set out in Annex to M RG 0.05-412-11-01 [68]:
- instrumentation components:
  - maintenance — twice a year;
  - current repairs — once a year;
  - overhaul — once in 6-10 years (only for those items, for which this type of repair is provided for in accordance with the manufacturer's instructions);
- instrument panels and cabinets:
  - maintenance — twice a year;
  - current repairs — once a year;
  - calibration of measuring channels — once a year;
  - checks of resistance of the cable insulation — once every four years.

The periodicity of maintenance and repair of equipment and the range of works to be confirmed/determined in accordance with the manufacturer/supplier’s documentation.

Maintenance of the HI-STORM 190 UA casks is to be performed in accordance with the requirements for maintenance and operation developed by Holtec and approved under Special Program.

The scope of HI-STORM maintenance comprises:

- monitoring of the state of HI-STORM, including:
  - cleaning of the input ventilation ducts of dust, snow, etc.;
  - cleaning of the output ventilation channels;

- maintenance of temperature sensors (replacement for inspection and calibration);
- inspection of the outer surfaces of HI-STORM coating;
- monitoring and maintenance of radiation monitoring tools installed on the storage site;
- clearing of the site of foreign objects (snow, leaves).

Periodicity of service:

- visual inspection of the storage area is to be conducted daily;
- monitoring of the temperature measuring equipment — according to the passports of devices, but not less than 1 time in 3 years;
- remote monitoring of the MPC condition using video cameras through upper air ducts during inspection of the upper air ducts — not more than once every four years.

Inspection and testing of the equipment at the spent fuel storage facility are carried out according to the operating instructions by the manufacturers of equipment in compliance with the schedule of technical condition checks for transport and technological equipment.

Support Of Maintenance Works

The following repair shops will be provides for servicing the CSFSF equipment:

- electrical and mechanical workshop for clean equipment, not contaminated by radioactive substances in the maintenance building;
- workshop for equipment contaminated with radioactive substances in the reception building;
- workshop for maintenance of road transport in the garage.

The workshops will be equipped with the appropriate machine tools and instrumentation. The workshops will be equipped with manual hoists for mechanization of repair works.

In order to provide for repair, the temporary working lighting using ~12 V (sockets network) is planned to be installed in the following buildings and structures of the CSFSF:

- reception building;
- maintenance building with the MPC storage facility;
- electrical equipment building;
- guardhouse;
- administrative building;
- fire water supply pumping station;
- garage.

The temporary working lighting is provided in the premises of ventilation chambers, transporter parking location, maintenance and repair workshops, electrical rooms, machinery rooms, where additional lighting is needed during inspection or repair of the technological equipment. Power supply is provided from the main lighting network of the related facilities through step-down transformers installed in the appropriate boxes.

Detailed description of the power supply systems is presented in Volume 5, “Electrical Part” of this project.

In order to meet own needs for compressed air at the CSFSF site, a system of compressed air is envisaged.

The consumers of compressed air are located in the following buildings:

- the reception building;

- maintenance building with an MPC warehouse;
- garage (for the transporter and automobiles).

Preparation and delivery of compressed air is intended to provide reliable supply of compressed air of required quality, pressure and flow for the pneumatic drives of the technological equipment provided by Holtec, as well as for repairs.

Detailed description of the compressed air system is shown in Volume 3.3 “Technological Part”, Part 3 "Utilities" of this project.

Storage facilities for tools and spare parts will be provided in the maintenance building with the MPC warehouse and in the reception building.

12.8 Providing For Security During The Facility Commissioning

The fully complete objects should be accepted for operation in accordance with “The Procedure For Acceptance For Operation Of Completed Construction Objects”, approved by Resolution № 461 of the Cabinet of Ministers of Ukraine of April 13, 2011.

For the period of construction, installation and commissioning, the Customer (consumer) shall provide qualified technical supervision and interim acceptance of the units of equipment and facilities, including the hidden works.

The construction company is to supply the Customer with the following technical documentation:

- design and estimate documentation (as-built drawings, cost estimates);
- work logs;
- statements of interim acceptance and inspection;
- statements of acceptance of hidden works;
- other mandatory documents required under DBN.

In accordance with the requirements of Section 8 of PNAE G-14-029-91 [69], the commissioning of the CSFSF will be carried out with the permission of the State supervisory authorities.

The completeness of the storage facility prior to putting into operation will be checked by:

- the working commission of the CSFSF;
- the state supervisory authorities.

The working commission of the CSFSF appointed by order of the head of inspection, will check:

- compliance of the work performed with the project;
- availability of equipment, equipment test reports and certificates of completion of commissioning works;
- availability of the necessary documents in accordance with Section 7
- of PNAE G-14-029-91 [69] and their compliance with the design;
- level of training of the personnel, the availability of exam protocols and the order on admission to works.

The resolution of the commission is produced in the form of a statement.

The bodies of state supervision shall check the CSFSF readiness, personnel and documentation, and present the inspection test results in due course.

DP NAEK Energoatom will grant the permit for operation of the CSFSF on the basis of statement of commissioning by the State Acceptance Commission provided there are relevant documents produced by the State supervision authorities.

The documents of CSFSF commissioning as well as all the construction and assembly documentation must be kept at the facility during the entire life cycle of the CSFSF.

13. IDENTIFICATION OF POTENTIALLY HAZARDOUS FACILITIES

13.1 General Provisions

The risk of emergencies of technological nature is largely determined by the condition of potentially hazardous facilities.

Identification of potentially hazardous facilities (PHF) is performed in all enterprises owning or using facilities for use, production, processing, storage or transportation of hazardous substances. PHF identification is also done for all enterprises that have intention to start construction of such facilities.

The legal basis for the identification of PHF are the Code of Civil Defence of Ukraine [74], the Law of Ukraine “On Hazardous Facilities” [75], the rules of technological safety in the field of civil protection in enterprises, organizations, institutions, and hazardous areas [76].

PHF identification implies analysis of the structure of the facility and the nature of its operation. An important task at the stage of PHF identification is to determine the characteristics (properties) of PHF in terms of possible adverse impact on the production, population and the environment.

The process of identification shall consider and taken into account internal and external sources of potential hazard.

Internal sources determine the danger of buildings, structures, equipment, processes, objects and substances circulating in the facility.

External hazards that are not directly related to the operation of the facility, but may cause emergency situations and have a negative impact on their development. External sources include natural phenomena and accidents on the nearby facilities.

The analysis allows to establish the presence or absence of hazards, which in certain circumstances may cause emergencies, as well as to determine their possible levels.

The facilities are identified as potentially hazardous, if they contain at least one source of hazard that may result in emergency situation of facility-specific, local, regional or state level.

PHF identification is carried out in accordance with the Methodology For Identification Of Potentially Hazardous Facilities [77].

In the case of identification of facility as potentially hazardous, the high-risk factor is also identified.

Identification of the high-risk factor (HRF) is performed in accordance with the Procedure For Identification And Registration Of High-Risk Factors [78].

13.2 Identification Of Potentially Hazardous Facilities

PHF identification is carried out in accordance with the Methodology For Identification Of Potentially Hazardous Facilities [77] and involves the following stages:

- selection of emergency codes, the occurrence of which is possible at the facility;
- analysis of indicators of emergency signs and determination of threshold values;
- determination of the results of analysis of hazards, which under certain conditions could cause emergency situations;

- definition of hazards for each of the specific sources;
- determination of a list of hazardous substances used at the facility, their amounts and hazard classes;
- evaluation of the distribution zone and possible consequences of emergency situations;
- establishment of the most probable emergency levels;
- determination of proper state registers (inventories) to register the hazardous facilities;
- determination of the compliance of the facility with the regulations in hazardous facilities determination.

13.2.1 Selection Of Emergency Classification Codes, The Occurrence Of Which Is Possible At The Facility

Selection of the code of emergency at the facility is carried out in accordance with the Classifier of Emergencies (DK 019:2010) [79]. Emergency Codes selected for the facility under design are listed in Table 13.1.

Table 13.1 **— Emergency Codes Of Possible Hazards**

Emergency	Name Of Emergency
10000	MAN-MADE EMERGENCY
10100	MAN-MADE EMERGENCY OR DISASTER ON TRANSPORT (EXCEPT FIRE AND EXPLOSION)
10110	Emergency on transport with the release (threat of release) of hazardous and harmful
10112	Emergency on transport with the release (threat of release) of radioactive
10200	EMERGENCIES DUE TO FIRE, EXPLOSIONS
10210	Emergencies due to fire, explosions in buildings and structures
10211	Emergencies due to fire, explosion in buildings, on technological lines or technological equipment of industrial facilities
10212	Emergencies due to fire, explosion in non-residential buildings
10220	Emergencies due to fire, explosion at the facility for exploration, extraction, processing, transportation or storage of flammable, combustible and explosive substances
10230	EMERGENCIES DUE TO FIRE, EXPLOSIONS ON TRANSPORT
10231	Emergencies due to fire, explosion on railways
10250	Emergencies due to fire, explosion on radiation, chemically or biologically hazardous facility without spillage (release) of hazardous substances
10500	EMERGENCIES WITH THE RELEASE (THREAT OF RELEASE) OF RADIOACTIVE SUBSTANCES
10520	Emergencies with the release (threat of release) of radioactive substances at the enterprises of nuclear-fuel cycle (except nuclear power plants)
10600	Emergencies due to sudden destruction of buildings and structures
10610	Emergencies due to destruction of elements of transport infrastructure
10620	Emergency due to destruction of buildings or structures of industrial purpose
20000	NATURAL EMERGENCIES
20100	GEOPHYSICAL EMERGENCIES
20110	Emergencies related to earthquakes
20300	METEOROLOGICAL EMERGENCIES
20310	Meteorological emergencies related to precipitation

Emergency	Name Of Emergency
20320	Meteorological emergencies, temperature-related
20330	Meteorological emergencies, other
20700	MEDICAL-BIOLOGICAL EMERGENCIES
20720	Emergencies related to poisoning of people
20721	Emergencies related to poisoning of people as a result of use of poor-quality food
20722	Emergencies related to poisoning of people as a result of use of poor-quality water
20723	Emergencies related to the poisoning of people with toxic or other substances (individual cases)
30000	SOCIAL EMERGENCIES
30100	ARMED ATTACKS, SEIZURE AND RETENTION FACILITIES OF STATE IMPORTANCE (MOST IMPORTANT AND IMPORTANT STATE FACILITIES) OR REAL THREATS OF SUCH ACTIVITIES
30170	Armed attacks, seizure and retention of nuclear power plants, chemical industry facilities and facilities used to produce and store biohazardous materials or the threat of such actions
30500	EMERGENCIES INVOLVING DISAPPEARANCE OR THEFT OF WEAPONS AND HAZARDOUS SUBSTANCES FROM THE FACILITIES OF STORAGE, USE, PROCESSING OR DURING TRANSPORT
30510	Emergencies related to the disappearance or theft of firearms technical items from the facilities of storage, use, processing or during transport
30520	Emergencies related to the disappearance or theft of ammunition from the facilities of storage, use, processing or during transport
30530	Emergencies related to the disappearance or theft of armored vehicles from the facilities of storage, use, processing or during transport
30560	Emergencies related to the disappearance or theft of radioactive substances (also devices, equipment containing radioactive substances) from the facilities of storage, use, processing or during transport
30600	EMERGENCIES RELATED TO ACCIDENTS WITH PEOPLE
30610	Emergencies related to accidents in the performance of job duties
40000	MILITARY EMERGENCIES

13.2.2 Indicators Of Emergency Signs And Determination Of Threshold Values

Analysis of signs of emergency, selected in the previous step, and definition of their threshold values was performed using the classification features of emergencies [80]. The results are set out in Table 13.2.

Table 13.2 **- Indicators Of Emergencies And Their Thresholds**

Indicator No.	Description	Thresholds Value
1	Man-made emergency	

182

571402_201_001_PZ01_ред.2

Indicator No.	Description	Thresholds Value
1.1	Death or injury to people (staff) due to explosions and fires (except in cases of fires and explosions in residential buildings and structures), destruction of underground structures (including the collapse of roofs in mines	2 or more people killed, 5 or more people injured.
1.2	Death or injury to people (staff) due to accidents, emergency events (except in cases of road traffic accidents) and other hazardous events (including casualties)	3 or more people killed, 10 or more people injured.
1.6	Immediate threat to life from hazardous (affecting) factors of emergency situation (accident event) leading to emergency evacuation of more than 50 people.	1 event
1.7	Emission dangerous chemicals of appropriate hazard class (corresponding to the level of toxicity), including dangerous goods (release from the technological equipment of the facility), which can create or creates affecting factors for vehicle (facility) personnel, the public or other environmental object	For dangerous chemicals of Hazard Class 3 — 0.1 t; for dangerous chemicals of Hazard Class 4 — 0.5 t.
1.8	Emission of radioactive substances from vehicles or damage to radioactive cargo (packaging, cask, etc.) related to traffic accidents (accident, fire or other hazardous event)	1 event
1.10	Accident on the railways (including subways), which lead to the collision of passenger or freight trains with other trains or rolling stock, running off the track of rolling stock of passenger or freight trains on hauls and stations, as well as death and/or injury of people	3 or more people killed, 10 or more people injured.

Indicator No.	Description	Thresholds Value
1.11	Accident on the railways (including subways), which lead to the collision of passenger or freight trains with other trains or rolling stock, running off the track of rolling stock of passenger or freight trains on hauls and stations, as well as damage to rolling stock to the extent of its decommissioning	3 or more items
1.12	Explosion (fire) during movement of a vehicle with explosive (flammable) substances, hazardous chemicals or petroleum products (with damage to containers (tanks, casks, packaging, etc.) of the dangerous goods	1 event
1.25	Fire (explosion), for the elimination of which, in addition to the forces and means of fire-rescue units or other emergency services, additional forces and resources involved in other groups of civil protection are required, and direct damages (estimated in accordance with the legislation) caused by fire (explosion) exceeded 0.5 thousand minimum wages	1 event
1.40	Accident at the facility, where nuclear materials are used, sources of ionizing radiation or radioactive wastes are stored, resulting in (possible) employees exposure to the effective radiation dose of more than 2 mSv/year (category A workers — more than 50 mSv/year)	1 event
1.41	Radioactive contamination of the environment due to radiation accident at the facility, where nuclear materials are used, sources of ionizing radiation or radioactive wastes are stored, resulting in (possible) population exposure to the effective radiation dose of more than 1 mSv/year	1 event
1.45	Nuclear or radiological accident, which represents a threat to Ukraine, reportable in accordance with the International Convention on Early Notification of Nuclear Accidents or pursuant to bilateral intergovernmental agreements	1 event

Indicator No.	Description	Thresholds Value
1.47	The collapse of more than 10% of a building or structure (bearing structures of the building) of the main production facility leading to consequences (responsibility) of Class CC2 or CC3	1 event
1.48	Failure of more than 10 percent of the total amount of main technological equipment on a manufacturing enterprises of strategic economical or state security importance due to the destruction (damage) of its buildings and structures	1 event
1.49	Suspension of production activities of the enterprises of strategic economical or state security importance due to the destruction of its buildings and structures used for production purposes (including transport infrastructure)	12 or more hours
2	Natural emergencies	
2.1	Death or personal injury (disease, poisoning) due to natural hazards or events of medical and biological nature	3 or more people killed, 10 or more people hospitalized.
2.2	Immediate threat to life from hazardous (affecting) factors of emergency situation of natural origin leading to emergency evacuation of more than 50 people.	1 event
2.3	Earthquakes in excess of background seismicity by 1 point	1 event
2.4	Earthquakes with intensity of more than 5 points on the MSK-64 scale in the places of location of high-risk facilities	1 event
2.31	Contraction of dangerous infectious diseases by people: dysentery and other intestinal infectious diseases of established or unknown etiology, salmonellosis, viral hepatitis A	3 or more people in organized communities within 3 days.
2.35	Cases of poisoning of 10 or more people with industrial dangerous chemicals or other hazardous substances	10 to 25 people — individual poisoning, 26 or more people — group poisoning;
2.36	Simultaneous poisoning of people of the same group as a result of consumption of food or water: - botulism, - same type toxicants, - wild mushrooms and plants or combination of toxicants of two or more species	 1 or more people. 10 or more people. 5 or more people.

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185

Indicator No.	Description	Thresholds Value
3	Social emergencies	
3.1	Death or personal injury due to hazardous events (including accidents on the water)	3 or more people killed, 10 or more people injured.
3.4	Armed attacks, capture and holding of building of law enforcement bodies	1 event
3.8	Armed attacks or unauthorized actions by individuals with regard to nuclear facilities	1 event
3.13	Disappearance or theft of firearms of Destruction Categories 1 and 2 with ammunition	1 event
3.15	Disappearance or theft of grenades, artillery shells, mines, bombs or explosive charges	1 event
3.16	Disappearance or theft of armored vehicles	1 event
3.21	Disappearance or theft of dangerous chemicals, which can create or create affecting factors for facility personnel or other environmental objects	For dangerous chemicals of Hazard Class 3 — 0.2 t; for dangerous chemicals of Hazard Class 4 — 2 t;

13.2.3 Identification Of Hazards That May Be Sources Of Emergencies

According to the analysis of hazard sources, which under certain conditions (accident, violation of operating conditions, occurrence of natural hazards, etc.) can give rise to emergencies, relevant sources of hazard listed in Table 13.3 have been identified using the List of the main sources of hazards inherent in potentially dangerous facilities (Appendix 2 to Methods Of Identification Of Potentially Hazardous Objects [77]).

Table 13.3 — **Sources Of Emergency Situations**

Hazard Source Name	Hazard Source Analogue
Tanks with diesel fuel	Tanks, reservoirs, bottles and other containers with hazardous substances
Fuel dispenser	Technological equipment, associated with the use, production, processing or transportation of hazardous substances
Canisters with motor oils	Tanks, reservoirs, bottles and other containers with hazardous substances
MPC, HI-STAR, HI-STORM, HI-TRAC casks	Nuclear installations, facilities for radioactive waste management, sources of ionizing radiation
Lifting machinery	Stationary equipment for loading and unloading, lifting machinery

Hazard Source Name	Hazard Source Analogue
Railway facilities within the area	Station tracks and turnouts of railway stations, switching and crossing devices, cargo and passenger handling devices, marshalling yards, locomotives, wagons, and storage facilities

13.2.4 Definition Of Hazards Factors For Specific Sources Of Hazards

For each of the identified sources of hazard, the types of hazard have been identified on the basis of Annex 3, Methods Of Identification Of Potentially Dangerous Facilities [77]. See Table 13.4.

Table 13.4 — **Sources Of Emergency Situations**

Hazard Source Name	Hazard Type
Tanks with diesel fuel	Explosion, fire, chemical, environmental hazards
Fuel dispenser	Explosion, fire, chemical, environmental hazards
Tanks with diesel fuel for diesel power plants	Explosion, fire, chemical, environmental hazards
Canisters with motor oils	Fire, chemical, environmental hazards
MPC, HI-STAR, HI-STORM, HI-TRAC casks	Radiation hazard
Lifting crane	Physical hazard
Railway facilities within the area	Explosion, fire, chemical, environmental, radiation, physical hazards

13.2.5 Definition Of A List Of Hazardous Substance Used At The Facility, Their Amounts And Hazard Classes

For the facility in design, a list of hazardous substances used in the operation of the facility, their amounts and hazard classes have been identified according to GOST 12.1.007-76 [81] and GOST 19433-88 [82]. The results are set out in Table 13.5.

Table 13.5 **— List Of Hazardous Substances**

Hazardous Substance Name	Amount, tonnes	Hazard Class Under GOST 12.1.007-76 [81]	Hazard Class & Subclass Under GOST 19443-88
Diesel fuel*	8.06	4 (paragraph 5.1 of DSTU 3868-99 [83])	3, 3.3 (paragraph 4.3.1 of DSTU 3868-99 [83])
Motor oil*	0.07	4 (paragraph 7.5 of GOST 10541-78 [84])	-
Spent nuclear fuel	5648 (TM)	-	7
* — without regard for presence of hazardous substances (fuels and oils) in the railway rolling stock, technology and road transport serving the CSFSF			

13.2.6 Evaluation Levels Of Possible Emergencies

Based on the previously obtained data, the evaluation of distribution area in case of emergency for different identified initial hazards, possible consequences of emergencies and the highest possible levels of emergency have been made. The evaluation results are summarized in Table 13.6.

Evaluation of the zone of possible disaster was made using a conservative method and is to be refined on the basis of the materials developed pursuant to Order No. 122 of State Agency for Occupational Safety Supervision of 17.06.1999 [85] on Plans Of Localization And Liquidation Of Emergencies And Accidents.

Assessment of possible consequences of emergency situations for each of the identified hazard sources (in terms of number of dead and injured) was made on the basis of threshold values for the previously defined emergency situations.

The level of emergency for each of the hazard sources is established in accordance with the Procedure For Classification Of Emergency Situations By Levels [86] and the Classification Of Emergency Situations Of Natural And Man-Made Origin (Annex 4 to Methods Of Identification Of Potentially Hazardous Facilities [77]).

Table 13.6 **— Assessment Of Possible Consequences And Hazard Levels**

Hazard Source Name	Propagation	Number Of Lethal Cases,	Number Injured, people	Emergency Level
Tanks with diesel fuel	Within the facility territory	2 or more	5 or more	Local
Fuel dispenser	Within the facility territory	2 or more	5 or more	Local
Tanks for motor oil	Within the facility territory	2 or more	5 or more	Local
MSC, HI-STAR, HI-STORM, HI-TRAC casks	Emergency beyond the territory of the	-	-	National
Lifting crane	Within the facility territory	3 or more	10 or more	Regional
Railway facilities within the area	Within the facility territory	3 or more	10 or more	Regional

13.2.7 Identification Of State (Sectoral) Registers (Cadastres) Used For Registration Of The Facilities

Table 13.7 Lists the relevant registers (cadastres) used/not used for registration of the facilities under design in accordance with the List Of Approved State (Sectoral) Registers Of Ukraine (Annex 5 to Methods Of Identification Of Potentially Hazardous Facilities [77]).

Table 13.7 **— List Of State (Sectoral) Registers (Cadastres)**

Name Of State (Sectoral) Register (Cadastre)	Registration Number (If Any)
State Register Of Potentially Hazardous Facilities	Not registered, subject to registration
State Register Of High-Risk Facilities	Not subject to registration
Register Of Accident-Prone Production Buildings And Structures	Not subject to registration
State Register Of Ionizing Radiation Sources	Not registered, subject to registration
State Register Of Radioactive Waste	Not subject to registration
State Register Of Radioactive Waste Storage Facilities	Not subject to registration
State Cadastre Of Radioactive Waste Storage Facilities	Not subject to registration
Register Of Waste Generation, Treatment And Disposal Facilities	Not subject to registration
Register Of Waste Disposal Facilities	Not subject to registration

13.2.8 Identification Of The Facility's Relation To The Acting Regulations

The results of identification of relation to the regulations (need to meet the corresponding thereof) listed in paragraphs 14, 15 of Methods Of Identification Of Potentially Hazardous Facilities [77] are presented in Table 13.8.

Table 13.8 — **Relation Of The Facility To Certain Regulations**

Facility Covered (Not Covered) By RI	RI Title
Covered for identification Paragraph 1 (to the extent concerning compliance with Annex 2 to Regulatory Threshold Masses Of Toxic Substances In Identification Of HRF)	Procedure For Identification And Recording Of High-Risk Facilities Resolution No. 956 of the Cabinet of Ministers of Ukraine of 14.07.2002 "On Identification And Declaring Of High-Risk Facilities Safety".
Covered Paragraph 3 — nuclear installations; Paragraph 13 — construction of railways and structures; Paragraph 21 — automobile refuelling stations.	List Of Activities And Facilities Of Increased Ecological Hazard. Resolution No. 554 of the Cabinet of Ministers of Ukraine of 27.07.2995 "On The List Of Activities And Facilities Of Increased Ecological Hazard".

Facility Covered (Not Covered) By RI	RI Title
Covered Paragraph 1 — equipment associated with the use, manufacture, processing, storage, recycling or disposal of hazardous and harmful substances; Paragraph 14 — electrical equipment intended for use (application) in hazardous areas; Paragraph 19 — cranes and lifting machines, elevators, escalators, moving walks, cable cars, ski lifts, in particular used in construction, and funiculars.	List Of Machines, Facilities, Mechanisms And Equipment Of High-Risk. Resolution No. 1107 of the Cabinet of Ministers of Ukraine of 26.10.2011 “On Approval Of Procedure For Issue Of Permits For High-Hazard Works And For Operation Of (Use) Of Machines, Mechanisms, And Equipment Of High Risk”.
Covered State enterprise NAEK Energoatom; State Specialized Enterprise “Chernobyl Nuclear Power Plant”	List of Highly Hazardous Enterprises-debtors, the termination of which requires implementation of special measures to prevent possible harm to the life and health of citizens, property, structures, and the environment. Resolution No. 339 of the Cabinet of Ministers of Ukraine of 15.05.2013 “On Implementation of Article 85 Of the Law of Ukraine ‘On Rehabilitation of Debts’ Solvency or Recognition as Insolvent’”
Covered Exclusion zone and Compulsory resettlement zone, including “Shelter” facility and other potentially hazardous facilities of the specialized enterprises located in these zones	List of facilities and separate territories subject to continuous and compulsory servicing on a contractual basis by the state emergency and rescue services. Resolution No. 1214 of the Cabinet of Ministers of Ukraine of 04.08.2000 “On Approval of Separate Territories Subject to Continuous and Compulsory Servicing on a Contractual Basis by the State Emergency and Rescue Services”

13.2.9 Conclusion On The Results Of Identification Of PHFs

According to the results of identification, the CSFSF is a potentially hazardous facility as defined by Paragraph 17 of Methods Of Identification Of Potentially Hazardous Facilities [77]. The maximum level of emergency in accordance with the Procedure For Classification Of Emergency Situations By Levels [86] is defined as “national”. The facility is subject to

registration in the State Register Of Potentially Hazardous Facilities and the State Register Of Ionizing Radiation Sources.

13.2.10 Identification Of The Facility Under Design In Terms Of High Hazard

The facility, identified as potentially hazardous pursuant to Paragraph 1 of Procedure For Identification And Registration Of High-Risk Factors [78], is subject to identification for the purpose of its classification as the facility of high hazard.

At the same time, on the basis of Paragraph 1 of Procedure For Identification And Registration Of High-Risk Factors [78]б the PHF is subject to identified only in relation to its components containing hazardous substances listed in the Annexes 1 and 2 to Regulation on Threshold Masses of Hazardous Substances for the Identification of High Risk [78], and can not be identified as PHF on the condition of presence of RASs.

13.2.11 List Of Potentially Hazardous Facilities With Hazardous Substances, Isolated For Identification

For identification of the facilities under design in terms of hazard, the following objects (sites) with the presence of hazardous substances, as defined in Annexes 1 and 2 to Regulation on Threshold Masses of Hazardous Substances for the Identification of High Risk [78], are listed in Table 13.9.

The classification of hazardous substances under certain categories in terms of types of possible accidents is based on the classification set out in paragraphs 1 and 2 to Regulation on Threshold Masses of Hazardous Substances for the Identification of High Risk [78].

Table 13.9 — **List Of Potentially Hazardous Facilities With Hazardous Substances, Isolated For Identification Purposes**

PHF Name, Isolated For Identification, And Its Composition	Location of PHF	Name, Weight Of Hazardous Substance Or Group Of Hazardous Substances Used In The Facility	Name Or Category Of Hazardous Substance Or Group Of Hazardous Substances Used For Facility Identification	Identification Results (Belonging Of The HRF To Some Hazard Class)
Filling station	CSFSF site	Diesel fuel — 7.31 t	Category 2 (GZh), Groups 1 and 2 (explosion, fire)	Non classified as HRF*
Garage (warehouse)	CSFSF site	Motor oil — 0.03 t*	Category 2 (GZh), Group 2 (fire)	Non classified as HRF*

PHF Name, Isolated For Identification, And Its Composition	Location of PHF	Name, Weight Of Hazardous Substance Or Group Of Hazardous Substances Used In The Facility	Name Or Category Of Hazardous Substance Or Group Of Hazardous Substances Used For Facility Identification	Identification Results (Belonging Of The HRF To Some Hazard Class)
Electrical equipment building (diesel power plant premises)	CSFSF site	Diesel fuel — 0.75 t, motor oil — 0.04 t. Total — 0.79 t.	Category 2, (GZh) Groups 1 and 2 (explosion, fire)	Non classified as HRF*
* — for substantiation see Section 13.2.12.				

Other potentially hazardous facilities of high risk, except for the above, are not established.

13.2.12 Mass of Hazardous Substances Located At PHFs

For each potentially hazardous facility specified in Table 13.9, each production site, shop, unit, appliance being part of it, the hazardous substances have been identified wit determination of weight of each and the total weight. The data is set out in Table 13.10.

Table 13.10 — **List Of Hazardous Substances, Their Amounts And Hazard Categories**

PHF Name	Description of production (sites, installations, apparatuses, etc.) as parts of PHF	Hazardous substance name and weight, t	Weight of individual hazardous substance and mass of hazardous substances of each category to which it can be attributed according to the standards as to threshold weights, t									
			Separate substance	1	2	3	4	5	6	7	8	9	10
Filling station	Underground tanks (2x5 m3)	Diesel fuel — 7.31 t	-	-	7.31	-	-	-	-	-	-	-	-
Garage (warehouse)	Canisters with motor oils (6x5 l)	Motor oil — 0.03	-	-	0.03	-	-	-	-	-	-	-	-
Building for electrical engineering devices (DPP)	Service tank (839 l)	Diesel fuel — 0.75	-	-	0.75	-	-	-	-	-	-	-	-
	Oil system (26.4 l)	Motor oil — 0.04	-	-	0.04	-	-	-	-	-	-	-	-

PHF Name	Description of production (sites, installations, apparatuses, etc.) as parts of PHF	Hazardous substance name and weight, t	Weight of individual hazardous substance and mass of hazardous substances of each category to which it can be attributed according to the standards as to threshold weights, t									
			Separate substance	1	2	3	4	5	6	7	8	9	10
TOTAL			-	-	8.13	-	-	-	-	-	-	-	-

In accordance with Art. 1 of the Law of Ukraine “On Hazardous Facilities” [75] and paragraph 4 of the Procedure For The Identification And Recording Of High-Risk Facilities [78], the PHF belongs to HRF of the corresponding class, if the value of total mass of hazardous substance or several substances used, produced, processed, stored or transported is equal to or exceeds the standard threshold mass.

Based on the fact that the mass of individual hazardous substances and their total mass is below the threshold established for hazardous substances, i.e. the facility actually handles 8.13 tonnes of hazardous substances (flammable liquids) while the minimum threshold value for the Class 2 HRF is 5,000 tonnes (Annex 2 to Procedure For The Identification And Recording Of High-Risk Facilities [78], Category 2), in accordance with paragraph 4 of Procedure For The Identification And Recording Of High-Risk Facilities [78], the identified potentially dangerous facility is not classified as of high risk.

13.2.9 Conclusion On The Results Of Identification Of HRFs

According to the results of identification, the facility under does not belong to the sites of increased danger and is not subject to registration in the State Register Of High-Risk Facilities and declaring of safety of high-risk facility.

14. ENVIRONMENTAL IMPACT ASSESSMENT

The state policy of Ukraine, as provided for in the Constitution of Ukraine, [87] is aimed to ensure the environmental safety and maintenance of the ecological balance on the territory of Ukraine.

For this purpose, Ukraine carries out, on its territory, ecological policy aimed at maintaining safe environment for the living and inanimate nature, protection of life and health of the population from the negative effects caused by the environmental pollution, to achieve a harmonious interaction between the society and the nature, protection, rational use and restoration of the natural resources [87, 89].

CSFSF designing process shall be performed in three stages. Assessment of the CSFSF environmental impact was carried out at the first stage of the design, as part of the investment feasibility study. The EIA results were approved by Decree of the Cabinet of Ministers of Ukraine No. 131-r of 04 February 2009 on the basis of the comprehensive conclusion (positive) issued by Ukrderzhbudekspertyza SE on 26 August 2008 under
№84 / 54 / 288o.

EIA as part of the CSFSF project (second approvable design stage) was carried out with consideration of:

- refinement of design solutions of the technology provider;
- raw data, regulated by the Law of Ukraine on Regulation of the Town Planning Activity;
- requirements of the normative-legal acts in the field of environmental protection, which became effective following the provision (26.08.2008) of the comprehensive conclusion of the state examination of the CSFSF investment feasibility study [115].

The presented section of the EIA is based on the requirements of DBN A.2.2-1-2003 [90], the Ukrainian environmental and sanitary legislation, as well as on some specific conditions of the design object in the exclusion zone, and the unconditional (obligatory) resettlement — the exclusion and compulsory resettlement zone [97].

The materials of Environmental Impact Assessment are available in Volumes 12.1, “Environmental Impact Assessment. Part 1. EIA Materials”, and 12.2, “Environmental Impact Assessment. Part 2. Annexes”.

14.1 Description Of Activities

The Central Spent Fuel Storage Facility (CSFSF) is a nuclear facility of national importance.

The CSFSF is intended to store spent nuclear fuel (SNF) from VVER reactors installed in units Rivne 1 to 4, Khmelnitsky 1 to 2, Yuzhnoukrainska 1 to 3 by means of the gradual increase in the capacity, equipping with the systems providing for preparation, for storage, transportation and safe storage.

The CSFSF uses the technology of “dry” storage of spent nuclear fuel in special casks, namely:

- the storage of spent nuclear fuel to be used is a surface “dry” storage with double-barrier insulation system;
- CSFSF lifetime — 100 years;
- CSFSF capacity — 16529 SFAs, including: 12,010 pcs of VVER-1000 SFAs and 4,519 pcs of VVER-400.

The CSFSF is based on the technology by Holtec International (hereinafter — Holtec).
The system developed by Holtec comprises the following components:

- MPC — multi-purpose cask;
- HI-STAR 190 UA (hereinafter—HI-STAR)—transportation cask;
- HI-STORM 190 UA (hereinafter—HI-STORM)—storage cask;
- HI-TRAC 190 UA (hereinafter—HI-TRAC)—transfer cask;
- cask transfer facility (CTF);
- cask transfer device (CTD);
- vertical cask transporter (VCT);
- a rail car transporter for the HI-STAR.

14.2 Service Life

The planned service life is up 100 years, including the active period (accumulation and storage of casks with SFAs) of up to 50 years and the subsequent passive period (storage of casks with SFAs).

14.3 Socio And Economic Need For The Proposed Activity

The social and economic need for the planned activity is the assurance of sustained long-term operation of Ukraine's nuclear power plants.

The CSFSF construction will make it possible to make use of own spent nuclear fuel storage facilities, and avoid dependence from spent nuclear fuel storage services provided abroad.

14.4 Need For Resources During Construction And Operation

14.4.1 Land Resources

In order to implement the planned activities, the land plot of 18.2 hectares was allocated for permanent use. The intended purpose of the land plot, in accordance with the Classifier [99], is "1.10.5, Construction of the Central Spent Fuel Storage Facility for the VVER Reactors of Nuclear Power Plants of Ukraine."

14.4.2 Primary Resources

Basic structures and materials, precast concrete and reinforced concrete elements, metal structures, concrete, rubble, sand, bricks, concrete blocks, cement and other materials will be supplied from specialized enterprises in Kiev and Zhitomir regions of Ukraine.

14.4.3 Energy Resources

The CSFSF uses one type of fuel — diesel fuel.

Fuel consumption on the site during construction of the CSFSF is 94.254 t/year.

The total annual fuel consumption by the CSFSF site during the operation is 25 m³/year.

The annual energy consumption during construction of the CSFSF is 1671.06 thousand kWh/year.

The annual energy consumption during operation of the CSFSF is 4,750.98 thousand MWh/year.

14.4.4 Water Resources

The annual water consumption during construction of the CSFSF is 7,233 m^3/year.
The annual water consumption during operation of the CSFSF is 3,309.5 m^3/year.

14.4.5 Human Resources

Construction will be carried out by the Ukrainian construction and assembly companies. The maximum demand for human resources 430 people per day, including the biggest shift of 280 people (70% of the total staffing requirements).

The number of the CSFSF staff is preliminarily assessed at 161 people of permanent staff and 95 people in the maximum shift.

Beside the personnel of the CSFSF, according to the National Guard of Ukraine, there will be up to 58 servicemen of the National Guard in ordinary daily duty, and up to 68 servicemen in strengthened duty.

14.4.6 Transport

The transport resources available during construction and operation are as follows:

- rail transport (general-purpose and specialized transport) — a network of public and on-site railway tracks;
- road transport (civil and passenger transport) — existing roads.

14.5 Process Waste and Opportunity for Their Reuse, Recycling, Decontamination or Safe Disposal

The process waste and the opportunity for their reuse, recycling, utilization, decontamination or safe disposal: non-radioactive waste will be disposed of in public dumps, radioactive waste will be collected, stored temporarily and sent to the specialized facilities for recycling/disposal.

14.6 Environmental And Other Constraints On The Proposed Activity

The ecological and sanitary-epidemiological restrictions applied to the construction and operation of the CSFSF are aimed at the implementation of the proposed activity and operation without deterioration of the existing environmental performance around the CSFSF, taking into account the compliance with the limits of radiation-hygienic parameters established by DGN 6.6.1-6.5.001-98 [101] and DGN 6.6.1-6.5.061-2000 [102].

Also, the environmental and sanitary-epidemiological limits are determined by the presence of control limits, threshold levels and levels of action as to the radioactive contamination of the sites for the exclusion and compulsory resettlement zone [112].

Moreover, the environmental and sanitary-epidemiological limits are determined by the presence of the sanitary protection zone around the designed site, according to DSP-173-96 [100].

The size of the sanitary protection zone and a surveillance zone defined in CSFSF TEOI CSFSF [104].

- the sanitary protection zone — within 100 m from the border of the site, taking into account the geometry of the CSFSF site;
- the CSFSF control zone — within 600 m from the storage site.

As part of the fire safety design for object, the following restrictions are established:

- the buildings and structures are located on the site of the enterprise with regard for the minimum required distances (fire breaks) between them, as established by SNIP II-89-80* [50].
- the limitations concerning the fire resistance of the buildings and structures (degree of fire resistance) stipulated by the fire resistance classes of the building structures established by DBN V.1.1-7-2002 [17].
- the number of storeys and the floor areas of buildings within the fire compartments are limited by the requirements of SNiP 2.09.02-85 [118], SNiP 2.11.01-85 [119], DBN V.2.2-28:2010 [120].
- the restrictions as to the equipment of the enterprise territory, the buildings and structures, the systems, indoor and outdoor fire water supply, fire-protection systems (fire alarm, automatic fire suppression, fire warning and evacuation, smoke detection, centralized fire monitoring, lightning protection), as well as the implementation of the measures in fire protection of the engineering systems not related to the fire-protection system (heating and ventilation systems, electrical systems, emergency lighting systems, etc.) are set by DBN V.2.5-56:2014 [22], DBN V.2.5-64:2012 [46], DBN V.2.5-67:2013 [121], DBN V.2.5-74:2013 [20], DBN V.2.5-28:2006 [21], DSTU B V.2.5-38:2008 [26], NPAOP 40.1-1.32-01 [122], PUE [16] and others.
- during operation of the enterprise, the restrictions are applied in terms of performance of a set of organizational and technical measures to ensure fire safety conditions and in accordance with the requirements of NAPB A.01.001-2014 [27].

Fire safety restrictions are described in Volume 9 (571402.201.009-PB).

The planning terms and restrictions are provided in Appendix D, Volume 12.2. Environmental Impact Assessment. Part 2. Annexes.

14.7 Public Participation

For the purpose of informing the public about the proposed activity, taking into account the requirements of the Convention On Access To The Information, Public Participation In Decision-Making And Access To Justice In The Environmental Matters" [58] ratified by Ukraine on July 06, 1999 [59], the following actions were take at the feasibility study stage:

- publication of the Statement of Intent (25.01.2007);
- holding of a public consultation process on the construction of the central storage facility for nuclear fuel from the VVER nuclear power plants of Ukraine (after 06.02.2008);
- holding of a round table in Slavutych on the construction of the CSFSF (28.02.2008);
- holding of a round table in Ivankiv on the construction of the CSFSF (01.03.2008);

- public hearings on the planned activity in Slavutych, Kyiv Region (22.03.2008);

publication of the Environmental Impact Statement (07.03.2007).

Following the principles of the environmental policy of National Nuclear Energy Generating Company “Energoatom” and in accordance with the requirements of the legislation of Ukraine, the information on the proposed activity is kept up to date on the website of the National Nuclear Energy Generating Company “Energoatom”. The links to the materials on the public relations under the CSFSF project are posted on the official website of the National Nuclear Energy Generating Company “Energoatom” as shown in Table 14.1.

Table 14.1 — **Links To The Materials On Public Relations Under The CSFSF Project**

Description	**Electronic address (URL) of the remote resource**
Media about CSFSF	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/media/
Materials for the public	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/press/
Official documents	http://www.energoatom.kiev.ua/ru/actvts/stroitelstvo/cssnf/official/

For the purpose of informing the public about the planned activity, the Project stage involves the following actions:

- publication of the Environmental Impact Statement;
- information update on the website of National Nuclear Energy Generating Company “Energoatom”.

14.8 Assessment Of Impact Of Construction, Operation And Accidents At The CSFSF On The Territory Of The Neighboring States

On stage IFS stage [104], in accordance with the Convention on Environmental Impact Assessment in a Transboundary Context [115], ratified by Ukraine on 19 March 1999 [117], the activities in the neighbouring states in raising awareness about the possible impact of the CSFSF were held.

14.9 Obligations In Relation To Environmental Safety

General designer — Public Joint Stock Company “Kyiv Research and Design Institute ‘Energoproect’”(PJSC KIEP) will supervise the compliance of the activities with the design solutions.

Operating organization — Energoatom National Nuclear Energy Generating Company — will ensure:

- safe operation in accordance with the regulations, operating instructions, and technological regulations valid in Ukraine;
- appropriate management structure, and maintenance personnel qualification;
- continuous monitoring during operation, ensuring the implementation of environmental safety measures.

14.10 Results Of The Environmental Impact Assessment Of The Planned Activity

No thermal pollution or evaporation is expected during operation of the CSFSF. The CSFSF operation does not affect the sunlight exposure intensity, temperature, wind velocity,

humidity, atmospheric inversions, fog duration, and other climate features. With that being said, there is no impact on the climate and microclimate.

Under normal conditions of work and in case of accidents, additional radiation exposure is extremely insignificant.

Due to a sufficient distance from the site to the territories with controlled levels of the living environment, the pollutant emissions will not have negative impact on health and lifestyle of the population of the adjacent areas. Analysis of the results of the calculations of surface pollutant concentrations shows that implementation of this project is performed with adherence to the respective sanitary and hygienic standards for each pollutant considered.

In terms of air pollution, the operation of the facility is permissible.

The acoustic effects of the operation of the facility will be permanent and will accompany the activities on the site during the whole operation period. Analysis of the obtained results of the calculations of acoustic effects show that the noise discomfort zone of the technological equipment does not exceed the boundaries of the SPZ and will not affect the formation of further sound field.

Operation of the facility, in terms of expected noise, is acceptable.

The impact of electric and electromagnetic fields during operation of the facility will be permanent during the whole operation period. The impact of electrical equipment (transformers, generators, electrical drives, diesel generator power units) is absent. The impact of radio antennas is permissible. Due to a quite large distance from the facility to the territories with controlled quality of the living environment, the site operation will not result in exceeding the sanitary and hygienic standards. Electromagnetic field generated around the radio facilities (radio antennas) is safe for the human health.

Operation of the facility, in terms of electric and electromagnetic impact, is acceptable.

There are no active karst and karst-suffosion processes, as well as landslides and shifts that could lead to disruption of normal operation of the facility.

Implementation of this project gives no direct discharges into the aquatic environment.

Results of the environmental impact assessment are provided in the project with consideration of refinement of the CSFSF technology, equipment and infrastructure and with consideration of requirements of normative-legal acts in the field of environmental protection, and confirm the EIA results represented in the investment feasibility study. Environmental impact of the planned activity is acceptable.

Radiation contamination risk assessment

- the impact on the environment does not exceed the current state of the environment, does not exceed the exposure standards valid for the E&CRZ, and can be considered acceptable (according to the reference levels)

Assessment of the human health risk from air pollution by chemicals

- the risk of non-carcinogenic effects is extremely low, the likelihood of adverse effects increases pro rate to the increase of the hazard coefficients for certain substances;

- the risk of carcinogenic effects is conditionally acceptable;
- the social risk of the planned activities is conditionally acceptable.

Analysis of the results obtained from the performed calculations and assessment of the CSFSF radiation impact shows that the risk of the facility for the environment and public health is acceptable.

Analysis of the results obtained from the performed calculations during assessment of the risk of the air pollution with chemical contaminants to the public health shows that the risks of the planned activity impact on the environment are assumed acceptable.

Upon the assessment of the risks, implementation of this project is not subject to any restriction.

The analysis of the design values of radiation impact on the components of the environment in the border areas of the Republic of Belarus as a result of construction, normal operation and accidents at the CSFSF, carried out and the design stage, proves the conclusions state in the IFS as to the transboundary impact of the CSFSF.

According to the results of analysis, the environmental impact of the planned facility during construction and operation is considered acceptable.

The materials of environmental impact assessment are available in Volumes 12.1, “Environmental Impact Assessment. Part 12.1. EIA Materials”, and 12.2, “Environmental Impact Assessment. Part 1. Materials 12.2 EIA and environmental impact assessment. Part 2. Annexes.”

15 ASSESSMENT OF SAVINGS FROM IMPLEMENTATION OF ENERGY-EFFICIENCY MEASURES

An assessment of efficiency of the measures to save energy has been carried out in conformity with DBN B.2.6-31:2006 [44] State Building Regulation.

In order to determine whether the existing walls and coverings meet the requirements of DBN B.2.6-31:2006 [44], thermotechnical calculations of enclosing structures have been conducted for the buildings as follows:

- acceptance building;
- administrative building (CD facility);
- maintenance building with MPC storage room;
- security facilities complex;
- guard building (CD facility);
- checkpoint 1;
- checkpoint 2;
- electrical equipment building;
- fire pump station;
- garage.

Design of heating, ventilation and air conditioning systems for CSFSF construction buildings includes the measures that, when meeting quality and operational requirements, will contribute to an efficient use of thermal energy and minimize heat losses to the environment.

15.1 Source Data

Design parameters of outside air for heating and ventilation systems have been assumed as per DSTU-H B B.1.1-27:2010 State Standard “Building Climatology” [106]:

- temperature of the cold period for calculating heating and ventilation systems is minus 22°C;
- temperature of the warm period for calculating ventilation systems is minus +23°C;
- temperature of the cold period of year for calculating air conditioning systems is +28°C;
- average annual relative humidity is 74%.

15.2 Thermotechnical Calculation of Enclosing Structures for Offuice Building (CD Facility), Guard Building (CD Facility), Checkpoint 1 and Checkpoint 2

As required by Item 2.1 of DBN B.2.6-31:2006 [44], it is mandatory for enclosing structures that the following condition is met:

$$R_{\Sigma red} \geq R_{qmin} \qquad (15.1)$$

where $R_{\Sigma red}$ is a reduced resistance to heat transfer of the enclosing structure, m^2.K/W;

R_{qmin} is a minimum allowable resistance to heat transfer of the enclosing structure, m^2.K/W.

As required by Item 2.2 of DBN B.2.6-31:2006 [44], the minimum allowable value of resistance to heat transfer of the enclosing structure R_{qmin}, m^2.K/W, for civil buildings should be established according to Table 1 of DBN B.2.6-31:2006 [44] depending on:

- the temperature in the facility operation area as per Appendix B [44];
- heat-to-humidity conditions as per Appendix G [44].

As follows from Appendix B to DBN B.2.6-31:2006 [44], the construction object is located in the operation temperature area I.

As follows from Appendix G to DBN B.2.6-31:2006 [44], at the preset temperature of inside air in the cold period (+18°C), a normal heat-to-humidity condition for the premises is designed with a relative humidity of inside air not exceeding 60%.

Under normal heat-to-humidity conditions in keeping with Appendix K [44], we assume "B" conditions for operation of material in the enclosing structures.

For the wall cladding of buildings in the operation temperature area I, a minimum allowable resistance to heat transfer must be:

R_{qmin} = 3.3 (m^2 x K)/W (Table 1, [44]).

A minimum thickness δ (m) of thermal covering was derived from the boundary condition to meet the requirement of (1) $R_{\Sigma red} \geq R_{qmin,}$ i.e. for the condition of:

$$(R_{\Sigma red}=R_{qmin}) \qquad (15.2)$$

As the condition (1) is verified, the reduced resistance to heat transfer of the enclosing structure, $R_{\Sigma red}$ m^2.K/W, is calculated as per Appendix I (Item 2.10 [44]) by (I.1):

$$R_{\Sigma np} = \frac{1}{\alpha_в} + \sum_{1}^{i} \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_з}, \qquad (15.3)$$

where α_B = 8.7 W/(m^2 x K) is a heat transfer coefficient, W/(m^2.K), of the inner surface of enclosing structure ([44], Appendix E);

α_3 = 23 W/(m^2 x K) is a heat transfer coefficient for winter conditions, W/(m^2 x K), of the outer surface of enclosing structure ([44], Appendix E);

δ_i is the thickness of the i-th layer of the structure, m;

λ_i is the heat conductivity, W/(m.K), of the i-th layer of the structure under the rated duty, according to Item 2.11 and Appendix Л [44].

15.2.1 Office Building (CD Facility)

Wall cladding is composed as follows:

- ventilated façade from 4 mm thick composite panels (neglected for the calculation);
- IZOVAT-80 mineral wool slabs, density of 80 kg/m^3, thickness is to be defined by design, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.041 W/(m.K);
- walls are made from foam concrete blocks D700 600x400x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 400 mm, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Table 1 of DBN B.2.6-31:2006 [44]).

For the wall cladding of buildings in the operational temperature area I, a minimum allowable resistance to heat transfer must be:

R_{qmin} = 3.3 (m^2 x K)/W (Table 1, DBN B.2.6-31:2006 [44]).

For a multi-layer structure, resistance to heat transfer, R_{const} (m^2.K/W), is calculated by (5) DBN B.2.6-31:2006 [44]:

$$R_{конст.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{\delta}{0{,}041} + \frac{0{,}4}{0{,}27}$$

$$R_{конст.} = \frac{\delta}{0{,}041} + 1{,}481$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8{,}7} + \left(1{,}481 + \frac{\delta}{0{,}041}\right) + \frac{1}{23} = 0{,}115 + 1{,}481 + \frac{\delta}{0{,}041} + 0{,}043 = 1{,}639 + \frac{\delta}{0{,}041}$$

A minimum thickness, δ (m), of the thermal covering is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.639 + δ/0.041) = (R_{qmin}= 3.3)

1.639 + δ/0.041 = 3.3

δ/0.041 = 3.3 – 1.639

δ = (3.3 – 1.639) x 0.041 = 0.0681 m

Assume δ = 100 mm considering slab fabrication conditions.

The requirements of Item 2.1 DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm are met:

[$R_{\Sigma red}$ = 4.078 m^2.K/W] ≥ [R_{qmin} = 3.3 m^2.K/W].

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-80 mineral wool slabs (density of 80 kg/m^3).

Basement is made of the following materials:

- 10 mm thick ceramic granite tile (neglected for the calculation);
- Ceresit CT 17 bonding aggregate (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness being defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- walls made from foam concrete blocks D700 600x400x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 300 mm, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table Л.1 [44]).

For the wall cladding of buildings in the operational temperature area I, a minimum allowable resistance to heat transfer must be:

R_{qmin} = 3.3 (m^2 x K)/W (Table 1, DBN B.2.6-31:2006 [44]).

For a multi-layer structure, resistance to heat transfer, R_{const} (m^2.K/W), is found by:

$$R_{конст.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{\delta}{0{,}045} + \frac{0{,}4}{0{,}27}$$

$$R_{конст.} = \frac{\delta}{0{,}045} + 1{,}481$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma_{red}} = \frac{1}{8,7} + \left(1,481 + \frac{\delta}{0,045}\right) + \frac{1}{23} = 0,115 + 1,481 + \frac{\delta}{0,045} + 0,043 = 1,639 + \frac{\delta}{0,045}$$

A minimum thickness, δ (m), of the thermal covering is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.639 + δ/0.045) = (R_{qmin}= 3.3)

1.639 + δ/0.045 = 3.3

δ/0.045 = 3.3 – 1.639

δ = (3.3 – 1.639) x 0.045 = 0.075 m

Assume δ = 100 mm considering slab fabrication conditions.

The requirements of Item 2.1 DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm are met:

[$R_{\Sigma red}$ = 3.861 m^2.K/W] ≥ [R_{qmin} = 3.3 m^2.K/W].

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane mounted mechanically (neglected for the calculation);
- 50 mm thick insulant – 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, thickness to be determined by the calculation, density of 110 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs, density of 110 kg/m^3, average thickness of 100 mm (neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- 200 mm thick reinforced concrete plates, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K).

For the roof covering of buildings in the operational temperature area I, a minimum allowable resistance to heat transfer must be:

R_{qmin} = 4.95 (m^2 x K)/W (Table 1, DBN B.2.6-31:2006 [44]).

For a multi-layer structure, resistance to heat transfer, R_{const} (m^2.K/W), is found by (5) DBN B.2.6-31:2006 [44]:

$$R_{const.} = \sum_{1}^{3} \frac{\delta_i}{\lambda_i} = \frac{0,05}{0,046} + \frac{\delta}{0,042} + \frac{0,2}{2,04}$$

$$R_{const.} = \frac{\delta}{0,042} + 1,184$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma_{np}} = \frac{1}{8,7} + \left(1,184 + \frac{\delta}{0,042}\right) + \frac{1}{23} = 0,115 + 1,184 + \frac{\delta}{0,042} + 0,043 = 1,342 + \frac{\delta}{0,042}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.342 + δ/0.042) = (R_{qmin}= 4.95)

1.342 + δ/0.042 = 4.95

δ/0.042 = 4.95 – 1.342

δ = (4.95 – 1.342) x 0.042 = 0.151 m

Assume δ = 200 mm considering slab fabrication conditions.

The requirements of Item 2.1 DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 200 mm (0.2 m) are met:

[$R_{\Sigma red}$ = 6.1 m^2.K/W] ≥ [R_{qmin} = 4.95 m^2.K/W].

The accepted thickness of the heat-insulation layer is 200 mm (0.2 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

Thermotechnical calculations for enclosing structures of the guard (CD facility), checkpoint 1 and checkpoint 2 buildings have been carried out in a similar manner. Results of the calculations are given in Table 15.1.

15.2.2 Guardhouse (CD Facility)

Wall cladding is made from the materials as follow:

- ventilated façade from 4 mm thick composite panels (neglected for the calculation);
- IZOVAT-80 mineral wool slabs, density of 80 kg/m^3, thickness is to be defined by design, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.041 W/(m.K);
- walls are made from foam concrete blocks D700 600x300x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 400 mm, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56 of Table Л.1 of DBN B.2.6-31:2006 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

[$R_{\Sigma red}$ = 3.708 m^2.K/W] ≥ [R_{qmin} = 3.3 m^2.K/W].

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-80 mineral wool slabs (density of 80 kg/m^3).

Basement is made of the following materials:

- 10 mm thick façade ceramic granite tile (neglected for the calculation);
- Ceresit CT 17 bonding aggregate (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);

- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- walls made from foam concrete blocks D700 600x300x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 300 mm, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table Л of DBN B.2.6-31:2006 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 of DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

[$R_{\Sigma red}$ = 3.491 m^2.K/W] ≥ [R_{qmin} = 3.3 m^2.K/W].

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs, density of 110 kg/m^3, average thickness of 100 mm (neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- 200 mm thick reinforced concrete plates, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 200 mm.

The requirements of Item 2.1 of DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 200 mm (0.2 m) are met:

[$R_{\Sigma red}$ = 5.88 m^2.K/W] ≥ [R_{qmin} = 4.95 m^2.K/W].

The accepted thickness of the heat-insulation layer is 200 mm (0.2 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.2.3 Checkpoint 1

Wall cladding is made from the materials as follow:

- ventilated façade (neglected for the calculation);
- IZOVAT-80 mineral wool slabs, density of 80 kg/m^3, thickness is to be defined by design, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.041 W/(m.K);

- walls from foam concrete blocks D700 600x300x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 350 mm, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56 of Table Л.1 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

$[R_{\Sigma red} = 3.893\ m^2.K/W] \geq [R_{qmin} = 3.3\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-80 mineral wool slabs (density of 80 kg/m^3).

Basement is made of the following materials:

- 10 mm thick façade ceramic granite tile RAL 7004 (neglected for the calculation);
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- walls from foam concrete blocks D700 600x300x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 350 mm, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table Л.1 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 of DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

$[R_{\Sigma red} = 3.491\ m^2.K/W] \geq [R_{qmin} = 3.3\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs, density of 110 kg/m^3, average thickness of 100 mm (neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);

- 200 mm thick reinforced concrete plates, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 200 mm.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 200 mm (0.2 m) are met:

$[R_{\Sigma red} = 5.88\ m^2.K/W] \geq [R_{qmin} = 4.95\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 200 mm (0.2 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.2.4 Checkpoint 1

Wall cladding is made from the materials as follow:

- ventilated façade (neglected for the calculation);
- IZOVAT-80 mineral wool slabs, density of 80 kg/m^3, thickness is to be defined by design, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.041 W/(m.K);
- walls from foam concrete blocks D700 600x300x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 350 mm, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56 of Table Л.1 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

$[R_{\Sigma red} = 3.893\ m^2.K/W] \geq [R_{qmin} = 3.3\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-80 mineral wool slabs (density of 80 kg/m^3).

Basement is made of the following materials:

- 10 mm thick façade ceramic granite tile RAL 7004 (neglected for the calculation);
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- 2 mm thick Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- walls from foam concrete blocks D700 600x350x300 DSTU B B.2.7.137:2008 [107], density of 630-740 kg/m^3, thickness of 350 mm, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table Л.1 [44]).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 100 mm.

The requirements of Item 2.1 of DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

$[R_{\Sigma red} = 3.491\ m^2.K/W] \geq [R_{qmin} = 3.3\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC membrane mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- grade D400 light concrete on the slope, 20-150 mm thick, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.23 W/(m.K).
- 200 mm thick reinforced concrete plates, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K).

After the calculation has been carried out basing on the slab fabrication condition, we assume δ to be 200 mm.

The requirements of Item 2.1 of DBN B.2.6-31:2006 [44] regarding the mandatory compliance with the condition (1) with the designed thickness of the heat-insulation layer being 200 mm (0.2 m) are met:

$[R_{\Sigma red} = 5.97\ m^2.K/W] \geq [R_{qmin} = 4.95\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 200 mm (0.2 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.3 Thermotechnical Calculation of Enclosing Structures for Acceptance Building

The acceptance building consists of two structural blocks:

- Acceptance building (within axes 1-8, A-B): central block (a space for transport and service operations);
- Acceptance building (within axes 1-8, A-D): auxiliary block.

15.3.1 Thermotechnical Calculation of Enclosing Structures for Acceptance Building (within Axes 1-8, A-B)

As required by Item 2.1 of DBN B.2.6-31:2006 [44], it is mandatory for outer fences that the following condition is met:

$$R_{\Sigma red} \geq R_{qmin} \qquad (15.1)$$

where $R_{\Sigma red}$ is a reduced resistance to heat transfer of the enclosing structure, m^2.K/W;

R_{qmin} is a minimum allowable resistance to heat transfer of the enclosing structure, m^2.K/W.

As required by Item 2.4 of DBN B.2.6-31:2006 [44], the minimum allowable value of resistance to heat transfer of the enclosing structure R_{qmin} , m^2.K/W, for production buildings should be established according to Table 2 of DBN B.2.6-31:2006 [44] depending on:

- the temperature in the facility operation area as per Appendix B [44];
- heat-to-humidity conditions as per Appendix G [44];
- thermal inertia of the enclosing structure D that is found by the formula (4) [44].

As follows from Appendix B [44], the construction object is located in the operation temperature area I.

As follows from Appendix G [44], at the given (≤12°C) temperature of inside air in the cold period (≤12°C), a normal heat-to-humidity condition for the premises is assigned with a relative humidity of inside air not exceeding 75%.

Under normal heat-to-humidity conditions in keeping with Appendix K [44], conditions "B" are assumed for operation of material in the enclosing structures.

The thermal inertia for the structure assumed using the formula (4) of DBN B.2.6-31:2006 [44] will be:

$$D = \sum_{i}^{n} R_i \cdot S_i$$

where R_i is a thermal resistance, m^2.K/W, of a layer in the multi-layer enclosing structure;

S_i is an estimated heat absorption coefficient for a separate layer of the enclosing structure given operating condition B, W/(m^2.K), according to Appendix L [44].

For buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under a *normal* heat-to-humidity condition for premises where D>1.5 must be:

- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for wall cladding;
- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for basement;
- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for roof covering.

A minimum thickness δ (m) of thermal covering was derived from the boundary condition to meet the requirement of (1) $R_{\Sigma red} \geq R_{qmin,}$ i.e. for the condition of:

($R_{\Sigma red}=R_{qmin}$)

As the condition (1) is verified, the reduced resistance to heat transfer of the enclosing structure, $R_{\Sigma red}$ m^2.K/W, is calculated as per Appendix I (Item 2.10 of DBN B.2.6-31:2006 [44]) by (I.1):

$$R_{\Sigma np} = \frac{1}{\alpha_в} + \sum_{1}^{i} \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_з},$$

where α_B = 8.7 W/(m^2 x K) is a heat transfer coefficient, W/(m^2.K), of the inner surface of enclosing structure ([44], Appendix E);

α_3 = 23 W/(m^2 x K) is a heat transfer coefficient for winter conditions, W/(m^2 x K), of the outer surface of enclosing structure ([44], Appendix E);

δ_i is the thickness of the i-th layer of the structure, m;

λ_i is the heat conductivity, W/(m.K), of the i-th layer of the structure under the rated duty, according to Item 2.11 and Appendix Л [44].

Wall cladding is made from the materials as follow:

- corrugated sheet (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/$m^{3)}$, thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);

- 300 mm thick reinforced concrete wall, an estimated heat transfer coefficient for operational conditions B, λ_B, is 2.04 W/(m.K) (Item 81 of Table Л.1 of DBN B.2.6-31:2006 [44]).

The thermal inertia for the structure assumed using the formula (4) of DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i = \frac{0,3}{2,04} \cdot 18,95 = 2,79$$

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under a *normal* heat-to-humidity condition for premises where D>1.5 must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by (5) of DBN B.2.6-31:2006 [44]:

$$R_{констр.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{\delta}{0,045} + \frac{0,3}{2,04}$$

$$R_{констр.} = \frac{\delta}{0,045} + 0,147$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8,7} + \left(0,147 + \frac{\delta}{0,045}\right) + \frac{1}{23} = 0,115 + 0,147 + \frac{\delta}{0,045} + 0,043 = 0,305 + \frac{\delta}{0,045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 0.305 + δ/0.045) = (R_{qmin}= 1.7)

0.305 + δ/0.045 = 1.7

δ/0.045 = 1.7 – 1.305

δ = (1.7 – 0.305) x 0.045 = 0.062775 m

δ is accepted as 70 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 70 mm (0.07 m) are met:

[$R_{\Sigma red}$ = 1.861 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 70 mm (0.07 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1 layer - 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);

- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 200 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44]).

The thermal inertia for the structure assumed using the formula (4) of DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i = \frac{0,04}{0,046} \cdot 0,77 + \frac{0,3}{2,04} \cdot 18,95 = 3,457$$

For the roof covering of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under a *normal* heat-to-humidity condition for premises where D>1.5 must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) of DBN B.2.6-31:2006 [44]:

$$R_{констр.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{0,04}{0,046} + \frac{\delta}{0,042} + \frac{0,3}{2,04}$$

$$R_{констр.} = \frac{\delta}{0,042} + 1,016$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8,7} + \left(1,016 + \frac{\delta}{0,042}\right) + \frac{1}{23} = 0,115 + 1,016 + \frac{\delta}{0,042} + 0,043 = 1,174 + \frac{\delta}{0,042}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.174 + δ/0.042) = (R_{qmin}= 1.7)

1.174 + δ/0.042 = 1.7

δ/0.042 = 1.7 – 1.174

δ = (1.7 – 1.174) x 0.042 = 0.02209 m

δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] of DBN B.2.6-31:2006 regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.364 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.3.2 Thermotechnical Calculation of Enclosing Structures for Acceptance Building (within Axes 1-8, B-D)

Wall claddings (within axes 1-8, B-D) are made from the materials as follow:

- corrugated sheets (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m$^{3)}$, thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);
- 300 mm thick foam concrete wall, D700 600x300x300 DSTU B.2.7-137:2008, density of 630-740 kg/m^3, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56 of Table L.1 [44]).

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance must be:

R_{qmin} = 3.3 (m^2 x K)/W (Table 1 [44]

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition to meet the requirement (1) ($R_{\Sigma red} \geq R_{qmin}$), i.e. for the condition:

($R_{\Sigma red}=R_{qmin}$)

To verify the condition (1), the reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found in accordance with Appendix I [44], Item 2.10, using the formula (I.1):

$$R_{\Sigma пр} = \frac{1}{\alpha_в} + \sum_1^i \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_з},$$

where α_B = 8.7 W/(m^2 x K) is a heat transfer coefficient, W/(m^2.K), of the inner surface of enclosing structure ([44], Appendix E);

α_3 = 23 W/(m^2 x K) is a heat transfer coefficient for winter conditions, W/(m^2 x K), of the outer surface of enclosing structure ([44], Appendix E);

δ_i is the thickness of the i-th layer of the structure, m;

λ_i is the heat conductivity, W/(m.K), of the i-th layer of the structure under the rated duty, according to Item 2.11 and Appendix L [44].

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) [44]:

$$R_{газобет.} = \sum_1^n \frac{\delta_i}{\lambda_i} = \frac{\delta}{0{,}045} + \frac{0{,}3}{0{,}27}$$

$$R_{конст.} = \frac{\delta}{0{,}045} + 1{,}111$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8{,}7} + \left(1{,}111 + \frac{\delta}{0{,}045}\right) + \frac{1}{23} = 0{,}115 + 1{,}111 + \frac{\delta}{0{,}045} + 0{,}043 = 1{,}269 + \frac{\delta}{0{,}045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}=R_{qmin}$)

($R_{\Sigma red}$ = 1.269 + δ/0.045) = (R_{qmin}= 3.3)

1.269 + δ/0.045 = 3.3

δ/0.045 = 3.3 – 1.269
δ = (3.3 – 1.269) x 0.045 = 0.0914 m
δ is accepted as 100 mm basing on the slab fabrication conditions.
The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 100 mm (0.1 m) are met:
$[R_{\Sigma red} = 3.491\ m^2.K/W] \geq [R_{qmin} = 3.3\ m^2.K/W]$.
The accepted thickness of the heat-insulation layer is 100 mm (0.1 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Wall basement (within axes 1-8, B-D) is made from the following materials:

- 10 mm thick façade ceramic granite tile, an estimated heat transfer coefficient for the operational conditions B (λB = 1.1 W/(m.K) (Item 80, Table L.1 [44];
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table L, [44]).

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance must be:
R_{qmin} = 3.3 (m^2 x K)/W (Table 1 [44]
For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) [44]:

$$R_{const.} = \sum_{1}^{3} \frac{\delta_i}{\lambda_i} = \frac{\delta}{0,045} + \frac{0,3}{0,27}$$

$$R_{const.} = \frac{\delta}{0,045} + 1,111$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma np} = \frac{1}{8,7} + \left(1,111 + \frac{\delta}{0,045}\right) + \frac{1}{23} = 0,115 + 1,111 + \frac{\delta}{0,045} + 0,043 = 1,269 + \frac{\delta}{0,045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:
($R_{\Sigma red}$=R_{qmin})
$R_{\Sigma red}$ = 1.269 + δ/0.045) = (R_{qmin}= 3.3)
1.269 + δ/0.045 = 3.3
δ/0.045 = 3.3 – 1.269
δ = (3.3 – 1.269) x 0.045 = 0.0914 m
δ is accepted as 100 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 100 mm (0.1 m) are met:

[$R_{\Sigma red}$ = 3.491 m^2.K/W] ≥ [R_{qmin} = 3.3 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

Roof covering (within axes 1-8, B-D) is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 300 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44])

For the roof covering of buildings in the operational temperature area I, a minimum allowable heat transfer resistance must be:

R_{qmin} = 4.95 (m^2 x K)/W (Table 1 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) [44]:

$$R_{констр.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{0,04}{0,046} + \frac{\delta}{0,042} + \frac{0,2}{2,04}$$

$$R_{констр.} = \frac{\delta}{0,042} + 0,9676$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8,7} + \left(0,9676 + \frac{\delta}{0,042}\right) + \frac{1}{23} = 0,115 + 0,9676 + \frac{\delta}{0,042} + 0,043 = 1,1256 + \frac{\delta}{0,042}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.1256 + δ/0.042) = (R_{qmin}= 4.95)

1.1256 + δ/0.042 = 4.95

δ/0.042 = 4.95 – 1.1256

δ = (4.95 – 1.1256) x 0.042 = 0.161 m

δ is accepted as 200 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 200 mm (0.2 m) are met:

[$R_{\Sigma red}$ = 5.88 m^2.K/W] ≥ [R_{qmin} = 4.95 m^2.K/W].

The accepted thickness of the heat-insulation layer is 200 mm (0.2 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.4 Thermotechnical Calculation for Heated Portion of Maintenance Building with MPC Storage Room

As required by Item 2.1 of DBN B.2.6-31:2006 [44], it is mandatory for outside enclosing structures that the following condition is met:

$$R_{\Sigma red} \geq R_{qmin}$$

where $R_{\Sigma red}$ is a reduced resistance to heat transfer of the enclosing structure, m^2.K/W;

R_{qmin} is a minimum allowable resistance to heat transfer of the enclosing structure, m^2.K/W.

As required by Item 2.4 of DBN B.2.6-31:2006 [44], a minimum allowable value of resistance to heat transfer of the enclosing structure R_{qmin}, m^2.K/W, for production buildings should be established according to Table 2 of DBN B.2.6-31:2006 [44] depending on:

- the temperature in the facility operation area as per Appendix B [44];
- heat-to-humidity conditions as per Appendix G [44].
- thermal inertia of the enclosing structure D that is found by the formula (4) [44].

As follows from Appendix B [44], the construction object is located in the operation temperature area I.

As follows from Appendix G [44], at the given temperature of inside air in the cold period (+5°C), a normal heat-to-humidity condition is assigned for the space with a relative humidity of inside air not exceeding 75%.

Under normal heat-to-humidity conditions in keeping with Appendix K [44], we assume “B” conditions for operation of material in the enclosing structures.

Wall claddings are made from the materials as follow:

- corrugated sheets (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);
- Wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56 of Table L.1 [44]).

The thermal inertia for the structure assumed using the formula (4) [44] will roughly be:

$$D = \sum_{1}^{7} R_i \cdot S_i = \frac{0,3}{0,27} \cdot 3,98 = 4,42$$

where R_i is a thermal resistance, m^2.K/W, of a layer in the multi-layer enclosing structure;

S_i is an estimated heat absorption coefficient for a separate layer of the enclosing structure given operating condition B, W/(m^2.K), according to Appendix L [44].

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under normal heat-to-humidity condition for premises where D>1.5) must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition to meet the requirement (1) ($R_{\Sigma red} \geq R_{qmin}$), i.e. for the condition:

($R_{\Sigma red}=R_{qmin}$)

To verify the condition (1), the reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found in accordance with Appendix I [44], Item 2.10, using the formula (I.1):

$$R_{\Sigma пр} = \frac{1}{\alpha_в} + \sum_1^i \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_з},$$

where α_B = 8.7 W/(m^2 x K) is a heat transfer coefficient, W/(m^2.K), of the inner surface of enclosing structure ([44], Appendix E);

α_3 = 23 W/(m^2 x K) is a heat transfer coefficient for winter conditions, W/(m^2 .K), of the outer surface of enclosing structure ([44], Appendix E);

δ_i is the thickness of the i-th layer of the structure, m;

λ_i is the heat conductivity, W/(m.K), of the i-th layer of the structure under the rated duty, according to Item 2.11 and Appendix L [44].

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) [44]:

$$R_{констр.} = \sum_1^n \frac{\delta_i}{\lambda_i} = \frac{\delta}{0{,}045} + \frac{0{,}3}{0{,}27}$$

$$R_{констр.} = \frac{\delta}{0{,}045} + 1{,}111$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8{,}7} + \left(1{,}111 + \frac{\delta}{0{,}045}\right) + \frac{1}{23} = 0{,}115 + 1{,}111 + \frac{\delta}{0{,}045} + 0{,}043 = 1{,}269 + \frac{\delta}{0{,}045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}=R_{qmin}$)

($R_{\Sigma red}$ = 1.269 + δ/0.045) = (R_{qmin}= 1.7)

1.269 + δ/0.045 = 1.7

δ/0.045 = 1.7 – 1.269

δ = (1.7 – 1.269) x 0.045 = 0.019395 m

Following the calculation, δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1, DBN B.2.6-31:2006 [44], regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.380 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

Wall basement is made from the following materials:

- 10 mm thick façade ceramic granite tile, an estimated heat transfer coefficient for the operational conditions B (λB = 1.1 W/(m.K) (Item 80, Table L.1 [44];
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);

- Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table L, [44]).

Following the calculation, δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.389 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

Roof covering is made from the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1 layer - 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 220 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44])

After the calculation has been completed, δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1 [44] regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.326 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.5 Thermotechnical Calculations of Wall Claddings for Electrical Equipment Building, Fire Pump Station and Garage

As required by Item 2.1 of DBN B.2.6-31:2006 [44], it is mandatory for outside enclosing structures that the following condition is met:

$$R_{\Sigma red} \geq R_{qmin}$$

where $R_{\Sigma red}$ is a reduced resistance to heat transfer of the enclosing structure, m^2.K/W;

R_{qmin} is a minimum allowable resistance to heat transfer of the enclosing structure, m^2.K/W.

As required by Item 2.4 of DBN B.2.6-31:2006 [44], a minimum allowable value of resistance to heat transfer of the enclosing structure R_{qmin} , m^2.K/W, for production buildings should be established according to Table 2 of DBN B.2.6-31:2006 [44] depending on:

- the temperature in the facility operation area as per Appendix B [44];
- heat-to-humidity conditions as per Appendix G [44].
- thermal inertia of the enclosing structure D that is found by the formula (4) [44].

As follows from Appendix B [44], the construction object is located in the operation temperature area I.

As follows from Appendix G [44], at the given temperature of inside air in the cold period (≤12°C), a normal heat-to-humidity condition is assigned for the space with a relative humidity of inside air not exceeding 75%.

Under normal heat-to-humidity conditions in keeping with Appendix K [44], we assume “B” conditions for operation of material in the enclosing structures.

The thermal inertia for the structure assumed using the formula (4) DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i$$

where R_i is a thermal resistance, m^2.K/W, of a layer in the multi-layer enclosing structure;

S_i is an estimated heat absorption coefficient for a separate layer of the enclosing structure given operating condition B, W/(m^2.K), according to Appendix L [44].

For the buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under *normal* heat-to-humidity condition for premises where D>1.5) must be:

- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for wall cladding;
- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for basement;
- R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44] for roof covering.

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition to meet the requirement (1) ($R_{\Sigma red} \geq R_{qmin}$), i.e. for the condition: ($R_{\Sigma red} = R_{qmin}$)

To verify the condition (1), the reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found in accordance with Appendix I [44], Item 2.10, using the formula (I.1):

$$R_{\Sigma_{np}} = \frac{1}{\alpha_в} + \sum_1^i \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_з},$$

where α_B = 8.7 W/(m^2 x K) is a heat transfer coefficient, W/(m^2.K), of the inner surface of enclosing structure ([44], Appendix E);

α_3 = 23 W/(m^2 x K) is a heat transfer coefficient for winter conditions, W/(m^2 .K), of the outer surface of enclosing structure ([44], Appendix E);

δ_i is the thickness of the i-th layer of the structure, m;

λ_i is the heat conductivity, W/(m.K), of the i-th layer of the structure under the rated duty, according to Item 2.11 and Appendix L [44].

15.5.1 Calculation of Wall Claddings for Electrical Equipment Building, Fire Pump Station and Garage

The wall claddings are made from the materials as follows:

Electrical equipment building:

- corrugated sheets (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m$^{3)}$, thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);
- Wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Table L.1 [44]).

Fire pump station:

- corrugated sheets (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m$^{3)}$, thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);
- Wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Item 56, Table L.1 [44]).

Garage:

- corrugated sheets (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m$^{3)}$, thickness is to be defined by calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.045 W/(m.K);
- Ceresit CT 190 mortar (neglected for the calculation);
- Wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B, λ_B, is 0.27 W/(m.K) (Table L.1 [44]).

The thermal inertia for the structure assumed using the formula (4) [44] will roughly be:

$$D = \sum_{1}^{7} R_i \cdot S_i = \frac{0,3}{0,27} \cdot 3,98 = 4,42$$

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under normal heat-to-humidity condition for premises where D>1.5) must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) DBN B.2.6-31:2006 [44]:

$$R_{конст.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{\delta}{0,045} + \frac{0,3}{0,27}$$

$$R_{конст.} = \frac{\delta}{0,045} + 1,111$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8,7} + \left(1,111 + \frac{\delta}{0,045}\right) + \frac{1}{23} = 0,115 + 1,111 + \frac{\delta}{0,045} + 0,043 = 1,269 + \frac{\delta}{0,045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.269 + δ/0.045) = (R_{qmin}= 1.7)

1.269 + δ/0.045 = 1.7

δ/0.045 = 1.7 – 1.269

δ = (1.7 – 1.269) x 0.045 = 0.019395 m

δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1, DBN B.2.6-31:2006 [44], regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.380 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

15.5.2 A Calculation of Wall Basement for Electrical Equipment Building, Fire Pump Station and Garage

The wall basement is made from the materials as follows:

Electrical equipment building:

- 10 mm thick façade ceramic granite tile RAL 7004, an estimated heat transfer coefficient for the operational conditions B (λB = 1.1 W/(m.K) (Item 90, Table L.1 [44];
- Ceresit Cm 17 bonding aggregate;
- Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);

- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table L, [44]).

Fire pump station:

- 10 mm thick façade ceramic granite tile RAL 7004, an estimated heat transfer coefficient for the operational conditions B (λB = 1.1 W/(m.K) (Item 90, Table L.1 [44];
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table L, [44]).

Garage:

- 10 mm thick façade ceramic granite tile RAL 7004, an estimated heat transfer coefficient for the operational conditions B (λB = 1.1 W/(m.K) (Item 90, Table L.1 [44];
- Ceresit Cm 17 bonding aggregate (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- reinforcing fiberglass mesh (neglected for the calculation);
- Ceresit CT 190 mortar (neglected for the calculation);
- IZOVAT-145 mineral wool slabs (density of 145 kg/m^3), thickness to be defined by calculation, an estimated heat transfer coefficient for the operational conditions B (λB = 0.045 W/(m.K);
- Ceresit CT 190 mortar for bonding heat-insulation slabs (neglected for the calculation);
- wall from 300 mm thick foam concrete blocks, density of 700 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.27 W/(m.K) (Item 56 of Table L, [44]).

The thermal inertia for the structure assumed using the formula (4) DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i = \frac{0,01}{1,1} \cdot 12,55 + \frac{0,3}{0,27} \cdot 3,98 = 4,54$$

For the wall cladding of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under normal heat-to-humidity condition for premises where D>1.5) must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) DBN B.2.6-31:2006 [44]:

$$R_{const.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{0,01}{1,1} \frac{\delta}{0,045} + \frac{0,3}{0,27}$$

$$R_{const.} = \frac{\delta}{0,045} + 1,12$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma red} = \frac{1}{8,7} + \left(1,12 + \frac{\delta}{0,045}\right) + \frac{1}{23} = 0,115 + 1,12 + \frac{\delta}{0,045} + 0,043 = 1,278 + \frac{\delta}{0,045}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})

($R_{\Sigma red}$ = 1.278 + δ/0.045) = (R_{qmin}= 1.7)

1.278 + δ/0.045 = 1.7

δ/0.045 = 1.7 – 1.278

δ = (1.7 – 1.278) x 0.045 = 0.01899 m

δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1, DBN B.2.6-31:2006 [44], regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.389 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-145 mineral wool slabs (density of 145 kg/m^3).

15.5.3 A Calculation of Roof Covering for Electrical Equipment Building and Fire Pump Station

The roof covering is made from the materials as follows:

Electrical equipment building:

- 10 mm thick pebble-dash (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1 layer - 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);

- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 220 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44]).

Fire pump station

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 220 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44])

The thermal inertia for the structure assumed using the formula (4) DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i = \frac{0,04}{0,046} \cdot 0,77 + \frac{0,22}{2,04} \cdot 18,95 = 2,714$$

For the roof covering of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under normal heat-to-humidity condition for premises where D>1.5) must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) DBN B.2.6-31:2006 [44]:

$$R_{конст.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{0,04}{0,046} + \frac{\delta}{0,042} + \frac{0,22}{2,04}$$

$$R_{конст.} = \frac{\delta}{0,042} + 0,978$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma пр} = \frac{1}{8,7} + \left(0,978 + \frac{\delta}{0,042}\right) + \frac{1}{23} = 0,115 + 0,978 + \frac{\delta}{0,042} + 0,043 = 1,136 + \frac{\delta}{0,042}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

($R_{\Sigma red}$=R_{qmin})
($R_{\Sigma red}$ = 1.136 + δ/0.042) = (R_{qmin}= 1.7)
1.136 + δ/0.042 = 1.7
δ/0.042 = 1.7 – 1.136
δ = (1.7 – 1.136) x 0.042 = 0.023688 m
δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1, DBN B.2.6-31:2006 [44], regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

$[R_{\Sigma red} = 2.326\ m^2.K/W] \geq [R_{qmin} = 1.7\ m^2.K/W]$.

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.5.4 Calculation of Garage Building Roof Covering

The roof covering is made of the following materials:

- 10 mm thick pebble-dash for the roof covering (pebble sized 3 to 10 mm) (neglected for the calculation);
- 1.2 mm thick PVC PROTAN membrane (Ukraine-made) mounted mechanically (neglected for the calculation);
- 40 mm thick insulant - 1 layer of IZOVAT mineral wool slabs, density of 200 kg/m^3, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.046 W/(m.K);
- insulant – 1 layer of IZOVAT mineral wool slabs, density of 110 kg/m^3, thickness to be determined by the calculation, an estimated heat transfer coefficient for operational conditions B is λ_B = 0.042 W/(m.K);
- sloping from IZOVAT mineral wool slabs (density of 110 kg/m^3, neglected for the calculation);
- vapor seal – 200 μ thick polyethylene film (neglected for the calculation);
- foundation - 220 mm thick reinforced concrete plate, an estimated heat transfer coefficient for operational conditions B is λ_B = 2.04 W/(m.K) (Item 81, Table L.1 [44])

The thermal inertia for the structure assumed using the formula (4) DBN B.2.6-31:2006 [44] will roughly be:

$$D = \sum_{1}^{n} R_i \cdot S_i = \frac{0,05}{0,046} \cdot 0,77 + \frac{0,22}{2,04} \cdot 18,95 = 2,884$$

For the roof covering of buildings in the operational temperature area I, a minimum allowable heat transfer resistance (under normal heat-to-humidity condition for premises where D>1.5) must be:

R_{qmin} = 1.7 (m^2 x K)/W (Table 2 [44]

For a multi-layer structure, the heat transfer resistance R_{const} (m^2.K/W) is found by the formula (5) DBN B.2.6-31:2006 [44]:

$$R_{const.} = \sum_{1}^{n} \frac{\delta_i}{\lambda_i} = \frac{0,05}{0,046} + \frac{\delta}{0,042} + \frac{0,22}{2,04}$$

$$R_{const.} = \frac{\delta}{0,042} + 1,195$$

The reduced heat transfer resistance of the enclosing structure, $R_{\Sigma red}$ (m^2.K/W), is found by (I.1):

$$R_{\Sigma red} = \frac{1}{8,7} + \left(1,195 + \frac{\delta}{0,042}\right) + \frac{1}{23} = 0,115 + 1,195 + \frac{\delta}{0,042} + 0,043 = 1,353 + \frac{\delta}{0,042}$$

A minimum thickness, δ (m), of the covering heat insulation is found from the boundary condition:

$(R_{\Sigma red} = R_{qmin})$

$(R_{\Sigma red} = 1.353 + \delta/0.042) = (R_{qmin} = 1.7)$

1.353 + δ/0.042 = 1.7
δ/0.042 = 1.7 – 1.353
δ = (1.7 – 1.353) x 0.042 = 0.014574 m
δ is accepted as 50 mm basing on the slab fabrication conditions.

The requirements of Item 2.1, DBN B.2.6-31:2006 [44], regarding the mandatory compliance with the condition (1) with the assigned thickness of the heat-insulation layer being 50 mm (0.05 m) are met:

[$R_{\Sigma red}$ = 2.543 m^2.K/W] ≥ [R_{qmin} = 1.7 m^2.K/W].

The accepted thickness of the heat-insulation layer is 50 mm (0.05 m) for IZOVAT-110 mineral wool slabs (density of 110 kg/m^3).

15.6 Conclusions

During the designing process, an economic effect from the use of enclosing structures of the buildings having façade heat insulation is attained through increased thermal resistance of the enclosing structures and minimized heat losses.

For the design of CSFSF buildings and facilities, the enclosing structures have been chosen basing on the thermotechnical calculations that would minimize heat losses when the CSFSF buildings and facilities are in operation and optimize them when under construction.

Thicknesses of heat insulation layers for the buildings' enclosing structures have been adopted on the basis of the thermotechnical calculations. Results of the thermotechnical calculations are shown in Table 15.1 below.

Table 15.1. Results of a Thermotechnical Calculation of Enclosing Structures

Description	Values of Thermotechnical Calculation Parameters				
	D	R_{qmin}	$R_{\Sigma red}$	Insulant	δ
• Administrative building (CD facility): - outside walls	-	3.3	4.078	IZOVAT 80	100
- outside walls basement	-	3.3	3.861	IZOVAT 145	100
- roof covering	-	4.95	6.1	IZOVAT 110	200
• Guard building (CD facility): - outside walls	-	3.3	3.708	IZOVAT 80	100
- outside walls basement	-	3.3	3.491	IZOVAT 145	100
- roof covering	-	4.95	5.88	IZOVAT 110	200
• Checkpoint 1: - outside walls	-	3.3	3.893	IZOVAT 80	100
- outside walls basement	-	3.3	3.491	IZOVAT 145	100
- roof covering	-	4.95	5.88	IZOVAT 110	200
• Checkpoint 2: - outside walls	-	3.3	3.893	IZOVAT 80	100
- outside walls basement	-	3.3	3.491	IZOVAT 145	100
- roof covering	-	4.95	5.97	IZOVAT 110	200
• Acceptance building: • *within axes 1-8, A-B:*					
- outside walls	2.79	1.7	1.861	IZOVAT 145	70
- roof covering	3.457	1.7	2.364	IZOVAT 110	50
• *within axes 1-8, B-D:*					
- outside walls	-	3.3	3.491	IZOVAT 145	100
- outside walls basement	-	3.3	3.491	IZOVAT 145	100
- roof covering	-	4.95	5.88	IZOVAT 110	200

Description	Values of Thermotechnical Calculation Parameters				
	D	R_{qmin}	$R_{\Sigma red}$	Insulant	δ
• Heated portion of maintenance building with MPC storage room: - outside walls	4.42	1.7	2.380	IZOVAT 145	50
- outside walls basement	4.54	1.7	2.389	IZOVAT 145	50
- roof covering	2.714	1.7	2.326	IZOVAT 110	50
• Electrical equipment building: - outside walls	4.42	1.7	2.380	IZOVAT 145	50
- outside walls basement	4.54	1.7	2.389	IZOVAT 145	50
- roof covering	2.714	1.7	2.326	IZOVAT 110	50
• Fire pump station: - outside walls	4.42	1.7	2.380	IZOVAT 145	50
- outside walls basement	4.54	1.7	2.389	IZOVAT 145	50
- roof covering	2.714	1.7	2.326	IZOVAT 110	50
• Garage: - outside walls	4.42	1.7	2.380	IZOVAT 145	50
- outside walls basement	4.54	1.7	2.389	IZOVAT 145	50
- roof covering	2.884	1.7	2.543	IZOVAT 110	50

Note: The following conventions for the parameters are used in Table:
D – thermal inertia for the structure accepted
R_{qmin} – a minimum allowable resistance to heat transfer of enclosing structure, m^2.K/W
$R_{\Sigma red}$ – reduced resistance to heat transfer of enclosing structure, m^2.K/W
δ – the insulant thickness assumed by rounding the design value upward to the nearest value of the insulant standard size manufactured, mm

From an analysis of the numerical values of the calculation results presented in the Table 15.1, it may be concluded that all the chosen heat insulation structures and materials characteristically meet the requirement to the basis inequations of the calculation, i.e. the reduced heat transfer resistance of all the types of enclosing structures $R_{\Sigma red}$ is greater than the minimum allowable values of resistance to heat transfer of the enclosing structures R_{qmin}. Thus, the design options on the heat insulation for all of the CSFSF buildings and facilities will provide for minimum allowable heat losses during the entire calendar year that will allow compliance with the required regulatory and legal documents for energy efficiency.

15.7 Annual Heat Consumption by Heating Systems

A value of estimated annual heat consumption by the heating system of the guard building, Q_{ann}, GJ, should be defined by the formula:

$$Q_{ann\ heat} = [0.086 \times Q_{heat} \times S_{heat} \times a \times b \times c] / (t_i - t_o) \qquad 15.4$$

where t_o = minus 22°C is the temperature of outside air (temperature of the coldest five-day stretch having a reliability of 0.92 according to Table 2 of DSTU-H B.1.1-27:2010 [5];

t_i = 18°C is an estimated averaged temperature of inside air, °C, that is accepted as required by the design standards for variable-purpose premises whilst considering a temperature buildup versus a ceiling height;

S_{heat} = 3185.6 is a number of degree-days in the heating period that are found by:

$$S_{heat} = (t_i - t_{heat\ per})Z_{heat\ per} \quad (15.5)$$

where $t_{heat\ per}$ = -0.1 is a mean temperature, °C, of a period having a mean daily air temperature which is lower than or equal to 8°C, DSTU-H B.1.1-27:2010 [106];

$Z_{heat\ per}$ = 176 is a duration, days, of a period having a mean daily air temperature which is lower than or equal to 8°C, DSTU-H B.1.1-27:2010 [5];

S_{heat} = (18 + 0.1) x 176 = 3185.6 degree-days;

a = 0.8 is a coefficient which is to be taken into consideration if a heating system is equipped with automatic devices for lowering heating capacity in non-duty hours (a = 1 in this case);

b = 0.9 is a coefficient which is to be taken into consideration if the heating units are equipped with heat regulators;

c = 1 is a coefficient which covers absence of an automatic façade-to-façade regulation for the system;

Q_{heat} is an estimated heating capacity, kW, of a heating system.

The estimated heating capacity of the heating system for the guard building, Q_{heat}, kW, is found by the formula:

$$Q_{heat} = Q_1 \times b_1 \times b_2 \times b_3 + Q_2 - Q_3 \quad (15.6)$$

where Q_1 = 46 kW is estimated heat losses in the building through the enclosing structures;

b_1 = 1.11 is an averaged coefficient for metering an additional heat flow in the heating units installed;

b_2 = 1.02 is a coefficient for metering additional heat losses by the heating units installed near outside enclosures;

b_3 = 1.1 is a coefficient which should be taken into account once the heating units are equipped with heat regulators;

Q_2 is estimated heat losses, kW, in the pipelines which pass through non-heated spaces. This value is neglected in the calculation since the electric heating system is used;

Q_3 is the heat flow which regularly comes from lighting, people, etc. This is not included in the calculation due to its minor value.

The estimated heating capacity of the heating system is then as follows:

Q_{heat} = 46 x 1.11 x 1.02 x 1.1 = 57.29 kW.

The value of the estimated annual heat consumption by the heating system, Q_{ann}, GJ, is found as follows:

$Q_{ann\ heat}$ = [0.086 x 57.29 x 3185.6 x 1 x 0.9 x 1] / (18 + 22) = 353.14 GJ x 1000 x 0.000278 = 98.17 MW.

The heat consumed annually for heating inlet air for through-flow ventilation system which is in one-shift operation, kJ/yr, is found by:

$$Q = 0{,}143_{nmc}G_n\Delta t_{M1}K_3K_1 \quad (15.7)$$

where n = 5 is the number of working days in a week;

m = 8 is the duration of a shift, hr;

c is an air specific heat which is 1.005 kJ/kg°C;

G_n is a maximum consumption of inlet air, kg/hr;

where $t_{ave\ cold}$ is a mean air temperature in the coldest month that is found from DSTU-HB.1.1-27:2010;

A_{cold} is a mean temperature amplitude, °C, in the year's coldest month that is found for temperature from Appendix 2 to DSTU-HB.1.1-27:2010;

K_1 is a coefficient defined using Table 2 of Guide 9.91 to SNiP 2.04/05-91(Construction Rules and Regulations) depending on the duration of the system service during a day;

K_2 is a coefficient defined using Table 2 of Guide 9.91 to SNiP 2.04/05-91(Construction Rules and Regulations) depending on the time that falls on the middle of the system's daily work period;

M_1 = 219 is duration of the period when the air heater of the ventilation system consumes heat, days;

$$M_1 = 182.5(\Delta t_k/\Delta t_{k,g})^{0.5} \qquad (15.10)$$

$\Delta t_{k,g}$) is for a through-flow ventilation system

$$\Delta t_k = t_g - t_{cold} \qquad (15.11)$$

K_3 and K_4 are the coefficients defined using Table 3 in Guide 9.91 to SNiP 2.04/05-91(Construction Rules and Regulations) depending on the duration of the heat-consuming period.

For the garage:

Q=0.143x5x8x1.005x5150x1.2x21.08x230x1.06x1.615=112296149.18 kJ/g=31.22 MW

The calculation has been accomplished for all the buildings under design. The results are summarized in Table 15.2.

Table 15.2. Results of Calculations of Annual Heat Consumption by Heating Systems

Building	Estimated averaged inside air temper.	Degree-days in construct. Period (heating)	Heat losses of building, kW	Estimated annual heat consumption by building heating system, Q_{ann}, MW	Inlet air temper., °C	Inlet air consumed, m^3/hr	Estimated annual heat consumed by building through-flow ventilat. Systems, Q_{ann}, MW
Acceptance building	18	3185.6	246.0	525.01	10	20000	58.18
					16	5980	31.12
					18	8905	53.98
Maintenance building with MPC storage room	16	2833.6	55.0	109.91	16	2740	14.26
					18	1250	7.58
Administrative building (w/o CD)	18	3185.6	47.0	100.31	18	5180	31.40
Administrative building (with CD)	10	1777.6	5.0	7.44	5	1110	1.53
Electric equipment building	10	1777.6	6.0	8/93	16	2840	14.78
Garage	10	1777.6	97.5	145.14	18	5150	31.22
					24	9500	80.26
					16	13000	66.88
Fire pump station	5	897.6	18/0	16.04	-	-	-
Guard building (w/o CD)	18	3185.6	46.0	98.17	18	1895	51.77
					18	1560	9.46

Guard building (with CD)	10	1777.6	4.5	6.70	5	1110	1.53
Checkpoint 1	18	31.85.6	33.0	70.43	18	1000	27.32
Checkpoint 2	18	3185.6	7.0	14.94	-	-	-
Module building (container unit)	10	1777.6	2.0	2.98	-	-	-
Total for the site:				1106.00			481.27

16 AVAILABILITY OF CSFSF FOR MOBILITY IMPAIRED PEOPLE

The activities at CSFSF relate to those with harmful work environment (a letter from Separated Enterprise Atomproektinzhiniring No 03-46/388 dated 20.03.2015).

As required by Article 169 of the Ukraine Labor Code, the personnel that will be engaged in the activities at CSFSF must attend a medical examination through a procedure specified in The Procedure for Medical Examinations for Workers of Certain Categories. The Procedure was approved by the Ukraine Ministry of Health under its Order No 246 of 21.05.2007 and registered by Ukraine Ministry of Justice under No 846/14113 of 23.07.2007.

In compliance with the customary practice and policy of DP NAEK ENERGOATOM, admittance to work at CSFSF is given to personnel having appropriate qualification characteristics, a required level of education and not having medical and psychophysical counter-indications concerning professions.

Characteristics of the personnel employed must meet the qualification requirements put in given position.

Mobility impaired people are not thought to be involved in the CSFSF activities.

17 PERFORMANCE INDICATORS

Performance indicators are given in Table 17.1.

Table 17.1. Performance Indicators

Indicator	Unit of measurement	Quantity Including Start-Up Facilities (SUF)					
		Total	SUF-1	SUF-2	SUF-3	SUF-4	SUF-5
Type of Construction – New Construction							
Site area	ha	18.2	18.2	-	-	-	-
Development area	ha	4.9	4.9	-	-	-	-
Life	year	100	-	-	-	-	-
Capacity, including:	HI-STORM cask	458	4	33	33	24	32
For VVER-100 reactor	HI-STORM cask	388	3	28	29	21	27
For VVER-440 reactor	HI-STORM cask	70	1	5	4	3	5
Total estimated cost of construction in current prices as at 10.11.2016	K UAH	37 217 475.533	4 760 662.161	2 494 340.966	2 481 843.368	1 806 127.136	2 257 073. 918
including:							
construction work	K UAH	445 456.808	415 173.660	2 194.832	2 194.832	1 602.412	2 134.991
equipment	K UAH	30 455 845.778	3 440 685.221	2 076 288.009	2 065 873.344	1 503 400.129	1 878 624.997
others	K UAH	6 316 172.947	904 803.280	415 858.125	413 775.192	301 124.595	376 313.930
Additionally, cost of social-purpose facilities (10% of total construction estimate)	K UAH	3 721 747.553	476 066.216	249 434.097	248 184.337	180 612.714	225 707.392
Construction labor input	K man-hour	1756.57931	1685.00748	5.103	5.103	3.7113	5.06417
Number of jobs created	job	95	95	-	-	-	-
newly created jobs, incl.:	job	95	95	-	-	-	-
Total number of workmen	man	161	161	-	-	-	-
Construction duration	month	198	30	12	12	12	12
Annual needs for:							
water	K m^3	3.31	-	-	-	-	-
power	K kW/yr	4750.98	-	-	-	-	-
oil products (Diesel fuel)	t	19.7	-	-	-	-	-

Table 17.2. Performance Indicators (continued)

Indicator	Unit of measurement	Quantity Including Start-Up Facilities (SUF)				
		SUF-6	SUF-7	SUF-8	SUF-9	SUF-10
Site area	ha	-	-	-	-	-
Development area	ha	-	-	-	-	-
Life	year	-	-	-	-	
Capacity, including:	HI-STORM cask	32	32	34	32	32
For VVER-100 reactor	HI-STORM cask	27	27	26	27	27
For VVER-440 reactor	HI-STORM cask	5	5	8	5	5
Total estimated cost of construction in current prices as at 10.11.2016	K UAH	2 257 073.918	2 257 073.918	2 404 327.816	2 257 073.918	2 257 073.918
including:						
construction work	K UAH	2 134.991	2 134.991	2 270.755	2 134.991	2 134.991
equipment	K UAH	1 878 624.997	1 878 624.997	2 001 193.246	1 878 624.997	1 878 624.997
others	K UAH	376 313.930	376 313.930	400 863.815	376 313.930	376 313.930
Additionally, cost of social-purpose facilities (10% of total construction estimate)	K UAH	225 707.392	225 707.392	240 432.782	225 707.392	225 707.392
Construction labor input	K man-hour	5.06417	5.06417	5. 40147	5.06417	5.06417
Number of jobs created	job	-	-	-	-	-
newly created jobs, incl.:	job	-	-	-	-	-
Total number of workmen	man	-	-	-	-	-
Construction duration	month	12	12	12	12	12
Annual needs for:						
water	K m^3	-	-	-	-	-
power	K kW/yr	-	-	-	-	-
oil products (Diesel fuel)	t	-	-		-	-

Table 17.3. Performance Indicators (continued)

Indicator	Unit of measurement	Quantity Including Start-Up Facilities (SUF)				
		SUF-11	SUF-12	SUF-13	SUF-14	SUF-15
Site area	ha	-	-	-	-	-
Development area	ha	-	-	-	-	-
Life	year	-	-	-	-	-
Capacity, including:	HI-STORM cask	32	32	34	34	38
For VVER-100 reactor	HI-STORM cask	27	27	29	29	34
For VVER-440 reactor	HI-STORM cask	5	5	5	5	4
Total estimated cost of construction in current prices as at 10.11.2016	K UAH	2 257 073.918	2 257 073.918	2 397 423.605	2 397 423.605	2 675 809.450
including:						
construction work	K UAH	2 134.991	2 134.991	2 270.755	2 270.755	2 533.870
equipment	K UAH	1 878 624.997	1 878 624.997	1 995 439. 737	1 995 439.737	2 270 151.376
others	K UAH	376 313.930	376 313.930	399 713.113	399 713.113	446 124.204
Additionally, cost of social-purpose facilities (10% of total construction estimate)	K UAH	225 707.392	225 707.392	239 742.360	239 742.360	267 580.945
Construction labor input	K man-hour	5.06417	5.06417	5.40147	5.40147	6.00093
Number of jobs created	job	-	-	-	-	-
newly created jobs, incl.:	job	-	-	-	-	-
Total number of workmen	man	-	-	-	-	-
Construction duration	month	12	12	12	12	12
Annual needs for:						
water	K m^3	-	-	-	-	-
power	K kW/yr	-	-	-	-	-
oil products (Diesel fuel)	t	-	-	-	-	-

18 R&D SUPPORT

18.1 Methodological Support and Work Objective

CSFSF is a nationwide nuclear unit. According to Appendix B to DBN B.1.2-5:2007 [105], the nuclear energy facilities of categories I and II of responsibility for nuclear safety are subject to mandatory R&D support.

As per Atomic Energy Standard 5.6 [7], the category I and II facilities include, among other CSFSF units:

- Acceptance building – ranked to the nuclear safety category I as per Atomic Energy Standard 5.6 [7],
- Cask storage area - ranked to the nuclear safety category II as per Atomic Energy Standard 5.6 [7].

The rest of the buildings and facilities pertain to the nuclear safety category III as per Atomic Energy Standard 5.6 [7].

At CSFSF, a “dry” technique for SNF storage in inert atmosphere is utilized using the Holtec technology (USA). It is for the first time that a technology like this is implemented in Ukraine. A technology similar to the CSFSF one was implemented at Zaporizzhya NPP’s Dry Spent Fuel Storage Facility (DSFSF). Differences in the technologies do not allow full-scale application of DSFSF experience to CSFSF.

A service life designed for CSFSF is 100 years. CSFSF is intended to accept SNF from Rivne NPP, Khmelnitsky NPP and Yuzhoukrainsk NPP. That is, delivery of SNF to CSFSF will be provided in special transport containers by using general-use railway services.

CSFSF site is a location surrounded by the villages of Staraya Krasnitsa, Buryakovka, Chistogalovka and Stechanka, Kiev Region, in the exclusion zone which is contaminated radioactively due to Chernobyl disaster.

A primary goal of the R&D support is to tackle the problems which are not covered by regulatory documents and which can spring up at various stages of the construction facility’s lifespan.

A main task of the R&D support is to address design and construction problems with a minimum risk of errors in the conditions that are not regulated by applicable standards and rules and in the absence of sufficient expertise or direct implications in the domestic practice.

Basic efforts under the R&D support include examinations, scientific survey, observation of the facility’s technical state, surveys, study of building materials characteristics, verification of compliance with requirements of the construction standards and technical documentation of certain structures and accepted construction solutions, engineering survey, analyses of technical concepts for compliance with established requirements, and others.

18.2 Source Data

A CSFSF isometric diagram is shown in Fig. 18.1.

Fig. 18.1 CSFSF Isometric Diagram

Engineering surveys for the design stage have been completed in full. Currently, there is a forest growing on the site. Following preparatory work, it is necessary for category I and II buildings as per standard 5.6 [7] to carry out additional survey along the perimeter of building envelope with a grid of reference as required by the applicable survey standards.

In order to clarify layout options for the site, a need will be to take a more detailed topographic survey as it is impossible to show a site level exactly after the is deforested and stumped out.

Holtec International, a U.S. company, is a developer of the equipment for handling SNF for CSFSF. The development is carried out in accordance with the U.S. standard requirements with due account for the Ukrainian regulatory documents. The equipment includes metal, non-metal, reinforced concrete and concrete elements. The equipment designer has no experience in the equipment handling SNF from VVER reactors, however, they have a considerable experience in handling SNF from PWR reactors. The equipment design uses US-made materials including concrete.

HI-STORM storage cask design uses biological protection concrete which should retain its properties for as long as 100 years. Research is required to develop the composition of the concrete with Ukraine-made components to be used.

A cask transfer facility is to be designed for reloading MPCs from HI-STAR transport casks to HI-STAR storage casks. The cask transfer facility is being designed to U.S. standards using US-made materials (concrete, metal, reinforcement). The facility will be installed and on and connected with the foundation plate of the acceptance building. The acceptance building is designed in compliance with the requirements of the Ukrainian regulatory documents with Ukraine-made materials to be used. Additional facilities will have to be designed to link the acceptance building's foundations with the transfer facility.

The HI-STORM storage cask manufactured and painted in the USA will be operated in the Kiev Region conditions with SNF from VVER reactors at Ukraine's NPPs. It will be required to conduct cycles of observations in different seasons of the year in order to decrease likely failures and elaborate maintenance charts.

At the design stage, dimensioning calculations of buildings and facilities have been made in regard to extreme loads for buildings and facilities of categories I and II on responsibility for nuclear safety according to standard 5.6 for nuclear power plants [7]. Holtec is to deliver the main 180/20 t crane for the acceptance building. The crane is being designed to European regulatory documents. After a crane manufacturer is selected, it will be required for the next design stage to carry out checking calculations of the building with the crane manufacturer's data taken into account.

For developing a CSFSF operating procedure, it will be needed to develop process charts for operations to be undertaken with Holtec equipment and SNF from VVER reactors. In order to prevent personnel from being affected by dose loads as the operating charts are worked out, there will be a need for equipment models.

Weight of a HI-STORM storage cask filled with MPCs containing spent fuel assemblies (SFA) is up to 180 t. A total number of casks on the site is 458. The casks are put upon foundation plates that are 180 and 170 m long and 9 m wide. Roads having a width of up to 9 m are provided between the foundation plates for wheeled transport. The design envisions expansion joints after each 15 m to prevent influence of sequence in setting the casks upon the foundation plates. Confirmation of the design solution will require observation over yield of the plates.

The cask transfer facility inside the acceptance building is separated from the main foundation plate with expansion joints. Work to be done to build this unit will require development of a special design for the works and eventually monitor the yields.

18.3. List of Work Items for R&D Support

Nos	R&D Support Work Items	Life Cycle	Potential Contractor
1	Engineering survey for acceptance building and cask site	Design	KIZI
2	Topographic survey of CSFSF site after deforesting and stumping	Design	KIZI
3	Analysis of Holtec equipment for compliance with applicable regulatory documents	Design	
4	Analysis of materials used for Holtec equipment	Design	
5	Analysis of main crane for compliance with Ukrainian regulatory documents	Design	
6	Interaction of acceptance building structures with transfer facility	Design	KIEP
7	Building structures monitoring program	Design	KIEP
8	Checking calculations of acceptance building considering crane selected	Design	KIEP
9	Development of special design for work on transfer facility in acceptance building	Design	
10	Development of individual prices for commissioning works with Holtec equipment	Design	

Nos	R&D Support Work Items	Life Cycle	Potential Contractor
11	Research “Development of Concrete Having Higher Special Operating Properties”	Construction	Ukrditsement State Research Institute
11.1	Selection and analysis of scientific and technical literature and other information materials; Development of analytical review; Development of operational plan	Construction	Ukrditsement State Research Institute
11.2	Development of algorithms for calculating and modeling procedures for selection of concrete composition; Preliminary development of special beton recipe including studies of raw materials for special concrete	Construction	Ukrditsement State Research Institute
11.3	Manufacture of exploratory prototypes and related tests for durability, thermal stability and resistance to radiation; Generalization and assessment of findings; Refinement of special beton recipe	Construction	Ukrditsement State Research Institute
11.4	Development of standard technical and process documentation on concretes having higher special operating properties basing on the research performed including determination of required equipment, machines, mechanisms and their technical characteristics	Construction	Ukrditsement State Research Institute
12	Observation over acceptance building yields	Construction	
13	Observation over storage site yields	Construction	
14	Development of equipment models for process charts	Construction	
15	Development of process charts for operations	Construction	
16	Observation over storage cask	Operation	

17	Observation over storage site foundations	Operation	
18	Monitoring of HI-STORM emissions	Operation	
18.1	Development of observation program	Operation	
18.2	Observations depending on ambient conditions Operation		

18.4 Arrangement of R&D Support Activities

The R&D support work is to be performed in accordance with the R&D support program that is to be developed taking into consideration the applicable regulatory documents and should generally contain the following sections:

- Justification for the support activities;
- Objective and intent of the support activities;
- Source data for the activities;
- Work Contractors;
- Work stages and deadlines;
- A list of materials to be provided to the Customer at work stages and after completion of work;
- A procedure for accepting the R&D support activities.

The support activities must be executed under contracts between the Customer and the Contractor on bidding conditions.

The work may be performed by the main Contractor who may engage subcontractors for individual works or the Customer will develop an R&D support program to order services under separate contracts with Contractors.

19 CALCULATION OF A CONSEQUENCE (RESPONSIBILITY) CLASS AND A DIFFICULTY CATEGORY

The consequence class and difficulty category have been calculated in conformity with DSTU H B.1.2-16:2013 Standard “Determination of Consequence (Responsibility) Class and Difficulty Category for Construction Projects” [131].

According to Item 4.4 of DSTU H B.1.2-16:2013 [131], a consequence (responsibility) class is determined for each building and facility separately. For CSFSF, the consequence class is determined basing on the greatest characteristics of possible consequences.

Below are the source data for evaluating a consequence class:

- A number of personnel who are permanently inside a building/facility, i.e. those who are there for not over 8 hours a day and not over 150 days a year is given in Table 19.1.
- A number of personnel who are periodically inside a building/facility, i.e. those who are there for not over 8 hours a day and not over 150 days a year (in total of 45 to 1200 hours/year) is given in Table 19.1.
- A number of people who are outside CSFSF and for which violation of vital activity for more than three days is considered is presented in the letter by DAVZ No o1-2369/142 dated 28.10.2015 that is 274 persons, including:
  - in the radius of 3 km: Buryakovka RWDF – 35 persons, KP VEKTOR – 164 persons;
  - in the radius of 10 km: motor transport column - 28 persons, guard team No 3- 42 persons;
  - in the radius of 10 km in the former residential areas: temporary “self-settlers” – 2 persons in the village of Ilyintsy and 3 persons in Lubyanka.
- The CSFSF buildings and facilities do not relate to objects of cultural heritage in compliance with the Ukraine Law “On Protection of Cultural Heritage” No 1805-III of 08.06.2000 with amendments as of 12.02.2015 [129]:
- The CSFSF buildings and facilities do not relate to objects of engineering and transport infrastructure.
- For assessment of economic damages due to termination of operation or loss of integrity of the building or facility, data from facility-level estimates in Vol. 15.1 “Estimate Documents. Part 1. Estimate Summary and Facility-Level Estimates” was used.
- Service lives of buildings and facilities are given in Table 19.1.
- Minimum wages established under Article 8 of the Ukraine Law “On the State Budget of Ukraine for 2016” No 928-VIII of 25.12.2015 [128] are 1378 UAH since January 1.
- The list of buildings and facilities is in line with the breakdown of buildings and facilities in the project general plan (Vol. 2 “General Plan and Transport”).

19.1. Calculation of Consequence Class and Difficulty Category for a Facility in Total

Building/Facility	Specified period for operation of fixed assets	Depreciation charge factor	Number of people permanent-ly present in building	Number of people periodically present in building	Number of people present outside CSFSF (in 10 km zone). person	Cost of fixed assets, UAH	Possible material damage, UAH	Possible economic damage, min. wages	Conse-quenc e class	Difficu-lty catego-ry
Acceptance building	100	0.01	70	108	274	1 831 951 074	412 188 991.7	284 268	CC3	V
Cask storage site	100	0.01	0	13	274	23 965 453 628	5 392 227 066.3	3 718 777	CC3	V
Maintenance building with MPC storage room (with storage site and HI-STORM shoulder ring concreting bay	50	0.02	0	5	274	197 112 610	44 350 337.3	30 586	CC2	IV
Administrative building	50	0.02	38		274	22 987 137	5 172 105.8	3 567	CC2	III
Electric equipment building	50	0.02	0	2	274	27 538 810	6 196 232.3	4 273	CC2	III
Garage	50	0.02	0	4	274	126 037 654	28 358 472.2	19 558	CC2	IV
Petrol filling station	30	0.03	0	2	274	422 579	95 080.3	66	CC1	I
Fire pump station	50	0.02	0	4	274	7 431 993	1 672 198.4	1 153	CC1	I
Fire water tanks	50	0.02	0	2	274	1 313 853	295 616.9	204	CC1	I
Guard facilities	100	0.01	32	52	274	35 230 778	7 926 925.1	5 467	CC2	III
Checkpoint 1	50	0.02	18	50	274	16 790 312	3 777 820.2	2 605	CC2	III
Checkpoint 2	20	0.05	2	4	274	10 136 078	2 280 617.6	1 573	CC1	II

Building/Facility	Specified period for operation of fixed assets	Depreciation charge factor	Number of people permanent-ly present in building	Number of people periodically present in building	Number of people present outside CSFSF (in 10 km zone). person	Cost of fixed assets, UAH	Possible material damage, UAH	Possible economic damage, min. wages	Conse-quence class	Difficu-lty catego-ry
Rainfall runoff facilities	30	0.03	0	3	274	8 655 505	1 947 488.6	1 343	CC1	I
Sewerage pumping station	30	0.03	0	3	274	388 689	87 455.0	60	CC1	I
Oil collector (separator)	30	0.03	0	2	274	220 775	49 674.4	34	CC1	I
Telecommunication tower with module building	20	0.05	0	2	274	107 531 857	24 194 667.8	16 686	CC2	IV
ARMS control station	20	0.05	0	1	274	2 305 492	518 735.7	358	CC1	I
In-site railroads	30	0.03	0	9	274	679 441 149	152 874 258.5	105 431	CC2	IV

A possible economic damage was estimated as per Item 4 of DSTU-H B.1.2-16:2013 [131] by the formula:

$$\Phi = c\sum_{i}^{n} P_i\left(1-\frac{1}{2}T_{ef}\times K_{a,i}\right) \quad (19.1)$$

where c is a coefficient which accounts for the relative portion of fixed assets that will completely be lost during a failure. The value is assumed to be 0.45;

P_i, UAH is the cost of fixed assets pursuant to data from facility-level estimate calculations of the summarized estimate calculation;

T_{ef}, years is an established service life of fixed assets;

Ka, $I = 1/T_{ef}$ is a depreciation charge factor;

1450 UAH is minimum wages according to [128].

Conclusion: From the results of the calculation, a consequence class of the construction target is generally determined by the characteristics of the cask storage site and acceptance building. Basing on the material damage, the consequence class is CC3 and the difficulty category is V for the facility.

20 SCHEDULE OF QUANTITIES

The schedules of quantities are given in each Project volume by fields of specialization.

Abbreviations and Acronyms

ARMS	Automated Radiation Monitoring System
NPP	Nuclear Power Plant
VVER	Water-Water Power Reactor (a reactor of PWR type)
VCT	Vertical cask transporter (transfer vehicle)
BV	Waste holdup unit
LM	Lifting machinery
CP	Civil protection
CD	Civil defense
DP NAEK ENERGOATOM	State-owned Enterprise “Energoatom National Nuclear Energy Generating Company”
State-owned Specialized Enterprise Chernobyl NPP	State-owned Specialized Enterprise “Chernobyl Nuclear Power Plant”
CRZ	Compulsory resettlement zone
SPTA	Spare parts, tools and accessories
SA	Supervised area
RZ	Resettlement zone
WA	Work area
LRW	Liquid radioactive waste
PDM	Personal dosimetry monitoring
IRS	Ionizing radiation source
ETM	Engineering and technical measures
DMS	Dosimetry monitoring station
I&A	Instrumentation and automation
KP VEKTOR	Vektor Production Facilities
Checkpoint	Checkpoint
RL	Reference level
HFL	Highly flammable liquid
DI	Dose intensity
MHU	Ministry of Health of Ukraine
ICRP	International Commission on Radiological Protection
MPC	Multipurpose cask
EDR	Exposure or equivalent dose rate, as appropriate
HS	Hazardous substance
EIA	Environmental Impact Assessment
HRF	High-risk facility
OS	Occupational safety
SFA	Spent fuel assembly
SNF	Spent nuclear fuel
LLW	Low-level radioactive waste
RD	Regulatory documents
NRBU	Ukrainian Radiation Safety Standards
RI	Regulatory instrument
OP API	Separated Enterprise Atomproektinzhiniring
SNF	Spent nuclear fuel

RWDF	Radioactive waste disposal facility
PSAR	Preliminary Safety Analysis Report
PHF	Potentially hazardous facility
CMS	Construction Method Statement
RW	Radioactive waste
RS	Radiation safety
RAS	Radioactive substance
RN	Radionuclides
SPZ	Sanitary protection zone
PPE	Personal protective equipment
PRPE	Personal respiratory protective equipment
SOHF	Specialized occupational health facility
OSMS	Occupational safety management system
CMS	Control and management systems
OSH	Occupational safety and health
FA	Fuel assembly
TOR	Terms of Reference
M&R	Maintenance and repair
SRW	Solid radioactive waste
TE	Transuranium elements
RW	Radioactive waste
Emergency	Emergency
CSFSF	Central Spent Fuel Storage Facility
CTF	Cask transfer facility
NRS	Nuclear and radiation safety
NF	Nuclear fuel

Terms and definitions

Gas-aerosol discharge (discharge)	shall be understood as the ingress of radioactive substances into the atmospheric air from process loops and ventilation systems of a plant (NRBU-97)
Absorbed dose	shall be understood as the average dose absorbed in an organ or tissue calculated according to the formula where ___ is the aggregate energy released in an organ or tissue, ___ is the mass of an organ or tissue
Dose equivalent	shall be understood as a value defined as a product of the dose absorbed in a specific organ or tissue T by the radiation weighting factor wR
Effective dose	shall be understood as a sum of products of equivalent doses NT in specific organs and tissues by the appropriate tissue weighting factors wT
Allowed level	shall be understood as a derivative allowance for the ingress of radionuclides into a human organism over a calendar year, equivalent dose intensity, radionuclides concentration in the air, potable water and food, particle fluence rate, etc. averaged over a year and calculated for reference exposure conditions on the basis of dose limits
Radioactive contamination	shall be understood as the presence or propagation of radioactive substances in excess of their natural content in the environment and/or human body
Beyond-design-basis accident	shall be understood as an accident caused by accident initiator events not considered for design-basis accidents or an accident accompanied by additional failures of safety systems or personnel errors in comparison with design-basis accidents
Compulsory resettlement zone	shall be understood as an area subjected to the intensive contamination with the long-lived radionuclides with the soil contamination density exceeding the pre-accident level
Controlled zone	shall be understood as an area subjected to the intensified dosimetry monitoring
Supervised area of a facility	shall be understood as an area of the potential impact of radioactive discharges and emissions of a radiation/nuclear facility where technology processes are monitored to ensure radiation safety or a radiation/nuclear facility
Exclusion zone	shall be understood as an area of the evacuation of the population in 1986 (Law of Ukraine “On Legal Regime of the Area Subjected to Radioactive Contamination as a Result of the Chernobyl Disaster” # 791a-XII).
Reference levels	shall be understood as radiation hygiene regulations of Group One whose numeric values are set on the basis of the actual level of the radiation welfare attained at the radiation/nuclear facility or area in question. The RL value is specified by the management of the plant in concurrence with State Sanitary/Epidemiological Supervision agencies in order to keep exposure of personnel and/or population below dose limits and carry out radiation dosimetry control.
Critical event	shall be understood as an event which directly results in the materialization of a potential exposure. A critical event may be a combination of a number of particular ctitical events (NRBU-97/D-2000).

K-factor Exposure	shall be understood as the effective neutron multiplication factor shall be understood as the human exposure to the ionizing radiation from sources outside the human organism (external exposure) or from sources inside the human organism (internal exposure)
Potential exposure	shall be understood as the exposure of personnel and population considered during the design of practical activities and materializing after a certain critical event not covered by the regular technological process with the probability of occurrence below 1×10^{-2} per year
Design-basis accident	shall be understood as an infrequent event that can be expected at least once over the service life of the storage facility
Contaminated land	shall be understood as areas requiring radiation protection measures and other special interventions to be undertaken to limit the additional exposure caused by the Chernobyl accident and support regular economic activity
Reference probability of a critical event	shall be understood as a probability of occurrence of a critical event securing the non-exceedence of reference risks at various potential exposure dose levels
Risk (generalized risk)	shall be understood as a measure of the health hazard for a person affected by the exposure which is numerically equivalent to a product of two values: the exposure probability per unit time (year) and the probability of materialization of radiological stochastic and non-stochastic impact on the health of persons that can be subjected to the exposure in question
Acceptable risk	shall be understood as risk levels underlying the dose limits and threshold dose levels for termination of intervention for the population as prescribed by NRBU-97
Reference risk	shall be understood as numeric values of risks set for limiting potential exposure of the personnel and population which do not exceed acceptable risk levels
Buffer area (SZZ) of a facility	shall be understood as an area around a radiation/nuclear facility where the human exposure level under normal operating conditions can exceed the quota of the dose limit for population (Category B).

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Appendix C29

PBPRM. 2006. On Approval of Rules of Nuclear and Radiation Safety During Transportation of Radioactive Material

STATE NUCLEAR REGULATORY COMMITTEE OF UKRAINE

ORDER

30.08.2006 N 132

Registered in the Ministry
Justice of Ukraine
September 18, 2006
by N 1056/12930

On Approval of Rules of nuclear and radiation safety during transportation of radioactive materials (PBPRM 2006)

According to the Regulations of the State Committee for Nuclear regulation Ukraine approved by the Decree of President of Ukraine March 6, 2001 N 155 (155/2001) and in order to bring regulations on transportation of radioactive materials to requirements of "regulations for the safe transportation of radioactive materials.
Edition 2005. A series of IAEA safety standards, N TS-R-1 "
ORDER hereby:

1. The Regulations on nuclear and radiation safety of Transportation of Radioactive Materials (PBPRM 2006) (hereinafter - Rules) attached.

2. Office of guarantees and security of transportation (in face of Lopatin S.D.) should present this order in the prescribed manner to State Ministry of Justice of Ukraine.

3.. Office of guarantees and security of transportation (in face of Lopatin S.D.) should provide proof to the attention of stakeholders Information on the entry into force of the Rules.

4. The State Enterprise "State Scientific and Technical Center of Nuclear and Radiation Safety "(in face of Vasil'chenko V.M.) Should provide replication of Regulation in a month of the state registration.

5. Control over the execution of the order is conducted by the Deputy Chairman - Chief Inspector of Nuclear Safety Ukraine Demyanenko A.I.

Chairman O.A.Mykolaychuk

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Minister of Ukraine for
Emergencies Affairs and
Protection from the Consequences of

APPROVED
State Committee
Nuclear Regulation of Ukraine
30.08.2006 N 132

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by N 1056/12930

RULES

**Of nuclear and radioactive safety
During transportation of radioactive material
(PBPRM 2006)**

Chapter 1. Introduction

General Terms

1.1. The Rules are developed within the frame of the Program of Integration of Ukraine to the European Union (n0001100-00), approved by Decree of President of Ukraine from September 14, 2000 N 1072 (1072/2000) with the changes comply with the Laws of Ukraine "On Nuclear Energy and Radiation Safety "(39/95-VR)," On protection man from ionizing radiation "(15/98-VR) requirements of state sanitary norms "Norms of Radiation Ukraine Security (NRBU-97) "(v0062282-97), approved by the Ministry of Health of Ukraine from 14.07.97 N 208 (v0208282-97), typed in effect from 01.01.98 Resolution of the Chief Medical Officer Ukraine from 01.12.97 N 62 (v0062282-97) (hereinafter - NRBU- 97) and Basic sanitary rules of radiation safety of Ukraine, approved by the Ministry of Health of Ukraine of 02.02.2005 N 54 (Z0552-05), registered with the Ministry of Justice of Ukraine 20.05.2005 for N 552/10832.

Rules meet the document "Regulations of safe Transportation of radioactive materials. Edition 2005. Series of safety standards N TS-R-1. IAEA "(" Regulations for the Safe Transportation of Radioactive Material. 2005 Edition. Safety Standards Series N TS-R-1. IAEA ").

These Regulations establish standards of safety which provide acceptable level of control of radiation, as well as related criticality and heat danger to personnel and property and environment during transportation of radioactive materials. In these Rules the principles set out in the publication "Radiation protection and safe management of sources radiation. - A series of publications on safety N 120, IAEA, Vienna (1996) "and the publication" International basic safety standards for protection against ionizing radiation and for the safety of sources radiation. - A series of publications on safety N 115, IAEA, Vienna (1996) ".

1.2. These rules are supplemented by guidelines on safety and documents with security practices that meet IAEA document: "References to the IAEA Regulations 0n the safe transportation of radioactive materials. A series of rules IAEA N TS-G-1.1 (ST-2) "," Planning and management

readiness in case of transportation accidents involving radioactive materials. A series of IAEA safety standards N TS-G-1.2 (ST-3), "" Enforcing the Rules of safe transportation of radioactive materials. A series of IAEA safety standards N TS-G-1.4 " and the document "Quality Assurance for the Safe Transportation of radioactive materials. A series of IAEA safety standards N TS-G-1.3 ".

1.3. In some sections of the Regulations is attributed to implementation of specific measures, but responsibility for their implementation is not relies on a legal entity. Distribution of this liability is determined by the current legislation of Ukraine.

Goal

1.4. The purpose of this Regulation - to ensure the protection of persons and property and environment from radiation exposure during transportation of radioactive material. This protection is achieved by mandatory use of:

a) protective cover (hermetic sealing of) for radioactive content;

b) control of external radiation levels;

c) measures to prevent criticality;

d) measures to prevent damage due to heat exposure.

Meeting these requirements is provided:

a) by applying degree approach to contents limits packaging and means of transportation, as well as regulations of constructions characteristics of packagings depending on the danger posed by the radioactive contents;

b) by establishing requirements for the construction and operation and packaging and maintenance of packagings, including taking into account the nature of the radioactive contents;

c) by requiring the application of measures of administrative control, including, where appropriate, approvals by the competent authorities.

1.5. When transporting radioactive material security of individual People or professional people or workers (personnel) is ensured by compliance. This is achieved through quality assurance programs and programs for compliance with the Rules.

Scope of application

1.6. These rules apply to the transportation of radioactive materials by road, rail, sea, river and air transport, including transportation related to the use of radioactive material. Transportation includes all operations and conditions associated with the movement of radioactive material, and is this process, including:

design, manufacture, maintenance and repair packaging;

preparation, loading, dispatch, transport, including transit storage, unloading and receipt at final destination and transport of radioactive materials packages.

In carrying out these rules shall apply stepwise approach that can be characterized by three general levels of difficulty:

a) normal transportation conditions (no incidents);

b) Normal conditions of carriage (minor accident);

c) accident conditions of carriage.

1.7. These rules do not apply to:

a) radioactive material that is an integral part of the means transportation;

b) radioactive material moved within any institutions and are subject to the validity of appropriate security which operate in the establishment, where the movement does not use public highways or railways;

c) radioactive material implanted or introduced into humans or animals for diagnosis or treatment;

d) radioactive materials contained in consumer products, admitted by the regulatory body for use after their sale to the end user;

e) natural material and ores containing natural radionuclides that either are in their natural state, or have been processed for purposes other than for extraction of the radionuclides, and which is not expected to process in order to use these radionuclides provided the specific activity of the material that does not exceeds more than 10 times the value specified in paragraphs 4.2b and 4.7 or calculated in accordance with paragraphs 4.3, 4.5 and 4.6;

f) non-radioactive solid objects with radioactivity that present on any surfaces in quantities not exceeding levels defined in paragraph 2.25.

1.8. These rules do not provide such controls as route selection or the physical protection that can be implemented for reasons not related to radiation safety. Any such controls should consider radiation and non-radiation hazard without deviation from the norms of security established by these Rules.

1.9. For radioactive material with additional danger and during the transportation of radioactive materials along with other dangerous goods in addition to these Rules should apply the rules of transportation of dangerous loads that act on this form of transport.

Structure

1.10. As part of its structure, these rules include:

Chapter 2: The terms and definitions used in Regulation;

Section 3: General provisions for radiation protection, emergency measures to ensure the quality, ensure compliance with Rules, Rules of discrepancy, the special conditions of education;

Section 4: definition, classification and requirements for radioactive materials;

Section 5: definition, classification and requirements for packaging sets;

Chapter 6: preparation of radioactive materials for transportation, including selection of appropriate packaging, packing, categorization, labeling and marking of danger, filling transport documents;

Chapter 7: requirements for administration, transportation, transit storage of packaging;

Section 8: requirements for testing;

Chapter 9: Approval requirements and administrative control.

Section 2. Terms and Definitions

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1) For convenience, the brackets are also English terms language.

In these Rules the following definitions are used:

Alpha emitters of low toxicity (Low toxicity alpha emitters)

2.1. Alpha emitters of low toxicity - natural Uranus; depleted uranium; natural thorium; uranium-235 or uranium-238; thorium-232; thorium-228 and thorium-230 contained in ores or form of physical and chemical concentrates; or alpha emitters with half-life of less than 10 days.

Load (Consignment)

2.2. Load - any packaging or any packaging or Any consignment of radioactive material provided shipper for carriage.

Cargo Container (Freight container)

2.3. Cargo container - transport equipment constructed to facilitate transportation of packaged or unpackaged goods by one or more modes of transport without intermediate reloading cargo placed in it that should not open illegally, must be sufficiently rigid and durable recyclable and must be equipped with devices that improve usability, especially when transfer from one transport to another or from one mode of transport to another. Small cargo container - is container, any External dimensions not exceeding 1.5 m, or an internal volume of which is less than 3 cubic meters Any other freight container is considered large cargo container.

The shipper (Consignor)

2.4. Shipper - any physical or legal person, which prepares the goods for carriage.

The consignee (Consignee)

2.5. The consignee - any physical or legal person, receiving goods.

Exclusive use (Exclusive use)

2.6. Exclusive use - the use of only one shipper transportation vehicle or large freight container, for which all initial, intermediate and final loading and unloading operations are carried out in accordance with the instructions of the shipper or consignee.

Enforcement of Regulations (Compliance assurance)

2.7. Enforcing the Rules - a program of systematic measures taken by the competent authority to ensure the provisions of the Regulations in practice.

Quality (Quality assurance)

2.8. Quality - a program of systematic measures monitoring and inspections carried out by any organization or body involved in the transport of radioactive materials and aims to provide reasonable assurance that safety standards that are attributed to these Rules to follow practice.

Tool carriage (Conveyance)

2.9. Tool transportation means:
a) for transport by road or rail - any vehicle;
b) to transport waterway - any vessel or any hold, compartment or marked deck of the ship;
c) for air transport - any aircraft.

Approval (Approval)

2.10. Multilateral approval (Multilateral approval) - approval of the competent authority of the country of origin construction or transport where appropriate, as well as Where the goods should be transported through the territory or into the territory of any other country, approval by the competent authority of that country. In terms of "through or into" not specifically included in the term "over the territory", ie requirements on the approval and notification should not extend to the country, on whose territory, the radioactive material is transported on board of aircraft provided that this country is not expected scheduled landing.

2.11. Unilateral approval (Unilateral approval) - design approval required from the competent authority only of the country of origin of the design.

The competent authority (Competent authority)

2.12. The competent authority - any national or international regulatory body or entity endowed authority for any purpose in connection with these Terms or otherwise recognized as such.
According to the Regulations of the State Committee for Nuclear regulation Ukraine approved the Decree of President of Ukraine March 6, 2001 N 155 (155/2001), the functions of the competent body performs State Nuclear Regulatory Committee of Ukraine (Hereinafter - the State Nuclear Regulatory Committee of Ukraine).

Construction (Design)

2.13. Construction - description of radioactive material of special Form, radioactive material with low capacity for scattering, packaging or packaging that allows fully identify them. This description may include specifications, engineering and technical documentation (drawings), reports confirm compliance with regulatory requirements and other appropriate documentation.

Container Intermediate bulk cargo
(Intermediate bulk container)

2.14. Container Intermediate bulk
cargo (IBC) - portable packaging that:
a) has a volume of less than 3 cubic meters;
b) has a structure that allows you to make loading
transactions using lifting mechanisms;
c) resistant to stress arising during cargo
operations and freight as defined tests for
verification of performance;
d) designed according to the rules set forth in section
recommendations containers dedicated to Secondary
bulk containers (IBC), paper
"Recommendations on the Transport of Dangerous Goods, Ninth
Revised Edition (ST / SG / AC.10 / 1 / Rev.9), UN, New York and Geneva
(1995) ".

The maximum normal operating pressure (Maximum normal
operating pressure)

2.15. The maximum normal operating pressure - maximum
pressure above atmospheric pressure at sea level, which can
have a containment system for one year
under temperature conditions and solar radiation corresponding
environmental conditions, without venting excess
pressure, external cooling by means of additional system or
without operational controls during transport.

Non-irradiated uranium (Unirradiated uranium)

2.16. Non-irradiated uranium - uranium containing not more
June 3
2x10 Bq of plutonium per gram of uranium-235, not more than 9x10 Bq products
-3
division per gram of uranium-235 and not more than 5x10 g of uranium-236 per
gram
uranium-235.

Non-irradiated thorium (Unirradiated thorium)

2.17. Non-irradiated thorium - thorium containing not more
-7
10 g of uranium-233 per gram of thorium-232.

Unfixed contamination (Non-fixed
contamination)

2.18. Unfixed contamination - radioactive
contamination that can be removed from the surface under normal conditions
transportation.

The carrier (Carrier)

2.19. The carrier - any physical or legal person
transporting radioactive material by any type
transport.

Specific activity (Specific activity)

2.20. Radionuclide volume activity - activity unit

mass of the radionuclide. The specific activity material - Activity per unit mass of material in which the radionuclides are mainly distributed evenly.

Aircraft (Aircraft)

2.21. Cargo aircraft (Cargo aircraft) - Any aircraft, other than passenger aircraft carrying goods or property.

2.22. The passenger aircraft (Passenger aircraft) - aircraft carrying any person, except members of crew, staff working in the carrier and that are on duty authorized representative of the national authority or person accompanying the shipment.

Marked of the deck (Defined deck area)

2.23. Marked of the deck - part of the upper deck of vessel or vehicle deck of the ship or ferry, where there is space for placing radioactive materials.

Radiation Protection Program (Radiation Protection Programme)

2.24. Radiation Protection Program - the systematic measures whose purpose is to ensure proper planning and accounting activities on radiation protection.

Radioactive contamination (Contamination)

2.25. Radioactive contamination - presence of radioactivity in surface in quantities in excess of 0.4 Bq / cm for beta and gamma emitters and alpha emitters low toxicity or 0.04 Bq / cm for all other alpha emitters.

Radioactive contents (Radioactive contents)

2.26. Radioactive content - radioactive material with any radioactively contaminated or activated solid substances, liquids and gases contained in the packaging kit.

Tank (Tank)

2.27. Tank - tank-container, mobile tank tanker, rail tanker or receiving capacity capacity at least 450 liters of liquids, powders, granules, mixtures or solids when filling are gaseous or liquid form and then hardens, and at least 1,000 liters for emissions. Tank containers must be suitable for transportation by land and waterways, and to fill emptying without removal of its structural equipment shall have stabilizing elements and external fastening devices and be eligible for recovery in the filled state.

The level of radiation (Radiation level)

2.28. The level of radiation - on the dose,
expressed in millisieverts per hour.

Containment system (sealing) (Containment system)

2.29. Containment system (sealing) – system of
components of the packaging, as defined by the designer
system for keeping radioactive material in
transportation.

Localization system (Confinement system)

2.30. System of location - System placing fissile
material and packaging elements defined
designer and approved by the competent authority as the system
designed to ensure the safety criticality.

Special conditions (Special arrangement)

2.31. Special conditions - conditions approved by the competent
authority under which cargo may be carried, not
meet all applicable requirements of these Regulations.

The vessel (Vessel)

2.32. The ship - any seagoing vessel or means for swimming
inland waterways used for transportation
cargo (non-self-propelled or floating structures that
used or can be used as a means to
freight).

The vehicle (Vehicle)

2.33. Vehicle - Motor-Road transport means
(Drawn vehicle that is articulated,
inclusive) or railway platform or a railway wagon. Every
trailer should be considered as a separate vehicle.

The transport package (Overpack)

2.34. Transport Package - a (shell), such as a box,
box or bag, designed to accommodate one and conclusion
of more packages to form a single unit load,
one shipper used for convenience when
cargo operations and transportation.

Transportation (Shipment)

2.35. Transportation - special movement of goods
From place of origin to destination.

Natural uranium, depleted, enriched (Uranium - natural,
depleted, enriched)

2.36. Natural uranium - uranium (which may be chemically
Dedicated) containing the natural mixture of uranium isotopes (approximately
99.28% uranium-238 and 0.72% uranium-235 by mass). Depleted Uranium -
uranium containing a lesser amount in percentage of uranium-235
by weight compared to natural uranium. Enriched uranium - uranium

listing the number of uranium-235 in percentage by weight
more than 0.72%. In all cases there is a very small percentage
terms of the mass amount of uranium-234.

Fixed contamination (Fixed contamination)

2.37. Fixed contamination - radioactive
Pollution that is not unstable radioactive contamination.

Section 3. General Provisions

Radiation protection

3.1. Individual doses of radiation should not exceed
appropriate dose limits. Protection and safety shall be optimized
so that the magnitude of individual doses, the number of persons
subject to exposure and the likelihood of exposure to refrain
low as reasonably achievable, taking into account economic and
social factors, within limits, which is to ensure that
doses are individuals subject to the limit
doses. It is necessary to apply the structural and systemic approach,
which takes into account the relationship with other modes of transportation
activity.

3.2. For transportation of radioactive materials should be
developed a program of radiation protection. The nature and extent of
measures envisaged in the program, depending on the size and
the likelihood of exposure. The program should take into account
requirements
set out in paragraphs 3.1, 3.3-3.5 and 3.11. Document
must be available on request for inspection, conducted by
Nuclear Regulatory Committee of Ukraine.

3.3. In the case of occupational exposure during the work,
associated with transportation when under the total effective assessment
dose can reach:

a) 1-6 mSv a year - must perform dose assessment program
by radiation monitoring or individual jobs
radiation monitoring;

b) over 6 mSv per year - should be carried out individually
dosimetric control.

Individual monitoring or dose
control of working places should be documented in accordance with
the requirements of paragraph 14.5 of Basic sanitary rules of
Radiation Safety of Ukraine (z0552-05).

Emergency measures

3.4. In the event of accidents or incidents during transportation of
radioactive materials it is a must comply installed on
procedures in case of accidents relevant national and / or international
organizations to protect people, property and
environment. Instructions for these procedures are contained in
Provisions concerning planning and actions in case of accidents during
transport of radioactive materials approved by
Nuclear Regulatory Committee of Ukraine of 07.04.2005 N 38 (z0431-05),
registered in the Ministry of Justice of Ukraine on 22.04.2005
N 431/10711.

3.5. Emergency procedures should consider the possibility of the formation of other dangerous substances due to the interaction of content cargo with the environment in case of accident.

Ensurance of quality

3.6. Quality Assurance Programme should be developed and be made regarding the design, manufacture, testing, design documentation, use, maintenance and inspections for all radioactive material of special form, radioactive materials with low dispersible and packaging, as well as on transport operations and transit storage for enforcement of the relevant provisions of this Regulation. Producer, consignor or user shall provide possibility to Nuclear Regulatory Committee of Ukraine to carry out checks during manufacture or use and to demonstrate that:

a) methods used for manufacturing and materials meet the specifications for the approved design;

b) all packagings are periodically tested at necessary, repaired and maintained in good order to continue to meet all relevant requirements and specifications even after repeated use.

If approved under paragraph 9.2 SCNS Ukraine should be considered at quality assurance program and its adequacy.

Enforcing the rules

3.7. SCNS of Ukraine is responsible for ensure compliance with these Rules. Means of implementation of these responsibilities include the development and implementation of control programs for the design, manufacture, testing, inspection and maintenance of packagings radioactive materials of special form, radioactive material with low capacity for scattering, and the preparation of packaging, documentation, processing and signing packages and shippers carriers to confirm the provisions of the Regulations on practice.

3.8. Ministry of Health of Ukraine (hereinafter - MoH Ukraine) and SCNS Ukraine carry out selective control of radiation doses received in connection with transportation of radioactive materials, in order to ensure that the system of safety and protection meets NRBU- 97 (v0062282-97).

Inconsistency rules

3.9. In the case of non-compliance of radiation levels or Radioactive contamination of any limits set by these Regulations (except accidents during transportation):

a) the consignor shall be informed about discrepancy:

i) the carrier if the non-compliance found during transportation;

ii) the consignee if the non-compliance is found at receipt of the goods;

b) the carrier, consignor or consignee according to their competence should:

i) take immediate action to reduce the consequences of

non-compliance;

ii) investigate the non-compliance and its causes, circumstances and consequences;

iii) take appropriate steps to address the causes and the circumstances that led to inconsistencies and prevent repetition;

iv) notify the State Nuclear Regulatory Committee of Ukraine causes of non-compliance and corrective or preventive measures were to be taken;

c) notice of non-compliance should be sent to SCNS shipper and Ukraine as soon as possible in Whenever there was or there is Disaster

Special conditions

3.10. Loads for which can not be practically achieved compliance with these Rules must be transported only under special conditions. If Ukraine Nuclear Regulatory Committee recognized that compliance with these Rules is almost impossible to achieve and established by these Rules required safety standards are met through the application of alternative provisions hereof, SCNS that Ukraine may approve transactions transportation for special conditions of individual goods or planned a series of multiple loads. The overall level of security during transportation must be at least equivalent to the level that would have ensured if all the applicable requirements. For international transport this type require multilateral approval.

Teaching

3.11. Professional employees (staff) should have appropriate training on radiation protection, including safeguards measures to be followed in order to reduce occupational exposure to which they are exposed, exposure and other persons who might be affected by their actions.

3.12. Persons involved in the transportaion of radioactive materials should be trained on the requirements of the Regulation of which relate to the responsibilities of these individuals.

3.13. Persons that :

classify radioactive materials;

packaged radioactive material;

applied markings and labels on packaging;

prepare travel documents for radioactive materials;

sending or receiving radioactive materials transportation;

move or handle radioactive materials in transportation;

mark or put warning signs or load unload packaging / or means of transport;

fill packaging or freight containers;

otherwise directly involved in transportation radioactive materials as defined by the competent authority, must undergo such training:

a) general education training:

i) each person must undergo training, which involves review the terms hereof;

ii) such training should include a description of radioactive materials; requirements for the application of labels, labeling,

warning signs; requirements for packagings and to
division when placing radioactive materials; description and objectives
content of transport documents to radioactive materials; description
Documents available to respond to emergency situations;

b) functionally specialized training:

each person must go through a detailed study, which concerns
specific requirements for the carriage of radioactive material
applicable to the activities of that person;

c) training on safety:

the risk of exposure to radioactive leak case
Materials and duties, each person must go
training:

i) methods and procedures to be applied for
accident avoidance, such as proper use of freight
equipment and appropriate methods of laying radioactive
material;

ii) information on emergency response and its use;

iii) common potential hazards associated with different types of
radioactive materials and methods of preventing exposure at
such perils, including, if necessary, the use of
Personal protection equipment;

iv) Immediate procedures to be applied in the case
accidental release of radioactive material, including
any procedures for immediate response to the emergency situation in
that person is responsible, as well as procedures for personal protection,
to be followed.

3.14. Training required in accordance with paragraph 3.13,
must be provided or confirmed the appointment on
positions related to transport of radioactive materials,
shall be amended in accordance with retraining
satisfaction.

Training programs should be coordinated with
Nuclear Regulatory Committee of Ukraine.

Chapter 4. Requirements for radioactive material

Definition of radioactive material

4.1. Radioactive material - any material containing
radionuclides, in which specific activity and full activity
cargo exceed the values specified in paragraphs 4.2-4.7.

The basic values for radionuclide

4.2. Table. 1 shows the following basic values for individual
radionuclides:

a) A and A in TBq,
1 February
where A - activity value of radioactive material
1
special form that indicated in the Table. 1, or determined in accordance
with
the provisions of paragraphs 4.3-4.7 and used to determine the boundaries
activity to the requirements of these Regulations,

A - other activity value of radioactive material
2
(Radioactive materials other form) which is indicated in Table. 1 or
determined in accordance with the provisions of paragraphs 4.3-4.7 and
used to determine the activity limits for the requirements of
Regulations;

b) specific activity for the materials covered by the full
release in Bq / g;

c) activity limits for goods covered by the full release in Bq.

Determination of basic values for radionuclide

4.3. Regarding individual radionuclides not listed in Table. 1, identifying key values referred to in Point 4.2 requires multilateral approval. You use value A, calculated using dose
2
Unit inhalation (dose factor respectively to the table. II and III of the document "International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996) ") reference to the relevant type of system revenues according to recommendations of the International Commission on Radiological Protection, the provided that taken into account the chemical form of each radionuclide as in normal and emergency conditions in transportation. Alternatively without approval of the competent authority may be used values for radionuclides are given in Table. 2.

4.4. In calculating the values of A and A for radionuclide not
1 2
indicated in the table. 1, a chain of radioactive decay, which radionuclides are present in natural proportions and in which no child radionuclide with a half-life greater than or 10 days, or the half-life of the parent radionuclide should be considered as one radionuclide; Despite the activity and value that is used, A or A shall comply
February 1
activity and the value of the parent radionuclide chain. For radioactive decay chains in which any child radionuclide has a half-life greater than 10 days, or the half-life of the parent radionuclide parent radionuclide and daughter radionuclides are to be considered as a mixture of different radionuclides.

4.5. If mixtures of radionuclides basic values, which paragraph 4.2 are defined as follows:

$$X_m = \frac{1}{\sum_i \frac{f(i)}{X(i)}},$$

where f (i) - fraction of activity or activity concentration of the i-th radionuclide mixture;

X (i) - the corresponding value of A or A or under
February 1
Activity concentration for the material, which extends the full exemption or limit the activity of the cargo, which extends Full release about the meaning of i-radionuclide;

X - the original value of A or A concentration or activity
m 2 January
for the material, which extends the full release, or limit activity for goods for which exemption applies in respect of mix;

S - token amount.

4.6. If each radionuclide is known but not known Individual activity some of them, these radionuclides can combine in groups and in the formulas set out in paragraphs 4.5 and 6.13, can be used according to the smallest value radionuclides in each group. Groups may be made on the basis of full alpha activity and total beta, gamma activity, if they are known, using the smallest values according to alpha emitters or beta, gamma emitters.

Table 1 - Basic radionuclides values

Radionuclide (atonic number)	A 1	A 2	Specific activity for material, on which extend complete release	Limit of activity for material, on which extend complete realease
	(ТБк)	(ТБк)	(Бк/г)	(Бк)
Actinium (89)				
Ac-225 (a)	8x10^-1	6x10^-3	1x10^1	1x10^4
Ac-227 (a)	9x10^-1	9x10^-5	1x10^-1	1x10^3
Ac-228	6x10^-1	5x10^-1	1x10^1	1x10^6
Silver (47)				
Ag-105	2x10^0	2x10^0	1x10^2	1x10^6
Ag-108m (a)	7x10^-1	7x10^-1	1x10^1 (b)	1x10^6 (b)
Ag-110m (a)	4x10^-1	4x10^-1	1x10^1	1x10^6
Ag-111	2x10^0	6x10^-1	1x10^3	1x10^6
Aluminum (13)				
Al-26	1x10^-1	1x10^-1	1x10^1	1x10^5
Americium (95)				
Am-241	1x10^1	1x10^-3	1x10^0	1x10^4

	1	-3	0	4	
Am-242m (a)	1x10	1x10	1x10 (b)	1x10 (b)	
	0	-3	0	3	
Am-243 (a)	5x10	1x10	1x10 (b)	1x10 (b)	
Argon (18)					
	1	1	6	8	
Ar-37	4x10	4x10	1x10	1x10	
	1	1	7	4	
Ar-39	4x10	2x10	1x10	1x10	
	-1	-1	2	9	
Ar-41	3x10	3x10	1x10	1x10	
Arsen (33)					
	-1	-1	1	5	
As-72	3x10	3x10	1x10	1x10	
	1	1	3	7	
As-73	4x10	4x10	1x10	1x10	
	0	-1	1	6	
As-74	1x10	9x10	1x10	1x10	
	-1	-1	2	5	
As-76	3x10	3x10	1x10	1x10	
	1	-1	3	6	
As-77	2x10	7x10	1x10	1x10	
Astatine (85)					
	1	-1	3	7	
At-211 (a)	2x10	5x10	1x10	1x10	
Gold (79)					
	0	0	2	7	
Au-193	7x10	2x10	1x10	1x10	
	0	0	1	6	
Au-194	1x10	1x10	1x10	1x10	
	1	0	2	7	
Au-195	1x10	6x10	1x10	1x10	
	0	-1	2	6	
Au-198	1x10	6x10	1x10	1x10	
	1	-1	2	6	
Au-199	1x10	6x10	1x10	1x10	
Barium (56)					
	0	0	2	6	
Ba-131 (a)	2x10	2x10	1x10	1x10	
	0	0	2	6	
Ba-133	3x10	3x10	1x10	1x10	

	1	-1	2	6	
Ba-133m	2x10	6x10	1x10	1x10	
	-1	-1	1	5	
Ba-140 (a)	5x10	3x10	1x10 (b)	1x10 (b)	
Beryllium (4)					
	1	1	3	7	
Be-7	2x10	2x10	1x10	1x10	
	1	-1	4	6	
Be-10	4x10	6x10	1x10	1x10	
Вісмут (83)					
	-1	-1	1	6	
Bi-205	7x10	7x10	1x10	1x10	
	-1	-1	1	5	
Bi-206	3x10	3x10	1x10	1x10	
	-1	-1	1	6	
Bi-207	7x10	7x10	1x10	1x10	
	0	-1	3	6	
Bi-210	1x10	6x10	1x10	1x10	
	-1	-2	1	5	
Bi-210m (a)	6x10	2x10	1x10	1x10	
	-1	-1	1	5	
Bi-212 (a)	7x10	6x10	1x10 (b)	1x10 (b)	
Berkeley (97)					
	0	-4	0	4	
Bk-247	8x10	8x10	1x10	1x10	
	1	-1	3	6	
Bk-249 (a)	4x10	3x10	1x10	1x10	
Bromine (35)					
	-1	-1	1	5	
Br-76	4x10	4x10	1x10	1x10	
	0	0	2	6	
Br-77	3x10	3x10	1x10	1x10	
	-1	-1	1	6	
Br-82	4x10	4x10	1x10	1x10	
Carbon (6)					
	0	-1	1	6	
C-11	1x10	6x10	1x10	1x10	
	1	0	4	7	
C-14	4x10	3x10	1x10	1x10	
Calcium (20)					

Ca-41	non limited		5 1x10	7 1x10
Ca-45	1 4x10	0 1x10	4 1x10	7 1x10
Ca-47 (a)	0 3x10	-1 3x10	1 1x10	6 1x10
Cadmium (48)				
Cd-109	1 3x10	0 2x10	4 1x10	6 1x10
Cd-113m	1 4x10	-1 5x10	3 1x10	6 1x10
Cd-115 (a)	0 3x10	-1 4x10	2 1x10	6 1x10
Cd-115m	-1 5x10	-1 5x10	3 1x10	6 1x10
Cerium (58)				
Ce-139	0 7x10	0 2x10	2 1x10	6 1x10
Ce-141	1 2x10	-1 6x10	2 1x10	7 1x10
Ce-143	-1 9x10	-1 6x10	2 1x10	6 1x10
Ce-144 (a)	-1 2x10	-1 2x10	2 1x10 (b)	5 1x10 (b)
californium (98)				
Cf-248	1 4x10	-3 6x10	1 1x10	4 1x10
Cf-249	0 3x10	-4 8x10	0 1x10	3 1x10
Cf-250	1 2x10	-3 2x10	1 1x10	4 1x10
Cf-251	0 7x10	-4 7x10	0 1x10	3 1x10
Cf-252	-1 1x10	-3 3x10	1 1x10	4 1x10
Cf-253 (a)	1 4x10	-2 4x10	2 1x10	5 1x10
Cf-254	-3 1x10	-3 1x10	0 1x10	3 1x10
Chlorine (17)				

	1	-1	4	6	
Cl-36	1x10	6x10	1x10	1x10	
	-1	-1	1	5	
Cl-38	2x10	2x10	1x10	1x10	
Curium (96)					
	1	-2	2	5	
Cm-240	4x10	2x10	1x10	1x10	
	0	0	2	6	
Cm-241	2x10	1x10	1x10	1x10	
	1	-2	2	5	
Cm-242	4x10	1x10	1x10	1x10	
	0	-3	0	4	
Cm-243	9x10	1x10	1x10	1x10	
	1	-3	1	4	
Cm-244	2x10	2x10	1x10	1x10	
	0	-4	0	3	
Cm-245	9x10	9x10	1x10	1x10	
	0	-4	0	3	
Cm-246	9x10	9x10	1x10	1x10	
	0	-3	0	4	
Cm-247 (a)	3x10	1x10	1x10	1x10	
	-2	-4	0	3	
Cm-248	2x10	3x10	1x10	1x10	
Cobalt (27)					
	-1	-1	1	6	
Co-55	5x10	5x10	1x10	1x10	
	-1	-1	1	5	
Co-56	3x10	3x10	1x10	1x10	
	1	1	2	6	
Co-57	1x10	1x10	1x10	1x10	
	0	0	1	6	
Co-58	1x10	1x10	1x10	1x10	
	1	1	4	7	
Co-58m	4x10	4x10	1x10	1x10	
	-1	-1	1	5	
Co-60	4x10	4x10	1x10	1x10	
Chrome (24)					
	1	1	3	7	
Cr-51	3x10	3x10	1x10	1x10	
cesium (55)					

Cs-129	0 4x10	0 4x10	2 1x10	5 1x10
Cs-131	1 3x10	1 3x10	3 1x10	6 1x10
Cs-132	0 1x10	0 1x10	1 1x10	5 1x10
Cs-134	-1 7x10	-1 7x10	1 1x10	4 1x10
Cs-134m	1 4x10	-1 6x10	3 1x10	5 1x10
Cs-135	1 4x10	0 1x10	4 1x10	7 1x10
Cs-136	-1 5x10	-1 5x10	1 1x10	5 1x10
Cs-137 (a)	0 2x10	-1 6x10	1 1x10 (b)	4 1x10 (b)
Copper (29)				
Cu-64	0 6x10	0 1x10	2 1x10	6 1x10
Cu-67	1 1x10	-1 7x10	2 1x10	6 1x10
Dysprosium (66)				
Dy-159	1 2x10	1 2x10	3 1x10	7 1x10
Dy-165	-1 9x10	-1 6x10	3 1x10	6 1x10
Dy-166 (a)	-1 9x10	-1 3x10	3 1x10	6 1x10
Erbium (68)				
Er-169	1 4x10	0 1x10	4 1x10	7 1x10
Er-171	-1 8x10	-1 5x10	2 1x10	6 1x10
Europium (63)				
Eu-147	0 2x10	0 2x10	2 1x10	6 1x10
Eu-148	-1 5x10	-1 5x10	1 1x10	6 1x10
Eu-149	1 2x10	1 2x10	2 1x10	7 1x10
Eu-150	0	-1	3	6

(short-existing)	2x10	7x10	1x10	1x10	
Eu-150 (long - existing)	-1 7x10	-1 7x10	1 1x10	6 1x10	
Eu-152	0 1x10	0 1x10	1 1x10	6 1x10	
Eu-152m	-1 8x10	-1 8x10	2 1x10	6 1x10	
Eu-154	-1 9x10	-1 6x10	1 1x10	6 1x10	
Eu-155	1 2x10	0 3x10	2 1x10	7 1x10	
Eu-156	-1 7x10	-1 7x10	1 1x10	6 1x10	
Fluorine (9)					
F-18	0 1x10	-1 6x10	1 1x10	6 1x10	
Ferro (26)					
Fe-52 (a)	-1 3x10	-1 3x10	1 1x10	6 1x10	
Fe-55	1 4x10	1 4x10	4 1x10	6 1x10	
Fe-59	-1 9x10	-1 9x10	1 1x10	6 1x10	
Fe-60 (a)	1 4x10	-1 2x10	2 1x10	5 1x10	
Gallium (31)					
Ga-67	0 7x10	0 3x10	2 1x10	6 1x10	
Ga-68	-1 5x10	-1 5x10	1 1x10	5 1x10	
Ga-72	-1 4x10	-1 4x10	1 1x10	5 1x10	
gadolinium (64)					
Gd-146 (a)	-1 5x10	-1 5x10	1 1x10	6 1x10	
Gd-148	1 2x10	-3 2x10	1 1x10	4 1x10	
Gd-153	1 1x10	0 9x10	2 1x10	7 1x10	

	0	-1	3	6	
Gd-159	3x10	6x10	1x10	1x10	
Germanium (32)					
	-1	-1	1	5	
Ge-68 (a)	5x10	5x10	1x10	1x10	
	1	1	4	8	
Ge-71	4x10	4x10	1x10	1x10	
	-1	-1	1	5	
Ge-77	3x10	3x10	1x10	1x10	
Hafnium (72)					
	-1	-1	1	6	
Hf-172 (a)	6x10	6x10	1x10	1x10	
	0	0	2	6	
Hf-175	3x10	3x10	1x10	1x10	
	0	-1	1	6	
Hf-181	2x10	5x10	1x10	1x10	
	non limited		2	6	
Hf-182			1x10	1x10	
Mercury (80)					
	0	0	1	6	
Hg-194 (a)	1x10	1x10	1x10	1x10	
	0	-1	2	6	
Hf-195m (a)	3x10	7x10	1x10	1x10	
	1	1	2	7	
Hg-197	2x10	1x10	1x10	1x10	
	1	-1	2	6	
Hg-197m	1x10	4x10	1x10	1x10	
	0	0	2	5	
Hg-203	5x10	1x10	1x10	1x10	
Holmium (67)					
	-1	-1	3	5	
Ho-166	4x10	4x10	1x10	1x10	
	-1	-1	1	6	
Ho-166m	6x10	5x10	1x10	1x10	
Iodine (53)					
	0	0	2	7	
I-123	6x10	3x10	1x10	1x10	
	0	0	1	6	
I-124	1x10	1x10	1x10	1x10	
	1	0	3	6	
I-125	2x10	3x10	1x10	1x10	

	0	0	2	6	
I-126	2x10	1x10	1x10	1x10	
	non limited		2	5	
I-129			1x10	1x10	
	0	-1	2	6	
I-131	3x10	7x10	1x10	1x10	
	-1	-1	1	5	
I-132	4x10	4x10	1x10	1x10	
	-1	-1	1	6	
I-133	7x10	6x10	1x10	1x10	
	-1	-1	1	5	
I-134	3x10	3x10	1x10	1x10	
	-1	-1	1	6	
I-135 (a)	6x10	6x10	1x10	1x10	
Indium (49)					
	0	0	2	6	
In-111	3x10	3x10	1x10	1x10	
	0	0	2	6	
In-113m	4x10	2x10	1x10	1x10	
	1	-1	2	6	
In-114m (a)	1x10	5x10	1x10	1x10	
	0	0	2	6	
In-115m	7x10	1x10	1x10	1x10	
Iridium (77)					
	1	1	2	7	
Ir-189 (a)	1x10	1x10	1x10	1x10	
	-1	-1	1	6	
Ir-190	7x10	7x10	1x10	1x10	
	0	-1	1	4	
Ir-192	1x10 (c)	6x10	1x10	1x10	
	-1	-1	2	5	
Ir-194	3x10	3 x10	1x10	1x10	
Potassium (19)					
	-1	-1	2	6	
K-40	9x10	9x10	1x10	1x10	
	-1	-1	2	6	
K-42	2x10	2x10	1x10	1x10	
	-1	-1	1	6	
K-43	7x10	6x10	1x10	1x10	
Krypton (36)					

	1	1	4	7
Kr-81	4x10	4x10	1x10	1x10
	1	1	5	4
Kr-85	1x10	1x10	1x10	1x10
	0	0	3	10
Kr-85m	8x10	3x10	1x10	1x10
	-1	-1	2	9
Kr-87	2x10	2x10	1x10	1x10
Lanthanum (57)				
	1	0	3	7
La-137	3x10	6x10	1x10	1x10
	-1	-1	1	5
La-140	4x10	4x10	1x10	1x10
lutetium (71)				
	-1	-1	1	6
Lu-172	6x10	6x10	1x10	1x10
	0	0	2	7
Lu-173	8x10	8x10	1x10	1x10
	0	0	2	7
Lu-174	9x10	9x10	1x10	1x10
	1	1	2	7
Lu-174m	2x10	1x10	1x10	1x10
	1	-1	3	7
Lu-177	3x10	7x10	1x10	1x10
Magnesium (12)				
	-1	-1	1	5
Mg-28 (a)	3x10	3x10	1x10	1x10
Manganese (25)				
	-1	-1	1	5
Mn-52	3x10	3x10	1x10	1x10
	non limiteded		4	9
Mn-53			1x10	1x10
	0	0	1	6
Mn-54	1x10	1x10	1x10	1x10
	-1	-1	1	5
Mn-56	3x10	3x10	1x10	1x10
Molybdenum (42)				
	1	1	3	8
Mo-93	4x10	2x10	1x10	1x10
	0	-1	2	6
Mo-99 (a)	1x10	6x10	1x10	1x10

Nitrogen (7)					
	-1	-1	2	9	
N-13	9x10	6x10	1x10	1x10	
natrium (11)					
	-1	-1	1	6	
Na-22	5x10	5x10	1x10	1x10	
	-1	-1	1	5	
Na-24	2x10	2x10	1x10	1x10	
Niobium (41)					
	1	1	4	7	
Nb-93m	4x10	3x10	1x10	1x10	
	-1	-1	1	6	
Nb-94	7x10	7x10	1x10	1x10	
	0	0	1	6	
Nb-95	1x10	1x10	1x10	1x10	
	-1	-1	1	6	
Nb-97	9x10	6x10	1x10	1x10	
Neodymium (60)					
	0	-1	2	6	
Nd-147	6x10	6x10	1x10	1x10	
	-1	-1	2	6	
Nd-149	6x10	5x10	1x10	1x10	
Nickel (28)					
	non limited		4	8	
Ni-59			1x10	1x10	
	1	1	5	8	
Ni-63	4x10	3x10	1x10	1x10	
	-1	-1	1	6	
Ni-65	4x10	4x10	1x10	1x10	
Neptunium (93)					
	1	1	3	7	
Np-235	4x10	4x10	1x10	1x10	
Np-236	1	0	3	7	
short existing	2x10	2x10	1x10	1x10	
Np-236	0	-2	2	5	
long existing	9x10	2x10	1x10	1x10	
	1	-3	0	3	
Np-237	2x10	2x10	1x10 (b)	1x10 (b)	

Np-239	0 7x10	-1 4x10	2 1x10	7 1x10	
Osmium (76)					
Os-185	0 1x10	0 1x10	1 1x10	6 1x10	
Os-191	1 1x10	0 2x10	2 1x10	7 1x10	
Os-191m	1 4x10	1 3x10	3 1x10	7 1x10	
Os-193	0 2x10	-1 6x10	2 1x10	6 1x10	
Os-194 (a)	-1 3x10	-1 3x10	2 1x10	5 1x10	
Phosphorus (15)					
P-32	-1 5x10	-1 5x10	3 1x10	5 1x10	
P-33	1 4x10	0 1x10	5 1x10	8 1x10	
protactinium (91)					
Pa-230 (a)	0 2x10	-2 7x10	1 1x10	6 1x10	
Pa-231	0 4x10	-4 4x10	0 1x10	3 1x10	
Pa-233	0 5x10	-1 7x10	2 1x10	7 1x10	
plumbum (82)					
Pb-201	0 1x10	0 1x10	1 1x10	6 1x10	
Pb-202	1 4x10	1 2x10	3 1x10	6 1x10	
Pb-203	0 4x10	0 3x10	2 1x10	6 1x10	
Pb-205	non limited		4 1x10	7 1x10	
Pb-210 (a)	0 1x10	-2 5x10	1 1x10 (b)	4 1x10 (b)	
Pb-212 (a)	-1 7x10	-1 2x10	1 1x10 (b)	5 1x10 (b)	
Palladium (46)					
	1	1	3	8	

Pd-103 (a)	4x10	4x10	1x10	1x10
Pd-107	non limited		5 1x10	8 1x10
Pd-109	0 2x10	-1 5x10	3 1x10	6 1x10
Promethium (61)				
Pm-143	0 3x10	0 3x10	2 1x10	6 1x10
Pm-144	-1 7x10	-1 7x10	1 1x10	6 1x10
Pm-145	1 3x10	1 1x10	3 1x10	7 1x10
Pm-147	1 4x10	0 2x10	4 1x10	7 1x10
Pm-148m (a)	-1 8x10	-1 7x10	1 1x10	6 1x10
Pm-149	0 2x10	-1 6x10	3 1x10	6 1x10
Pm-151	0 2x10	-1 6x10	2 1x10	6 1x10
Polonium (84)				
Po-210	1 4x10	-2 2x10	1 1x10	4 1x10
praseodymium (59)				
Pr-142	-1 4x10	-1 4x10	2 1x10	5 1x10
Pr-143	0 3x10	-1 6x10	4 1x10	6 1x10
Platinum (78)				
Pt-188 (a)	0 1x10	-1 8x10	1 1x10	6 1x10
Pt-191	0 4x10	0 3x10	2 1x10	6 1x10
Pt-193	1 4x10	1 4x10	4 1x10	7 1x10
Pt-193m	1 4x10	-1 5x10	3 1x10	7 1x10
Pt-195m	1 1x10	-1 5x10	2 1x10	6 1x10
Pt-197	1 2x10	-1 6x10	3 1x10	6 1x10

	1	-1	2	6	
Pt-197m	1x10	6x10	1x10	1x10	
Plutonium (94)					
	1	-3	1	4	
Pu-236	3x10	3x10	1x10	1x10	
	1	1	3	7	
Pu-237	2x10	2x10	1x10	1x10	
	1	-3	0	4	
Pu-238	1x10	1x10	1x10	1x10	
	1	-3	0	4	
Pu-239	1x10	1x10	1x10	1x10	
	1	-3	0	3	
Pu-240	1x10	1x10	1x10	1x10	
	1	-2	2	5	
Pu-241 (a)	4x10	6x10	1x10	1x10	
	1	-3	0	4	
Pu-242	1x10	1x10	1x10	1x10	
	-1	-3	0	4	
Pu-244 (a)	4x10	1x10	1x10	1x10	
Radium (88)					
	-1	-3	2	5	
Ra-223 (a)	4x10	7x10	1x10 (b)	1x10 (b)	
	-1	-2	1	5	
Ra-224 (a)	4x10	2x10	1x10 (b)	1x10 (b)	
	-1	-3	2	5	
Ra-225 (a)	2x10	4x10	1x10	1x10	
	-1	-3	1	4	
Ra-226 (a)	2x10	3x10	1x10 (b)	1x10 (b)	
	-1	-2	1	5	
Ra-228 (a)	6x10	2x10	1x10 (b)	1x10 (b)	
Rubidium (37)					
	0	-1	1	6	
Rb-81	2x10	8x10	1x10	1x10	
	0	0	2	6	
Rb-83 (a)	2x10	2x10	1x10	1x10	
	0	0	1	6	
Rb-84	1x10	1x10	1x10	1x10	
	-1	-1	2	5	
Rb-86	5x10	5x10	1x10	1x10	
	non limited		4	7	
Rb-87			1x10	1x10	

Rb (natural)	non limited		4 1x10	7 1x10
Rhenium (75)				
Re-184	0 1x10	0 1x10	1 1x10	6 1x10
Re-184m	0 3x10	0 1x10	2 1x10	6 1x10
Re-186	0 2x10	-1 6x10	3 1x10	6 1x10
Re-187	non limited		6 1x10	9 1x10
Re-188	-1 4x10	-1 4x10	2 1x10	5 1x10
Re-189 (a)	0 3x10	-1 6x10	2 1x10	6 1x10
Re (natural)	non limited		6 1x10	9 1x10
Rhodium (45)				
Rh-99	0 2x10	0 2x10	1 1x10	6 1x10
Rh-101	0 4x10	0 3x10	2 1x10	7 1x10
Rh-102	-1 5x10	-1 5x10	1 1x10	6 1x10
Rh-102m	0 2x10	0 2x10	2 1x10	6 1x10
Rh-103m	1 4x10	1 4x10	4 1x10	8 1x10
Rh-105	1 1x10	-1 8x10	2 1x10	7 1x10
Radon (86)				
Rn-222 (a)	-1 3x10	-3 4x10	1 1x10 (b)	8 1x10 (b)
Ruthenium (44)				
Ru-97	0 5x10	0 5x10	2 1x10	7 1x10
Ru-103 (a)	0 2x10	0 2x10	2 1x10	6 1x10
Ru-105	0 1x10	-1 6x10	1 1x10	6 1x10

	-1	-1	2	5	
Ru-106 (a)	2x10	2x10	1x10 (b)	1x10 (b)	
Sulfur (16)					
	1	0	5	8	
S-35	4x10	3x10	1x10	1x10	
Trumpet (51)					
	-1	-1	2	4	
Sb-122	4x10	4x10	1x10	1x10	
	-1	-1	1	6	
Sb-124	6x10	6x10	1x10	1x10	
	0	0	2	6	
Sb-125	2x10	1x10	1x10	1x10	
	-1	-1	1	5	
Sb-126	4x10	4x10	1x10	1x10	
Scandium (21)					
	-1	-1	1	5	
Sc-44	5x10	5x10	1x10	1x10	
	-1	-1	1	6	
Sc-46	5x10	5x10	1x10	1x10	
	1	-1	2	6	
Sc-47	1x10	7x10	1x10	1x10	
	-1	-1	1	5	
Sc-48	3x10	3x10	1x10	1x10	
Selenium (34)					
	0	0	2	6	
Se-75	3x10	3x10	1x10	1x10	
	1	0	4	7	
Se-79	4x10	2x10	1x10	1x10	
Silicon (14)					
	-1	-1	3	6	
Si-31	6x10	6x10	1x10	1x10	
	1	-1	3	6	
Si-32	4x10	5x10	1x10	1x10	
Samarium (62)					
	1	1	2	7	
Sm-145	1x10	1x10	1x10	1x10	
	non limited		1	4	
Sm-147			1x10	1x10	
	1	1	4	8	
Sm-151	4x10	1x10	1x10	1x10	

	0	-1	2	6	
Sm-153	9x10	6x10	1x10	1x10	
Tin (50)					
	0	0	3	7	
Sn-113 (a)	4x10	2x10	1x10	1x10	
	0	-1	2	6	
Sn-117m	7x10	4x10	1x10	1x10	
	1	1	3	7	
Sn-119m	4x10	3x10	1x10	1x10	
	1	-1	3	7	
Sn-121m (a)	4x10	9x10	1x10	1x10	
	-1	-1	3	6	
Sn-123	8x10	6x10	1x10	1x10	
	-1	-1	2	5	
Sn-125	4x10	4x10	1x10	1x10	
	-1	-1	1	5	
Sn-126 (a)	6x10	4x10	1x10	1x10	
Strontium (38)					
	-1	-1	1	5	
Sr-82 (a)	2x10	2x10	1x10	1x10	
	0	0	2	6	
Sr-85	2x10	2x10	1x10	1x10	
	0	0	2	7	
Sr-85m	5x10	5x10	1x10	1x10	
	0	0	2	6	
Sr-87m	3x10	3x10	1x10	1x10	
	-1	-1	3	6	
Sr-89	6x10	6x10	1x10	1x10	
	-1	-1	2	4	
Sr-90 (a)	3x10	3x10	1x10 (b)	1x10 (b)	
	-1	-1	1	5	
Sr-91 (a)	3x10	3x10	1x10	1x10	
	0	-1	1	6	
Sr-92 (a)	1x10	3x10	1x10	1x10	
Tritium (1)					
	1	1	6	9	
T (H-3)	4x10	4x10	1x10	1x10	
Tantalum (73)					
Ta-178	0	-1	1	6	
(long existing	1x10	8x10	1x10	1x10	

	1	1	3	7
Ta-179	3x10	3x10	1x10	1x10
	-1	-1	1	4
Ta-182	9x10	5x10	1x10	1x10
terbium (65)				
	1	1	4	7
Tb-157	4x10	4x10	1x10	1x10
	0	0	1	6
Tb-158	1x10	1x10	1x10	1x10
	0	-1	1	6
Tb-160	1x10	6x10	1x10	1x10
Technetium (43)				
	0	0	1	6
Tc-95m (a)	2x10	2x10	1x10	1x10
	-1	-1	1	6
Tc-96	4x10	4x10	1x10	1x10
	-1	-1	3	7
Tc-96m (a)	4x10	4x10	1x10	1x10
	non limited		3	8
Tc-97			1x10	1x10
	1	0	3	7
Tc-97m	4x10	1x10	1x10	1x10
	-1	-1	1	6
Tc-98	8x10	7x10	1x10	1x10
	1	-1	4	7
Tc-99	4x10	9x10	1x10	1x10
	1	0	2	7
Tc-99m	1x10	4x10	1x10	1x10
Tellurium (52)				
	0	0	1	6
Te-121	2x10	2x10	1x10	1x10
	0	0	2	6
Te-121m	5x10	3x10	1x10	1x10
	0	0	2	7
Te-123m	8x10	1x10	1x10	1x10
	1	-1	3	7
Te-125m	2x10	9x10	1x10	1x10
	1	-1	3	6
Te-127	2x10	7x10	1x10	1x10
	1	-1	3	7
Te-127m (a)	2x10	5x10	1x10	1x10

	-1	-1	2	6	
Te-129	7x10	6x10	1x10	1x10	
	-1	-1	3	6	
Te-129m (a)	8x10	4x10	1x10	1x10	
	-1	-1	1	6	
Te-131m (a)	7x10	5x10	1x10	1x10	
	-1	-1	2	7	
Te-132 (a)	5x10	4x10	1x10	1x10	
Thorium (90)					
	1	-3	1	4	
Th-227	1x10	5x10	1x10	1x10	
	-1	-3	0	4	
Th-228 (a)	5x10	1x10	1x10 (b)	1x10 (b)	
	0	-4	0	3	
Th-229	5x10	5x10	1x10 (b)	1x10 (b)	
	1	-3	0	4	
Th-230	1x10	1x10	1x10	1x10	
	1	-2	3	7	
Th-231	4x10	2x10	1x10	1x10	
	non limited		1	4	
Th-232			1x10	1x10	
	-1	-1	3	5	
Th-234 (a)	3x10	3x10	1x10 (b)	1x10 (b)	
	non limited		0	3	
Th (natural)			1x10 (b)	1x10 (b)	
titanium (22)					
	-1	-1	1	5	
Ti-44 (a)	5x10	4x10	1x10	1x10	
Thallium (81)					
	-1	-1	1	6	
Tl-200	9x10	9x10	1x10	1x10	
	1	0	2	6	
Tl-201	1x10	4x10	1x10	1x10	
	0	0	2	6	
Tl-202	2x10	2x10	1x10	1x10	
	1	-1	4	4	
Tl-204	1x10	7x10	1x10	1x10	
Thulium (69)					
	0	-1	2	6	
Tm-167	7x10	8x10	1x10	1x10	

	0	-1	3	6	
Tm-170	3x10	6x10	1x10	1x10	
	1	1	4	8	
Tm-171	4x10	4x10	1x10	1x10	
Uranium (92)					
U-230 (rapid Acquisitions by lungs) (a) (d)	1	-1	1	5	
	4x10	1x10	1x10 (b)	1x10 (b)	
U-230 (medium Acquisitions by lungs) (a) (e)	1	-3	1	4	
	4x10	4x10	1x10	1x10	
U-230 (slow Acquisitions by lungs) (a) (f)	1	-3	1	-4	
	3x10	3x10	1x10	1x10	
U-232 (rapid Acquisitions by lungs (d)	1	-2	0	3	
	4x10	1x10	1x10 (b)	1x10 (b)	
U-232 (medium Acquisitions by lungs (e)	1	-3	1	4	
	4x10	7x10	1x10	1x10	
U-232 (slow Acquisitions by lungs (f)	1	-3	1	4	
	1x10	1x10	1x10	1x10	
U-233 (rapid Acquisitions by lungs (d)	1	-2	1	4	
	4x10	9x10	1x10	1x10	
U-233 (medium Acquisitions by lungs (e)	1	-2	2	5	
	4x10	2x10	1x10	1x10	
U-233 (slow Acquisitions by lungs (f)	1	-3	1	5	
	4x10	6x10	1x10	1x10	

U-234 (rapid acquisitions by lungs (d)	1	-2	1	4	
	4x10	9x10	1x10	1x10	
U-234 (medium acquisitions by lungs (e)	1	-2	2	5	
	4x10	2x10	1x10	1x10	
U-234 (slow acquisitions by lungs) (f)	1	-3	1	5	
	4x10	6x10	1x10	1x10	
U-235 (all types of acquisitions by lungs (a) (d) (e) (f)	non limited		1	4	
		1x10 (b)	1x10 (b)		
U-236 (rapid acquisitions by lungs (d)	non limited		1	4	
		1x10	1x10		
U-236 (medium acquisitions by lungs (e)	1	-2	2	5	
	4x10	2x10	1x10	1x10	
U-236 (slow acquisitions by lungs (f)	1	-3	1	4	
	4x10	6x10	1x10	1x10	
U-238 (all types of acquisitions by lungs (d) (e) (f)	non limited	*1*	*4*		
		1x10 (b)	1x10 (b)		
U (natural)	non limited	0	3		
		1x10 (b)	1x10 (b)		
U (fortified up to 20% o less) (g)	non limited	0	3		
		1x10	1x10		
U (depleted	non limited	0	3		
		1x10	1x10		
Ванадій (23)					
V-48	-1	-1	1	5	
	4x10	4x10	1x10	1x10	

	1	1	4	7	
V-49	4x10	4x10	1x10	1x10	
Tungsten (74)					
	0	0	1	6	
W-178 (a)	9x10	5x10	1x10	1x10	
	1	1	3	7	
W-181	3x10	3x10	1x10	1x10	
	1	-1	4	7	
W-185	4x10	8x10	1x10	1x10	
	0	-1	2	6	
W-187	2x10	6x10	1x10	1x10	
	-1	-1	2	5	
W-188 (a)	4x10	3x10	1x10	1x10	
Xenon (54)					
	-1	-1	2	9	
Xe-122 (a)	4x10	4x10	1x10	1x10	
	0	-1	2	9	
Xe-123	2x10	7x10	1x10	1x10	
	0	0	3	5	
Xe-127	4x10	2x10	1x10	1x10	
	1	1	4	4	
Xe-131m	4x10	4x10	1x10	1x10	
	1	1	3	4	
Xe-133	2x10	1x10	1x10	1x10	
	0	0	3	10	
Xe-135	3x10	2x10	1x10	1x10	
yttrium (39)					
	0	0	1	6	
Y-87 (a)	1x10	1x10	1x10	1x10	
	-1	-1	1	6	
Y-88	4x10	4x10	1x10	1x10	
	-1	-1	3	5	
Y-90	3x10	3x10	1x10	1x10	
	-1	-1	3	6	
Y-91	6x10	6x10	1x10	1x10	
	0	0	2	6	
Y-91m	2x10	2x10	1x10	1x10	
	-1	-1	2	5	
Y-92	2x10	2x10	1x10	1x10	
	-1	-1	2	5	
Y-93	3x10	3x10	1x10	1x10	

ytterbium (70)				
	0	0	2	7
Yb-169	4x10	1x10	1x10	1x10
	1	-1	3	7
Yb-175	3x10	9x10	1x10	1x10
Zinc (30)				
	0	0	1	6
Zn-65	2x10	2x10	1x10	1x10
	0	-1	4	6
Zn-69	3x10	6x10	1x10	1x10
	0	-1	2	6
Zn-69m (a)	3x10	6x10	1x10	1x10
Zirconium (40)				
	0	0	2	6
Zr-88	3x10	3x10	1x10	1x10
	non limited		3	7
Zr-93			1x10 (b)	1x10 (b)
	0	-1	1	6
Zr-95 (a)	2x10	8x10	1x10	1x10
	-1	-1	1	5
Zr-97 (a)	4x10	4x10	1x10 (b)	1x10 (b)

(A) A and / or A for these parent radionuclides shall include
2 *1*
Contribution from contribution from subsidiaries radionuclides with a half life of less
10 days listed below:

Mg 28	Al 28
Ar 42	K 42
Ca 47	Sc 47
Ti 44	Sc 44
Fe 52	Mn 52m
Fe 60	Co 60m
Zn 69m	Zn 69
Ge 68	Ga 68
Rb 83	Kr 83m
Sr 82	Rb 82
Sr 90	Y 90

Sr 91	Y 91m
Sr 92	Y 92
Y 87	Sr 87m
Zr 95	Nb 95m
Zr 97	Nb 97m, Nb 97
Mo 99	Tc 99m
Tc 95m	Tc 95
Tc 96m	Tc 96
Ru 103	Rh 103m
Ru 106	Rh 106
Pd 103	Rh 103m
Ag 108m	Ag 108
Ag 110m	Ag 110
Cd 115	In 115m
In 114m	In 114
Sn 113	In 113m
Sn 121m	Sn 121
Sn 126	Sb 126m
Te 118	Sb 118
Te 127m	Te 127
Te 129m	Te 129
Te 131m	Te 131
Te 132	I 132
I 135	Xe 135m
Xe 122	I 122
Cs 137	Ba 137m
Ba 131	Cs 131
Ba 140	La 140
Ce 144	Pr 144m, Pr 144
Pm 148m	Pm 148
Gd 146	Eu 146

Dy 166	Ho 166
Hf 172	Lu 172
W 178	Ta 178
W 188	Re 188
Re 189	Os 189m
Os 194	Ir 194
Ir 189	Os 189m
Pt 188	Ir 188
Hg 194	Au 194
Hg 195m	Hg 195
Pb 210	Bi 210
Pb 212	Bi 212, Tl 208, Po 212
Bi 210m	Tl 206
Bi 212	Tl 208, Po 212
At 211	Po 211
Rn 222	Po 218, Pb 214, At 218, Bi 214, Po 214
Ra 223	Rn 219, Po 215, Pb 211, Bi 211, Po 211, Tl 207
Ra 224	Rn 220, Po 216, Pb 212, Bi 212, Tl 208, Po 212
Ra 225	Ac 225, Fr 221, At 217, Bi 213, Tl 209, Po 213, Pb 209
Ra 226	Rn 222, Po 218, Pb 214, At 218, Bi 214, Po 214
Ra 228	Ac 228
Ac 225	Fr 221, At 217, Bi 213, Tl 209, Po 213, Pb 209
Ac 227	Fr 223
Th 228	Ra 224, Rn 220, Po 216, Po 212, Bi 212, Tl 208, Po 212
Th 234	Pa 234m, Pa 234
Pa 230	Ac 226, Th 226, Fr 222, Ra 222, Rn 218, Po 214
U 230	Th 226, Ra 222, Rn 218, Po 214
U 235	Th 231
Pu 241	U 237
Pu 244	U 240, Np 240m
Am 242m	Am 242, Np 238

Am 243	Np 239
Cm 247	Pu 243
Bk 249	Am 245
Cf 253	Cm 249

--(B) The following are the parent radionuclides and their subsidiaries Products included in the balance of age:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
Ag 108m	Ag 108
Cs-137	Ba-137m
Ce-144	Pr-144
Ba-140	La-140
Bi-212	Tl-208 (0,36), Po-212 (0,64)
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0,36), Po-212 (0,64)
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0,36), Po-212 (0,64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0,36), Po-212 (0,64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th-природ.	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0,36), Po-212 (0,64)
Th-234	Pa-234m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0,36), Po-212 (0,64)

U-235	Th-231
U-238	Th-234, Pa-234m
U-природ.	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Np-237	Pa-233
Am-242m	Am-242
Am-243	Np-239

(C) number can be determined by measuring decay rate or the level of radiation at a given distance from source.

(D) These values apply only to the United uranium acquire chemical form of UF_6, UO_2F_2 and $UO_2(NO_3)_2$ than normal, and accident conditions of carriage.

(E) These values apply only to the United uranium acquire chemical form of UO, UF_4 and UCl_4, and hexavalent combinations, both normal and accident conditions of carriage.

(F) These values apply to all combinations of uranium, other than as provided in paragraphs "d" and "e".

(G) These values apply only to unirradiated uranium.

4.7. In case of the absence of relevant data for specific radionuclide or mixture of radionuclides must use values given in Table. 2.

Table 2 - Key values for unknown radionuclides or mixtures

Radioactive contents	A 1 (TBk)	A 2 (TBk)	Specific activity for materials to which apply complete release (Bk/g)	Limit of activity for materilas to whicjh apply complete release (Bk)
	0,1	0,02	1	4
We know that there Only beta or Gamma emitters radionuclides			$1x10^{1}$	$1x10^{4}$
	0,2	$9x10^{-5}$	$1x10^{-1}$	$1x10^{3}$
We know that there				

| Only alpha Emitters
| Radionuclides, but not
| Emitters

	0,001	-5	-1	3
		9x10	1x10	1x10

| We know that there are
| Radionuclides
| Emit neutrons
Or relevant data
| no

Classification of radioactive material

4.8. Depending on the characteristics of radioactive materials in these Rules established this classification:

a) the degree of potential risk:

radioactive materials with very low radiological risk;

radioactive materials with a limited radiation risk;

radioactive materials with a significant radiation risk;

b) the form or physical state:

radioactive material of special form;

other radioactive materials;

c) the physical properties:

indivisible radioactive materials;

fissile materials and fissile-material released.

Radioactive materials with too low radiological risk

4.9. Radioactive material with too low radiological risk include:

radioactive material in limited quantities;

radioactive materials contained in the devices or other industrial products;

products made from natural uranium, depleted uranium or natural thorium.

Radioactive material in limited quantities

4.10. Radioactive material in limited quantities are indivisible and divisible-released radioactive materials special form or other form of activity that does not exceed corresponding limits specified in the table. 3.

Table 3 - Limits for radioactive activity material in limited quantities

Physical state	Limits of activity for materials
Hard materils:	
of special form	10^{-3} A1
other form	10^{-3} A2
Liquids	10^{-4} A2
Gas:	
Tritium	2×10^{-2} A2
ofspecial form	10^{-3} A1
other form	10^{-3} A2

Radioactive materials contained in the device or other industrial products

4.11. It is indivisible and divisible-released radioactive Materials of special form of radioactive material or other form, contained in instruments or other commercial products, or have their part, with activity not exceeding the limits for individual items listed in the table. 4. In this case:

radiation level at a distance of 10 cm from any point the outer surface of any device or unpacked products are not more than 0.1 mSv / h;

each device or object marked "radioactive" (RADIOACTIVE), except:

i) appliances with clocks or radiolyuminestsentnym coating;

ii) consumer products that either have been admitted regulator authority in accordance with paragraph 1.7d, or individually not exceeds the limit for cargo activity, which extends the full exemption specified in the table. 1 (column 5), provided that such goods are transported in a package that has the marking "RADIOACTIVE" (RADIOACTIVE) on the inner surface so that a warning the presence of radioactive material can be seen after opening the package;

active material is completely closed inactive elements (A device whose sole function is to accommodate within it radioactive material shall not be regarded as a device or industrial product).

Table 4 - Limits of activity radioactive materials in appliances and industrial products

Physical state	Limits of activity for materials
Hard materils :	
of special form	10^{-2} A$_1$
other form	10^{-2} A$_2$
liquids	10^{-3} A$_2$
gas:	
Tritiu	2×10^{-2} A$_2$
special form	10^{-3} A$_1$
other form	10^{-3} A$_2$

Products manufactured from natural uranium, depleted uranium or natural thorium

4.12. This industrial products in which the only radioactive Non-irradiated material is natural uranium, depleted Non-irradiated Non-irradiated natural uranium or thorium in any quantity. These products may be empty packagings which are not used for the transport of radioactive materials. The outer surface of the uranium or thorium shall be covered with an inactive shell, made of metal or other solid material.

Radioactive material with limited radiation risk

4.13. Radioactive materials with a limited radiation risk include:

radioactive materials with a low specific activity (LSA);

objects with surface contamination (SCO);

special form radioactive material and other radioactive materials with activity not exceeding A_1 and A_2 respectively.

Radioactive material with a low specific activity (LSA)

4.14. From low specific activity (Low specific activity material - LSA) - a radioactive material which by its nature has a limited specific activity, or radioactive material, which limits established by applicable average specific activity. Materials for external security surrounding

material LSA, in determining the average specific set activities should not be taken into account.

4.15. LSA materials are one of three groups:

a) LSA-I:

i) uranium and thorium ores and concentrates of such ores, and other ores containing naturally occurring radionuclides and intended for processing in order to use these radionuclides;

ii) natural uranium, depleted uranium, natural thorium or their a compound or mixture provided that they are irradiated and are in solid or liquid form;

iii) radioactive material for which no value A$_2$ limited, with the exception of fissile materials;

iv) other radioactive material in which the activity distributed throughout the volume and average specific set activity does not exceed more than 30 times the value activity concentration specified in paragraphs 4.2-4.7, except fissile materials.

b) LSA-II:

i) water with tritium concentration up to 0.8 TBq / l;

ii) other material in which the activity is distributed throughout volume, and set the average specific activity does not exceed 10^{-4} A$_1$ / g for solid and gaseous substances and 10^{-5} A$_2$ / g for liquid.

c) LSA-III:

solid materials (such as associated waste activated substances) other than powders, in which:

i) the radioactive material is distributed throughout the volume of solid material or solid objects or preferably evenly distributed in hard solid material that binding (eg concrete, bitumen, ceramic, etc.);

ii) the radioactive material is relatively insoluble, or structural contained in a relatively insoluble matrix, so even the destruction of the packaging of radioactive leakage material per package due to leaching at stay in water for seven days would not exceed 0,1 A$_2$;

iii) established the average specific activity of the solid material excluding any shielding material does not exceed 2×10^{-3} A$_2$ / h.

Requirements for LSA-III material

4.16. LSA-III material must be solid and have the Properties that during these tests in paragraph 8.3 all internal contents of the package are not water activity exceed 0,1 A$_2$.

Test of material LSA-III

4.17. LSA-III material shall be subjected to the test

leaching under paragraph 8.3 of the Rules.

Objects with surface contamination

4.18. Objects with surface contamination (Surface contaminated objects - SCO) - solid objects that are not itself radioactive but containing radioactive material distributed on their surface.

4.19. SCO belong to one of two groups:

a) SCO-I: solid objects, in which:

i) non-fixed contamination on the accessible surface, averaged over an area of 300 kv.sm (or the entire surface, if its area is less than 300 kv.sm) does not exceed 4 Bq / cm for beta and gamma emitters and alpha emitters of low toxicity or 0.4 Bq / cm for all other alpha emitters;

ii) the fixed contamination on the accessible surface, averaged over an area of 300 kv.sm (or the entire surface if its area 4 kv.sm less than 300) does not exceed 4×10 Bq / cm for beta and gamma emitters and alpha-emitters low 3 toxicity or 4×10 Bq / cm for all other alpha emitters;

iii) non-fixed contamination plus the fixed contamination on the inaccessible surface averaged at 300 kv.sm area (or the entire surface if its area is less 4 Kv.sm 300) does not exceed 4×10 Bq / cm for beta and gamma emitters and alpha-emitters low 3 toxicity or 4×10 Bq / cm for all other alpha emitters;

b) SCO-II: solid objects, which fixed or unfixed surface contamination exceeds the relevant limit, specified for SCO-I above, paragraph "a", in which:

i) non-fixed contamination on the accessible surface, averaged over an area of 300 kv.sm (or the entire surface, if its area is less than 300 kv.sm) does not exceed 400 Bq / cm for beta and gamma emitters and alpha emitters low toxicity or 40 Bq / cm for all other alpha emitters;

ii) the fixed contamination on the accessible surface, averaged over an area of 300 kv.sm (or the entire surface if its area 5 kv.sm less than 300) does not exceed 8×10 Bq / cm for beta and gamma emitters and alpha-emitters low 4 toxicity or 8×10 Bq / cm for all other alpha emitters;

iii) non-fixed contamination plus the fixed contamination on the inaccessible surface averaged at 300 kv.sm area (or the entire surface if its area is less 5 Kv.sm 300) does not exceed 8×10 Bq / cm for beta and gamma emitters and alpha-emitters low 4 toxicity or 8×10 Bq / cm for all other alpha emitters.

Radioactive material of special form

4.20. Radioactive material of special form (Special form radioactive material) - solid radioactive material that is not scattered or closed capsule containing radioactive material and design is approved by the competent authority.

Requirements for special form radioactive material

4.21. Radioactive material is a special form shall be as a minimum size of at least 5 mm.

4.22. Radioactive material should have a special form or the properties should be such that when tested, referred to in paragraphs 8.4-8.11 were made following requirements:

a) it must not break or crumble when tested crash, punch and bend specified in paragraphs 8.5, 8.6, 8.7 and 8.9a;

b) it should not melt or disperse in the heat tests specified in paragraphs 8.8 or 8.9b;

c) water activity when tested in accordance leaching paragraphs 8.10 and 8.11 should not exceed 2 kBq; or for the degree of leakage of sealed sources after appropriate testing volumetric leakage assessment method listed in document ISO 9978 "Radiation Protection - Sealed Radioactive Sources - Leakage Test Methods ", shall not exceed the corresponding allowable threshold GOST 27212-87 set "Sources of radiation yonyzyruyuscheho Closed radyonuklydnые. General specifications Requirements ".

4.23. If part of radioactive material special form is sealed capsule, the capsule should be made so that it can be opened only by destruction.

Tests of special form radioactive material

4.24. Samples of the radioactive material of special form Designs that simulate radioactive material special form, shall be tested:

on collision
to strike
bend,
thermal,
to leaching
in accordance with paragraphs 8.5-8.10 hereof.

Other radioactive materials

4.25. Other radioactive materials (radioactive materials of other form) - a radioactive material that does not meet requirements for special form radioactive material.

Radioactive material with significant radiation risk

4.26. Radioactive material with significant radiation risk include:

special form radioactive material and other radioactive more active materials A and A respectively;

radioactive materials with low dispersible.

Radioactive material with low dispersible

4.27. Radioactive material with a low capacity for scattering (Low dispersible radioactive material) - hard radioactive material or a solid radioactive material in a sealed capsule, that has limited capacity for dispersion and not is in powder form.

Requirements for radioactive material, low capacity for scattering

4.28. Radioactive material with a low capacity for scattering - is a radioactive material, the total number whose packaging satisfies the following requirements:

a) the radiation level at 3 m from unprotected radioactive material does not exceed 10 mSv / h;

b) in tests mentioned in paragraphs 8.36 and 8.37, released into the atmosphere in gaseous and aerosol forms particles with an aerodynamic equivalent diameter of 100 microns not more than 100 A. Each test can be used
2
a separate specimen;

c) during the test specified in paragraph 8.3, water activity less than 100 A. In conducting this test has
2
taken into account the devastating impact tests mentioned above, paragraph "b".

Tests of radioactive material with a low capacity for scattering

4.29. Samples of radioactive material with a low capacity for or scattering samples that simulate radioactive material low dispersible exposed:

enhanced thermal test in accordance with paragraph 8.36,

crash tested in accordance with paragraph 8.37,

leaching test in accordance with paragraph 8.3.

Подільні матеріали

4.30. До подільних матеріалів належать:

уран-233, уран-235, плутоній-239, плутоній-241 або будь-яка комбінація цих радіонуклідів.

Під це визначення не підпадають:

а) неопромінений природний уран або збіднений уран;

b) природний уран або збіднений уран, опромінений тільки в реакторах на теплових нейтронах.

Fissile-materials released

4.31. Fissile material that meets one of the provisions, the following shall be exempt from the requirements that apply to fissile material during transportation. For each load allowed only one type of release.

a) weight limit for cargo is given by formula

$$\frac{\text{mass of uranium - 235 (g)}}{X} + \frac{\text{mass of other fissile material (g)}}{Y} < 1,$$

where X and Y - mass limits defined in Table. 5, provided that the smallest external dimension of each package is not less than 10 cm and that:

i) each individual package contains not more than 15 g of fissile material; if the material is unpacked quantitative restriction should apply to cargo carried inside means of transport or on it, or

ii) fissile material is a homogeneous solution containing hydrogen or a mixture where the ratio of fissile radionuclides hydrogen less than 5% wt., or

iii) in any 10 liter volume of material contained no more than 5 g of fissile material.

Neither beryllium nor deuterium shall not be in quantities exceeding 1% of the applicable limits load mass specified in Table. 5, except for deuterium in natural concentration in hydrogen.

Table 5 - Limits to release cargo weight from the requirements for packages containing fissile material

Fissile material	Weight (g) of fissile materila mixed with other substances, in which Average density of hydrogen lower or equal density of water	WEIGHT (G) OF FISSIBLR MATERIALS MIXED WITH OTHER SUBSTANCES IN WHICH AVERAGE DENSITY OF HYDROGEN IS higher density of water
Uranium-235 (X)	400	290
Other fissible material (Y)	250	180

b) Uranium enriched in uranium-235 to a maximum of 1% wt., of total content of plutonium and uranium-233, not more than 1% mass of uranium-235, provided that the fissile material is distributed almost uniformly throughout the material. In addition, if uranium-235 present in the form of metal, oxide or carbide, it should not located in an ordered lattice.

c) Liquid solutions uranilnitratu enriched uranium-235 a maximum of 2% wt., with a total content of plutonium and uranium-233 in an amount not to exceed 0.002% of the mass of uranium, and minimum atomic ratio of nitrogen to uranium (N / U), equal to 2.

d) Packages containing individually total mass of plutonium less than 1 kg, of which not more than 20% by weight. may consist of plutonium-239, plutonium-241 or any combination of these radionuclides.

Chapter 5. Requirements for packagings

Definition and types of packagings

5.1. Packaging (Packaging) - a set of elements required to complete the placement and retention of radioactive content. In particular, it may include one or more receivers containers, materials, sinks, designs, providing

distance from the radiation protection and service equipment
for filling, emptying, venting and discharge pressure device
cooling, depreciation mechanical shocks, handling and
lining, thermal insulation, and service devices
are one with the packaging. Packing
kit can be in the form of wooden boxes, barrels or similar
receptacle, but may also be a freight container,
tank or container for medium-duty
bulk.

Package (Package) - packaging of its
radioactive contents in the provided form for transportation. Type
determined by the type of packaging and its packaging
radioactive contents.

5.2. In these Rules, the following types of packaging
Included:

a) exempt packagings;

1)

b) industrial packaging sets of type 1 (Type IP-1)
Type 2 (Type IP-2), Type 3 (Type IP-3);

c) packaging sets type A;

d) packaging sets type B (U);

e) packaging sets type B (M);

f) packaging sets of type C;

g) packagings for fissile material IF, AF,
B (U) F, B (M) F, CF;

h) packing kits uranium hexafluoride H (U), H (M).

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1) Hereinafter IP - acronym definition in English
"Industrial packaging"

**General requirements for the design
all types of packagings**

5.3. The packaging should be designed with
considering its mass, volume and shape so ensured
simplicity and safety of its transportation. In addition, construction
the packaging must be such that in the transportation
the package can be properly secured to vehicle traffic
or inside it.

5.4. The design of the packaging must be such
to any device placed on the packaging for
his rise will not fail when properly dealing with them, and
if their failure - not deteriorated packaging capacity
set to meet the other requirements of this Regulation. The design
must be considered appropriate factors of safety on
in case of recovery of the packaging jerk.

5.5. Devices and any details on the external surface
packaging that can be used for its
lift must be designed to withstand
its mass in accordance with the requirements of paragraph 5.4 or could be
withdrawn or
otherwise resulted in no usable condition at the time
transportation.

5.6. As far as practicable, the packaging
must be designed and processed so that external
surface had parts that act, and could easily be
deactivated.

5.7. As far as practicable, the finish
the packaging must be done so that it does not
accumulated water is not maintained.

5.8. Any devices that are attached to the packaging
kit during transportation, which is not part of the packaging
kit should not make it less safe.

5.9. The packaging should have the ability
to counteract the impact of any acceleration, vibration or resonance
vibration that can occur in normal traffic,
without any deterioration in the effectiveness of various locking devices
containers or integrity of the packaging in general.
In particular, nuts, bolts and other fasteners should be
are designed to prevent the possibility of their
arbitrarily reduce or even after disconnection
repeated use.

5.10. Packaging materials and any elements
or structures shall be physically and chemically compatible with each
other and with the radioactive contents. It is necessary to consider their
behavior under the influence of radiation.

5.11. All valves through which the radioactive contents could leave
outside, must be protected from unauthorized actions.

5.12. The design of the packaging must develop
taking into account the temperature and pressure in the external
environment,
can occur under normal conditions of carriage.

5.13. The design of the packaging, designed to
radioactive materials having other dangerous properties, these
Properties should be considered (see. paragraphs 1.9 and 6.25).

5.14. Also released packagings design
all types of packagings must provide
not exceeding the level of radiation on the surface of the package 2 mSv /
h.

Additional requirements for packagings intended
for transportation by air

5.15. The temperature on the surface of packaging available
kits containing radioactive material shall not
exceed 50 ° C at ambient temperature
38 ° C without the insolation.

5.16. The packaging must be designed,
to external temperatures ranging from -40 ° C to +55 ° C
containment integrity is not violated.

5.17. Packaging containing radioactive
materials must withstand without leakage an internal pressure that
creates a pressure differential of not less than maximum normal operating
pressure plus 95 kPa.

Design requirements for released Packagings

5.18. The design of dismissed packaging must meet the general requirements for the design of all types packagings of paragraphs 5.3-5.17.

5.19. The design of the packaging should provide not exceeding the radiation level at surface of the package 5 mSv / h.

5.20. Freed packaging for transportation fissile-material released must have a least common out-at least 10 cm.

Requirements for the construction industry packaging sets of type 1 (Type IP-1)

5.21. Construction of industrial packaging Type 1 (Type IP-1) comply with the general requirements for the design all types of packagings referred to in paragraphs 5.3-5.17.

5.22. The smallest overall external dimension packaging Kit must be at least 10 cm.

Requirements for the construction industry packagings Type 2 (Type IP-2)

5.23. Industrial design packaging type 2 (Type IP-2) must meet the requirements for packaging Type IP-1 and be tested in free fall and stacking accordance with paragraphs 8.22 and 8.23. After trials packaging IP-2 should prevent:

a) leakage or dispersal of the radioactive contents;

b) increased more than 20% the maximum level radiation on any external surface of the packaging

Requirements for the construction industry packagings Type 3 (Type IP-3)

5.24. Industrial design packaging type 3 (Type IP-3) shall meet the requirements for packaging Type IP-1 and, in addition, the requirements of paragraphs 5.25-5.37 specified lower.

5.25. On the outer surface of the packaging must be a device such as a seal, which is difficult to damage and intact is an indication that the packaging is not disclosed.

5.26. Any device to mount that is on the packaging Included should be designed so that both normal and accident conditions of carriage, the forces in These devices do not impair the ability of the packaging satisfy the requirements of the Regulations.

5.27. The design of the packaging should be designed for a temperature range from -40 ° C to +70 ° C items for packaging. Particular attention should be pay at the freezing point of the liquid and deterioration of packaging materials in specified temperature range.

5.28. The design and fabrication techniques must comply national or international standards, or other requirements, acceptable to the competent authority.

5.29. The design shall include a containment system securely closed circuit device for which no able to open accidentally or under pressure, which may arise within the package.

5.30. Radioactive material can form special considered as part of the containment system.

5.31. If the containment system is a separate part packaging, it should be closed tightly for reliable device circuit, not dependent on any other part of the packaging kit.

5.32. The design of any element of the defense system shell where appropriate, should be taken into account the possibility radiolytic decomposition of liquids and other vulnerable materials and the generation of gas due to chemical reactions and radiolysis.

5.33. Containment system should hold radioactive content at lower ambient pressure to 60 kPa.

5.34. All valves, other than pressure for discharge must equipped with a device for the maintenance of any leakage through valve.

5.35. Radiation protection that surrounds an element of packaging that defined as part of the containment system should be is designed to prevent the accidental release of this component from the shield. If radiation protection and an element within it form a separate unit, the radiation protection should be firmly closed for reliable device circuit, not dependent on any other structures packaging.

5.36. Packaging type IP-3 shall be subject test of water spray, free drop, making stack and get into pursuant to paragraphs 8.19-8.24 and not allow:

a) loss or dispersal of the radioactive contents;

b) increase of more than 20% the maximum level radiation on any external surface of the packaging kit.

5.37. The design of the packaging, designed to Liquid radioactive material must be provided availability untouched additional amount to compensate for changes temperature of the contents, dynamic effects and filling dynamics.

Alternative requirements for industrial packaging sets type IP-2 and IP-3 type

5.38. Any packagings can be used as industrial packaging sets type IP-2 provided that:

a) they meet the requirements for the packaging type IP-1 specified in paragraphs 5.21, 5.22;

b) they are designed according to the standards set out in Section 9 of the "Recommendations on the Transport of Dangerous Goods", or subject to other requirements at least equivalent to the said regulations;

c) after the tests required for groups package I or II of the UN, they would prevent:

i) the expiration or dispersal of the radioactive contents;

ii) increased more than 20% the maximum level radiation on any external surface of the package.

5.39. Tank-containers can also be used as Industrial packaging sets type IP-2 or Type IP-3, provided what:

a) they meet the requirements for the packaging type IP-1 specified in paragraphs 5.21, 5.22;

b) they are designed according to the standards set out in Chapter 12 "Recommendations on the Transport of Dangerous Goods", or subject to other requirements at least equivalent to the said standards and able to withstand a test pressure of 265 kPa;

c) They are designed so that any additional protection, that assumed was capable of withstanding the static and dynamic loads that occur during cargo operations normally conditions of carriage and prevent violations of integrity protection, which would lead to an increase of more than 20% of the maximum level radiation on any external surface tank-container.

5.40. Tanks that are not tank-containers, may also used as industrial package Type IP-2 or Type IP-3 for liquids and gases LSA-I and LSA-II, as mentioned in Table. 8, provided that they meet the standards, at least equivalent to those specified in paragraph 5.39.

5.41. Cargo containers can also be used as Industrial package Type IP-2 or Type IP-3, provided that:

a) The radioactive contents are restricted to solid materials;

b) they meet the requirements for the packaging type IP-1 specified in paragraphs 5.21, 5.22;

c) They are designed according to the standards set out in document ISO 1496/1 "Series 1 Freight Containers - Specifications and Testing - Part 1: General Cargo Containers "or GOST 18477-79 "Universal Konteynerы. Types, Basic Options and Dimensions "in GOST 20259-80" Universal Konteynerы. Sharing Specifications "and GOST 20260-80" Universal Konteynerы. Terms pryemky. Methods trials "except size and classification. Freight containers must be designed, that after the tests referred to in these documents, and the accelerations occurring during routine conditions of carriage they prevent:

i) the expiration or dispersal of the radioactive contents;

ii) increased more than 20% the maximum level radiation on any external surface freight containers.

5.42. Metal containers for medium-duty bulk can also be used as industrial Packaging Type IP-2 or Type IP-3, provided that:

a) they meet the requirements for the packaging type IP-1 specified in paragraphs 5.21, 5.22;

b) They are designed in accordance with the rules set section 16 "Recommendations on the Transport of Dangerous Goods" packing group I or II, and after the trials that attributed to this document, in conditions when selecting such orientation in the fall, at which inflicted maximum damage, they should avoid:

i) the expiration or dispersal of the radioactive contents;

ii) increased more than 20% the maximum level radiation on any external surface of the container Intermediate bulk cargoes.

Design requirements Type A packagings

5.43. The design of packaging sets type A must meet the requirements for packaging sets type IP-3.

5.44. Packaging type A, designed to accommodate in which liquid radioactive material shall:

a) be tested for free fall from a height of 9 m, Penetration testing in accordance with paragraph 8.25 and prevent:

i) loss or dispersal of the radioactive contents;

ii) increased more than 20% the maximum level radiation on any external surface of the packaging set;

b) either:

i) contain sufficient absorbent material absorb twice the volume of the liquid contents. Such absorbent material should be placed so that in case of leakage carried his contact with the liquid or

ii) have a containment system composed of primary inner and secondary outer elements are designed to ensure retention of the liquid contents within the secondary outer containment components, even if leakage the primary inner components.

5.45. Packaging designed for gases shall tested in free fall from a height of 9 meters and testing Penetration in accordance with paragraph 8.25 and to prevent leakage or dispersal of the radioactive contents. packaging Type A, designed for tritium gas or inert gas is exempt from this requirement.

Requirements for packaging design sets of type B (U)

5.46. Packaging type B (U) should be designed to meet the requirements specified in paragraphs 5.24-5.36, with the exception of subparagraph 5.36a, and, in addition, the requirements of paragraphs 5.47-5.60.

5.47. The packaging must be designed so that in the environmental conditions specified in paragraphs 5.49 and 5.50, heat generated inside the package radioactive contents in normal carriage, as confirmed tests under paragraphs 8.19-8.24, do not be provoked such an adverse effect on the packaging in which it will cease meet the appropriate requirements for containment and radiation protection if it is not served within one week. Particular attention should be paid to such action of heat, which may:

a) change the arrangement, the geometrical form or physical state radioactive contents or, if the radioactive material contained in containers or container (eg, fuel elements), cause deformation or melting, receptacle or radioactive material;

b) reduce the efficiency of the packaging through different thermal expansion, cracking or melting material Radiation Protection;

c) in combination with moisture, accelerate corrosion.

5.48. The packaging must be designed so that when external conditions mentioned in paragraph 5.49, and in absence of insolation temperatures on accessible surfaces of the package not exceed 50 ° C, unless the package is not shipped under exclusive use.

5.49. The ambient temperature must be taken equal to 38 hrad.C.

5.50. Terms of solar insolation be taken in accordance with values given in the table. 6.

5.51. Packaging that has a thermal protection for the requirements of the thermal test specified in paragraph 8.28, should be designed so that such protection will remain effectiveness in tests packaging that referred to in paragraphs 8.19-8.24, 8.27a and 8.27b and b or c in accordance. Any such protection, which is outside the packaging must not fail at putting any efforts to break, cut, sliding, friction or rough behavior.

Table 6 - Parameters insolation

Case	The shape and position of the surface	Insolation during 12 hours per shift (Wt/square Meter)
1	flat surface with the carriage in Horizontal - down basis	0
2	flat surface with the carriage in Horizontal - up basis	800
3	Surfaces during transportation vertical Position	200
4	Other base surface, directed down (Not horizontal)	200
5	All other surfaces	400

a) Alternatively, you can use a sinusoidal function of
Absorption, but the effect of possible
reflection from close located objects.

5.52. The packaging must be designed so
after that:
a) tests provided in paragraphs 8.19-8.24, leakage
-6
radioactive contents restricted meaning, no more than 10 A
2
per hour;
b) tests provided in paragraphs 8.26, 8.27b, 8.28 and
8.29, and tests provided in paragraphs:
i) 8.27c packaging with a mass less than 500 kg, the total
density of no more than 1000 kg / m determined by external
dimensions, and radioactive contents above 1000 A, which
2
not a special form of radioactive material;
ii) 8.27a for all other packages
it meets the following requirements:
i) retain sufficient shielding to ensure that at 1 m
Packaging of surface radiation level not more than 10 mSv / h
if the maximum radioactive contents which
designed packaging;
ii) limit the total leakage of radioactive contents
within one week of not more than 10 A for krypton-85 and not
2
more A - for all other radionuclides.
2
Where mixtures of different radionuclides should
apply the provisions set out in paragraphs 4.5-4.7, except
Krypton-85, which can be used for effective value
A (i), equal to 10 A. In the case referred to above in point
February 2
"A", should be considered when evaluating the external boundaries
radioactive contamination, provided for in paragraph 7.4.

5.53. Packaging for radioactive contents,
5
activity greater than 10 A, should be designed
2
so that in case of test by water immersion
paragraph 8.30 was not the destruction of the defense
shell.

5.54. Compliance with the permitted activity release limits shall
depend neither upon filters nor on a mechanical cooling system.

5.55. Packaging should not include a system
pressure relief of the containment system which would allow out
radioactive material into the environment under conditions
tests provided in paragraphs 8.19-8.24 and 8.26-8.29.

5.56. The packaging must be designed so
to the maximum normal operating pressure conditions
tests specified in paragraphs 8.19-8.24 and 8.26-8.29, mechanical
tension in the containment system has not reached levels that
may adversely affect the packaging, resulting in
then it ceases to meet the relevant requirements.
5.57. The maximum normal operating pressure in the package is not
exceed the excess (gauge) pressure, equal
700 kPa.

5.58. With the exception of the requirements of paragraph 5.15, in case packages
transported by air, the maximum temperature in
any easily accessible by transportation surface of the package in terms of exclusive use shall not exceed 85 ° C at
absence of insolation in the environmental conditions specified
in paragraph 5.49. To protect personnel may be provided
barriers or screens, but the need for any
No recent test.

5.59. Packaging containing radioactive material
low dispersible must be designed
so that any elements added to radioactive material
low dispersible, which are not part of it,
or any internal components of the packaging could not
adversely affect the characteristics of radioactive material
low dispersible.

5.60. The packaging should be designed with
based on the ambient temperature range of
-40 ° C to +38 hrad.C.

Design requirements for packagings of type B (M)

5.61. Packaging type B (M) should meet
requirements for type B (U), which are indicated in paragraph 5.46. However, packages shipped only within Ukraine or only between
certain countries, instead of the conditions outlined in paragraphs 5.27, 5.49, 5.50, 5.53-5.60, may be assumed with the
Ukraine and SNRCU approved by the competent authorities
these countries. Despite this, the requirements for packages of type B (U), listed
in paragraphs 5.53-5.60, must be performed to the extent that it
practicable.

5.62. Non periodic venting
overpressure packages of type B (M) for the carriage
provided that the operational controls for venting
or drop SCNS acceptable for Ukraine.

Design requirements for Type C packagings

5.63. Type C packaging must be designed
so as to meet the requirements specified in paragraphs 5.24-5.36, the except subparagraph 5.36a, and the requirements of paragraphs 5.47-5.50, 5.54-5.60 and, in addition, the requirements of paragraphs 5.64-5.66 specified
lower.

5.64. Packaging must meet criteria
valuation attributed for tests in paragraphs 5.56 and 5.52b,
after burial in an environment characterized by
thermal conductivity of 0.33 W / (m * K) and a temperature of 38 ° C to steady state. The initial terms of the evaluation should be accepted that any thermal insulation packaging not
damaged packaging is in conditions of maximum
the normal operating pressure and temperature of the environment
is 38 hrad.C.

5.65. The packaging must be designed so
that at the maximum normal operating pressure and after
carrying out:

a) the tests specified in paragraphs 8.19-8.24, leakage
-6
radioactive contents of it did not exceed 10 A per hour;
2
b) a series of tests specified in paragraph 8.34, he replied
following requirements:
i) retain sufficient shielding to ensure that at 1 m
from the packaging surface radiation level not
more than 10 mSv / h with the maximum radioactive contents which
designed packaging;
ii) the aggregate limit leakage of radioactive contents
within 1 week of not more than 10 A for krypton-85 and not
2
more A - for all other radionuclides.
2
Where mixtures of different radionuclides should
apply paragraphs 4.5-4.7, but for krypton-85
can be applied effective value of A (i), equal to 10 A.
February 2
In the case referred to above in paragraph "a", in the evaluation are
taken into account the external contamination that
referred to in paragraph 7.4.

5.66. The packaging must be designed so
that there is no breach of the containment system after
testing, according to water immersion
§ 8.30.

Requirements for packaging design
kits containing fissile material

5.67. Packaging for fissile materials should
be designed to:
a) Maintain subcriticality under normal and emergency conditions
transportation in particular, should take into account such contingencies
cases:
i) water leaking into the package or from them;
ii) reduce the effectiveness or mounted sinks
neutron moderator;
iii) redistribution or contents inside the package, or
because of his exit package;
iv) reduction of spaces within or between packages;
v) packages immersion in water or snow;
vi) temperature changes;
b) meet the requirements:
i) paragraph 5.22 for packages containing fissile material;
ii) attributed to the other provisions of these Rules concerning
Radioactive material properties;
iii) points 5.68-5.77.

Description of content evaluation packages containing
fissile material

5.68. If a chemical or physical form, isotopic composition, mass
or concentration or density factor slowing or
geometric configuration is unknown, estimates referred to in paragraphs
5.72-5.77 should be made on the assumption that every unknown
parameter has the value at which the neutron multiplication
reaches a maximum level corresponding to certain conditions and
the parameters of the estimates.

5.69. For irradiated nuclear fuel the assessments of
paragraphs 5.72-5.77, must be based on an isotopic composition that

shows:
a) The maximum neutron multiplication during or exposure
b) a conservative estimate of the neutron multiplication for evaluation packages. After irradiation but prior to shipment, to be conducted measurements to confirm the conservatism of the isotopic composition.

Requirements for configuration and temperature

5.70. Packaging following the tests specified in paragraphs 8.19-8.24, must prevent the entry of a cube with an edge 10 cm.

5.71. The packaging should be designed with taking into account the range of ambient temperature -40 ° C to +38 ° C unless the competent authority in the certificate the approval issued by the package design, will not otherwise indicated.

Evaluation of individual packaging unit

5.72. For packaging unit shall be assumed that Water can penetrate into all cavities packaging, including inside the containment system, or, alternatively, to come out of them. However, if the design incorporates special features to prevent such water penetration into certain amounts of free water or out of them even in the case of human error, we can assume that for these cavities are no leaks. Special conditions should include:
a) Multiple high standard water barriers, each of which would remain watertight if the package were subjected test set out in paragraph 5.77b, high degree of quality control in the manufacture, maintenance and repair packagings and tests to demonstrate the closure of each package before each shipment;
b) For packages containing uranium hexafluoride only maximum uranium enrichment 5 mass percent uranium-235:
i) the packaging, which, following the tests referred to in paragraph 6.82b, there is no direct physical contact between the valve and any other component of the packaging set except the original mounting points, and in which, in addition to addition, following the test prescribed in paragraph 8.28, valves remain resistant to leakage;
ii) a high degree of quality control in the manufacture, maintenance and repair of packagings coupled with tests to demonstrate the closure of each package before each shipment.

5.73. Another assumption has to be that close reflection confinement system shall at water layer thickness of at least 20 cm or such greater reflection as may be additionally created the outside of the packaging material. However, when can confirm that the confinement system remains intact within the packaging following the testing referred to in paragraph 5.77b, 5.74c can point to make the assumption of the package close reflection in the water layer at least 20 cm.

5.74. Packaging should remain subcritical under the conditions in paragraphs 5.72 and 5.73, and the conditions under which is packaging must be such that the maximum

neutron multiplication consistent with:

a) Routine conditions of carriage (incident free);

b) the test provided for in paragraph 5.76b;

c) the test provided for in paragraph 5.77b.

5.75. For packages to be transported by air:

a) package shall be subcritical under the conditions that meet the test package Type C, provided for in paragraph 8.34, with the assumption that performs the function of the reflection layer Water a minimum thickness of 20 cm, and the package stores water resistance;

b) in the assessment under paragraph 5.74 assumptions special facilities specified in paragraph 5.72, shall not be taken into consideration if the results of tests of packages type C, mentioned in paragraph 8.34, and then test and water resistance specified in paragraph 8.33, it is impossible to prevent water penetration into cavities or leakage of water from them.

Evaluation of set of packages under normal conditions of carriage

5.76. There must be a certain number of "N" packages at a fivefold increase is stored for subcriticality of this configuration of set and conditions for packages that lead to maximum neutron multiplication consistent with the following:

a) the gaps between packages should remain blank, reflection and features for this configuration of set of packages there shouldbe water layer that make thickness of at least 20 cm of surrounding set of packaging on all sides;

b) The state of the packages should be appreciated actual condition after the tests specified in paragraphs 8.19-8.24.

Evaluation of set of packages that are in emergency conditions Of transportation

5.77. There must be a certain number of "N" packages at two times saved for this subcriticality configuration of set and conditions for packages that lead to maximum neutron multiplication consistent with the following:

a) the gaps between the packages must be filled retarders, which contains hydrogen and reflection for this function party packaging configuration should perform water layer thickness at least 20 cm surrounding set of packages on all sides;

b) after the tests referred to in paragraphs 8.19-8.24, those made of the following tests that impose tighter restrictions:

i) test specified in paragraph 8.27b, and tests or listed in paragraph 8.27c for packages having a mass not exceeding 500 kg and an overall density, determined by external dimensions, is not more than 1000 kg / m, or 8.27a point for all other packages; then held test specified in paragraph 8.28 and completed by the tests specified in paragraphs 8.31-8.33, or

ii) the test specified in paragraph 8.29;

c) in the case where leaking any part fissile material outside the containment system due testing referred to in paragraph 5.77b, should be It is suggested that leakage of fissile material is each package in the party, and the configuration and deceleration for all fissile material such that the result is

The maximum neutron multiplication, in which the function close reflection layer of water surrounding performs a minimum thickness of 20 cm.

Requirements for packaging design kits containing uranium hexafluoride

5.78. Packaging designed to hexafluoride Uranium must meet the requirements specified in other paragraphs of Regulations concerning the properties of radioactivity and fission material. Except as provided in paragraph 5.81, hexafluoride uranium in quantities of 0.1 kg or more should be packaged and transported in accordance with ISO 7195 document "Packaging of Uranium Hexafluoride (UF6) for Transport" and claims 5.79-5.80 points.

5.79. Each packaging intended for placement it 0.1 kg or more of uranium hexafluoride shall be designed so that it meets the following requirements:

a) withstand without leakage and unacceptable stress, as indicated in the document ISO 7195 "Packaging of Uranium Hexafluoride (UF6) for Transport ", test design specified in paragraph 8.18;

b) withstand without leakage or scattering hexafluoride Uranium Free drop test specified in paragraph 8.22;

c) withstand without breach containment heat test specified in paragraph 8.28.

5.80. Packaging designed to contain 0.1 kg or more of uranium hexafluoride must not have devices pressure relief.

5.81. Subject to approval by the competent authority of the package, designed to contain 0.1 kg or more hexafluoride uranium be carried if:

a) packing kits are designed in accordance with the international or national standards other than ISO 7195 "Packaging of Uranium Hexafluoride (UF6) for Transport" [15], the provided that provided an equivalent level of safety;

b) packing kits are designed to withstand without leakage and unacceptable stress a test pressure less than 2.76 MPa as specified in paragraph 8.18;

c) to packagings intended to contain are 9000 kg or more of uranium hexafluoride, the packages do not meet the requirements of 5.79c.

In all other respects the requirements specified in paragraphs 5.78-5.80, must be satisfied.

Chapter 6. Preparation of radioactive materials to transportation

Terms

6.1. When preparing to transport radioactive material shipper must perform the following operations:

radioactive material classified under Section 4;

taking into account the use of radioactive material packaging under paragraphs 6.2-6.21;

pack radioactive material under 6.22-6.25 points;

determine the category of packaging under paragraphs 6.26-6.36;

put on the packaging labels and other necessary signs in accordance with paragraphs 6.3-6.44;

apply labeling under paragraphs 6.45-6.51;

fill in transport documents under 6.52-6.58 points.

Packaging for the transport of radioactive materials with very low radiological risk

6.2. For transportation of radioactive materials with too low radiological risk should apply released packaging.

Borders released the contents of packagings

6.3. For radioactive material contained in the device or other industrial products (such as a clock or electronic equipment, etc.) or a part thereof, and for a limited amount of radioactive material released packaging must not contain radioactive material with activity exceeds the limits specified in the table. 7.

Table 7 - Limits of activity for released packages

The device or subject		
Physical state	The device or subject	Limited number of material
of contents		
hard materials:		
of special form	A_1	10^{-3} A_1
other form	A_2	10^{-3} A_2
Liquids	10^{-1} A_2	10^{-4} A_2
Gas:		
Tritium	2×10^{-1} A_2	2×10^{-2} A_2
Special form	10^{-2} A_1	10^{-3} A_1
Other form	10^{-2} A_2	10^{-3} A_2

---

a) With respect to mixtures of radionuclides see. 4.5-4.7 points.

6.4. For products manufactured from natural uranium, depleted uranium or natural thorium may exempt packaging contain any quantity of such material provided that the outer

surface of the uranium or thorium is covered with an inactive sheath made of metal or
other durable material.

6.5. Industrial production in which the only radioactive Non-irradiated material is natural uranium, depleted Non-irradiated Non-irradiated uranium or natural thorium may be carried as excepted package provided that the outer surface of the uranium or thorium covered with an inactive sheath made of metal or other durable material.

6.6. When sending mail complete each activity liberated package must not exceed one tenth corresponding limits specified in the table. 7.

Packaging for the transport of radioactive materials with limited radiation risk

Packaging for transportation of LSA material and SCO

6.7. LSA and SCO materials must be transported in packaging sets type IP-1, IP-2, IP-3 under the table. 8, except as provided in paragraph 6.8.

Table 8 - Requirements for industrial use packages for LSA material and SCO

Radioactive content	Type of Indstrila packging	
	Exclusve use	Non exclusive use
LSA-I		
a)		
Hard materials	Type IP-1	TypeIP-1
Liquide	Type IP-1	TypeIP-2
LSA-II		
Hard materialsa	TypeIP-2	Type IP-2
Liquid and gas	TypeIP-2	Type IP-3
LSA-III	TypeIP-2	Type IP-3
SCO-I	TypeIP-1	Type IP-1
SCO-II	TypeIP-2	Type IP-2

---

a) Under the conditions specified in paragraph 6.8, materials LSA-I and SCO-I may be transported unpackaged.

6.8. Materials LSA and SCO, belonging to groups LSA-I and SCO-I, may be carried unpackaged under the following conditions:

a) all unpacked materials, except ores only natural radionuclides should be transported in way that under normal conditions of carriage there was no leakage radioactive contents from vehicle traffic or deterioration protection;

b) each way traffic should be in terms of exclusive use, except when traffic only SCO-I, in which contamination accessible and inaccessible surfaces does not exceed more than ten times the corresponding limit specified in paragraph 2.25;

c) in the case of SCO-I, for which there is reason to believe the presence of non-fixed radioactive contamination inaccessible surfaces exceeding the value specified in paragraph 4.19a, and, should apply measures that exclude hit means radioactive material in transport.

The boundaries of the content of industrial packagings IP-1, IP-2, IP-3

6.9. Number of LSA material or SCO in a single industrial box type IP-1 industrial package Type IP-2, industrial box type IP-3 or an object or group of objects depending the case should be limited so as to:

external radiation level at a distance of 3 m unprotected substance or object or group of objects is not exceed 10 mSv / h;

not exceeded activity threshold for means of transportation, specified in paragraph 7.17.

6.10. A separate package of non-combustible solid materials LSA-II and LSA-III in case of transportation by air is not shall include activity that exceeds 3000 A.

2

Packaging for the transport of radioactive materials with activity not exceeding A, A

1 2

6.11. For the transport of radioactive material with activity less than A, A must be used packagings

1 2

type A.

Borders of content of type A packagings

6.12. A packaging type should not contain activity exceeding the following values:

a) For special form radioactive material - A;

1

b) For radioactive material other than radioactive special form material - A.

2

6.13. Concerning mixtures of radionuclides, the composition and the corresponding whose activity is known to the radioactive contents of the packaging A set type used following condition:

$$\sum_i \frac{B(i)}{A_1(i)} + \sum_j \frac{C(j)}{A_2(j)} \leq 1,$$

where B (i) - the activity of i-radionuclide as radioactive special form material, and A (i) - A value for the i-th

radionuclide;
C (j) - Activity j-th radionuclide as radioactive
other forms of material and A (j) - A value for the j-th
2 2
radionuclide;
S - token amount.

Packaging for the transport of radioactive
materials with significant radiation risk

6.14. For the transport of radioactive material with activity
more A, A and radioactive materials with low ability to
1 2
scattering should apply packagings type
B (U), Type B (M) and Type C.

Borders content packaging sets type B (U) and Type B (M)

6.15. Packaging type B (U) and Type B (M) should not
include:
a) activity exceeding the values allowed for this
packaging design;
b) radionuclides different from those authorized for
the design of the packaging;
c) contents, form or physical or chemical state which
different from those allowed for the design
packaging that stated in their certificates
approval.

6.16. Packaging Type B (U) and Type B (M) in the carriage
air must satisfy the requirements of paragraph 6.15 and not
should include activities that exceed the following values:
a) For radioactive material with a low capacity for
dissipation - meaning permissible for the design
packaging that stated in the certificate
approval;
b) For special form radioactive material - 3000 A or
1
100000 A - depending on which one is lower;
2
c) For all other radioactive material - 3000 A.
2

Borders of content of packaging sets type C

6.17. Type C packaging must not contain:
a) activity exceeding the values allowed for this
packaging design;
b) radionuclides different from those authorized for
the design of the packaging;
c) contents, form or physical or chemical state which
different from those allowed for the design
packaging that stated in their certificates
approval.

**Packaging for transportation
fissile material**

6.18. Depending on the activity of fissile materials for their
transportation shall apply to packagings
fissile materials such as IP-2, Type IP-3, Type A, Type B (U),

type B (M) and Type C, the construction of which meets
5.67-5.77 points.

The boundaries of the content of packagings for fissile material

6.19. Except for-fissile material released,
packagings of fissile material shall not contain:
a) the mass of fissile material that does not meet the allowed
the design of the packaging, and activities that do not
responsible permitted for this type of packaging;
b) any radionuclide or fissile materials are not
allowed for the design of the packaging;
c) The contents, form, physical or chemical state or spatial
placement does not meet the design allowed for
packaging that stated in their certificates
approval.

Packaging for transportation
uranium hexafluoride

6.20. For transportation of uranium hexafluoride must
packagings used, the design of which meets
the requirements of paragraphs 5.78-5.81.

The boundaries of the content of packagings for the transport
uranium hexafluoride

6.21. Packaging for the transport of uranium hexafluoride
shall not include:
a) mass of uranium hexafluoride, which does not correspond to the
allowed
the design of the packaging;
b) the mass of uranium hexafluoride greater than the number that can
cause an untouched volume of less than 5%
maximum temperature of the package, which is specified for factory
systems that will be used packaging;
c) uranium hexafluoride other than in solid form or
uranium hexafluoride in internal pressure above atmospheric pressure
upon presentation packaging for transportation.

Packaging of radioactive materials

Requirements to be performed before the first carriage

6.22. Before the first transport of any package should
fulfill the following requirements:
a) If the design pressure of the containment system exceeds
35 kPa (gauge), compliance must be ensured
the containment system of each package approved design
requirements relating to the capacity of the system
maintain integrity at a given pressure;
b) for each package type B (U), Type B (M) and Type C, and
for each package containing fissile material efficiency
its radiation protection and containment and, where appropriate,
heat transfer characteristics and the effectiveness of the localization
must be within the limits applicable to or specified
approved design;
c) for packages containing fissile material and which aim
compliance with paragraph 5.67 specially equipped sinks
neutrons as a component of the package is necessary to
check to confirm the presence and distribution of
neutron poisons.

Requirements to be performed before each shipment

6.23. Before each shipment of any package should run the following requirements:

a) For any package must enforce all requirements contained in the relevant provisions of these Rules;

b) lifting devices which do not meet the requirements of paragraph 5.4, should be removed or otherwise reduced to a state that is not will use them for lifting the package, in accordance with § 5.5;

c) On the packaging, which is approved Nuclear Regulatory Committee of Ukraine, the need to enforce all the requirements specified in the approval certificates;

d) Each package type B (U), Type B (M) and Type C shall be sustained for as long as the conditions will not be achieved equilibrium close enough to the relevant requirements of temperature and pressure, unless these requirements have not been taken in order unilateral approval;

e) for each package type B (U), Type B (M) and Type C shall be ensured by inspection and / or appropriate test proper closing of all closures, valves, and other openings in containment system through which leakage can occur radioactive contents and, if provided, their sealing so that was clearly confirmed by the requirements paragraphs 5.52 and 5.65;

f) For each special form radioactive material must be ensured that all the requirements specified in approval certificate and the relevant provisions of these Rules;

g) for packages containing fissile material, where appropriate cases are conducted measurements specified in paragraph 5.69b, and check to confirm the closure of each package according to the requirements of paragraph 5.72;

h) for each radioactive material with low resolution dispersible must ensure that all the requirements specified in the approval certificate and the relevant provisions hereof.

Transportation of other goods

6.24. Packaging must not contain any other items except for items needed for the use of radioactive material. The interaction between these items and the package under the conditions transportation, corresponding to the design, shall not reduce security package.

Other hazards of radioactive material

6.25. When packing, labeling hazards labeling and warning signs, storage and transportation, except radioactive properties and the ability to share, you must consider any other dangerous properties the package contents such as explosiveness, flammability, pirofornist, chemical toxicity and corrosion activity in order to ensure implementation of appropriate transport of dangerous goods each of the countries through or into which materials will be transported, and when applicable with compliance with the rules of international transport organizations and hereof.

Categories of packaging

6.26. Also excepted packages, other packaging and transport packages must be assigned to one of the following categories: "I-WHITE" ("I-WHITE"), "II-YELLOW" ("II-YELLOW") or "III-YELLOW" ("III-YELLOW") - in accordance with the conditions specified in the table. 9, and such requirements:

a) for the package or overpack when determining the relevant category should be considered as a transport index and radiation level at the surface. If the vehicle index satisfies the conditions of one category, and the radiation level satisfies the conditions on the surface of a different category, the package or overpack should be credited to higher category. For this purpose, category "I-WHITE" should be considered as the lowest category;

b) transport index should be determined in accordance with procedures listed in paragraphs 6.29 and 6.30;

c) If the surface radiation level exceeds 2 mSv / h, the package or overpack shall be carried in under exclusive use and under the conditions specified in Points 7.22a, 7.24, 7.28, depending on the case;

d) a package transported under special conditions should be classified as "III-YELLOW", except covered by paragraph 6.27;

e) transport package containing packaging transported for special conditions to be classified as "III-YELLOW", except in cases covered by § 6.27.

Table 9 - Categories of packages and overpacks

conditions		
The transport index	The maximum level of radiation in any point of the outer surface	Category я
a) 0	not more 0,005 мЗв/hour	I-white
more then 0, But not more then 1	more 0,005 мЗв/hour, but not more	
a)	0,5 мЗв/hour	II-yellow
more then1 but not more then 10	more 0,5 мЗв/hour, but not more | | 2 мЗв/hour	III-yellow
more then 10	more 2 мЗв/hour but not more 10 мЗв/hour	III-yellow b)

---

a) If the measured TI is not greater than 0.05, the foregoing values may be zero in accordance with paragraph 6.29c.

b) There should also be carried under exclusive using.

6.27. For each package or overpack must be defined number of the United Nations (hereinafter - UN) and proper carrier name (see. Table. 11). In all cases, international transport of packages, for which approval is required construction or transport the competent authority when they can apply different types of approval in various countries, with related to the transportation, the UN number, proper transport name, category, labels and labeling must be according to certificates of origin of the design.

a) size of cargo	conversion factor
size of cargo <= 1 кв.м	1
1 кв.м < size of cargo <= 5 кв.м	2
5 кв.м < size of cargo <= 20 кв.м	3
20 кв.м < size of cargo	10

Determination of transport index (TI)

6.28. The transport index (Transport index - TI) - the number, assigned to the package, overpack or freight container or unpackaged LSA-I or SCO-I, which is used to providing control over radiation exposure.

6.29. The value of the transport index for the package, overpack or freight container or unpackaged LSA-I or SCO-I shall be determined as follows:

a) Determine the maximum radiation level in units "Millisieverts per hour" (mSv / h) at a distance of 1 m from the external surfaces of the package, overpack, freight container or unpackaged LSA-I or SCO-I. The measured values must multiplied by 100 and the resulting number is the transport index. For uranium and thorium ores and concentrates their maximum level radiation anywhere at a distance of 1 m from the external surface load can be taken:

0.4 mSv / h - for ores and physical concentrates of uranium and thorium;

0.3 mSv / h - for chemical concentrates of thorium;

0.02 mSv / h - for chemical concentrates of uranium, other than uranium hexafluoride.

b) For tanks, freight containers and unpackaged LSA-I and SCO-I value, determined in accordance with the above subparagraph "a", shall be multiplied by the appropriate factor terms specified in the table. 10.

c) The value obtained in accordance with the above subparagraphs "a" and "b", shall be rounded upward to the first decimal place (eg 1.13 rounded to 1.2) The value of 0.05 or less may be considered to be zero.

Table 10 - conversion factor for tanks, freight containers and unpackaged LSA-I and SCO-I

a) The largest cross-sectional area for cargo

measurements.

6.30. The transport index for each overpack, cargo container or means of transport shall be determined or as the sum of the transport indexes of all the packages contained in overpack, freight container or vehicle to transportation, or by direct measurement of radiation level, the except in the case of non-rigid overpacks for which transport index shall be determined only as the sum transport index of all packages.

Determining the criticality safety index

6.31. Criticality safety index (Criticality safety index - CSI) - set for the package, overpack or freight container containing fissile material, the number that used to control the total number of packages overpacks or freight containers containing fissile material.

6.32. Criticality safety index (CSI) for packages containing fissile material, it is necessary to calculate by dividing number 50 on the lower of the two values of N, determined in accordance with paragraphs 5.76 and 5.77 (ie CSI = 50 / N). The index security Criticality may be zero, provided that an unlimited number packages is subcritical (ie N in both cases, in fact, equal to infinity).

6.33. Criticality safety index for each vehicle package or freight container shall be determined as the sum of CSI All packages contain. Similarly, should CSI to determine the total amount of cargo on board or vehicle transportation.

Limits values transport index, safety index criticality and radiation level for packages and vehicles package

6.34. In goods transported under exclusive use, the transport index of any package or overpack shall not exceed 10, and the safety index criticality of any package or overpack not exceed 50.

6.35. In packages or overpacks transported under exclusive use by rail or road roads subject to the conditions set forth in subparagraph 7.22a, or under exclusive use or special conditions on board vessel or by air under the conditions specified respectively in paragraphs 7.24 or 7.28, the maximum level radiation in any part of the outer surface of the package (Other than excepted package) or overpack shall not exceed 2 mSv / h.

6.36. The maximum radiation level at any point the outer surface of the package or overpack under conditions exclusive use shall not exceed 10 mSv / h.

6.37. The level of radiation in any part of foreign surface excepted package shall not exceed 5 mSv / h.

Putting labels of danger

6.38. Responsibility for compliance labeling, applying labels, warning signs posted in 7.31d paragraphs 6.39-6.52 and relies on the shipper.

6.39. Each package, overpack each and every cargo container must be labeled in accordance with samples shown in figures 1, 2 or 3 (za056-06) under the proper category except large trucks containers and tanks, which allowed Signs indicate in the alternative provisions of paragraph 6.44. In addition, each package, overpack each and every cargo container containing fissile material must have signs danger according to the pattern shown in Figure 4; Any labels, not related to the content, or deleted closed. In respect of radioactive material with other hazardous properties, see. § 6.25.

Fig. 1. The label category I-WHITE (za056-06). The background color of the label - white, the color of the main plate Radiation risk (shamrock) and inscriptions - Black color stripes, indicating the category - red.

6.40. Labels that meet the standards set out in Fig. 1, 2 or 3 (za056-06), should be fastened to two opposing external surfaces of the package or overpack, or to the external surfaces of all four sides of freight container or tank. Labels corresponding sample shown in Fig. 4, in appropriate cases should mounted next to the labels that meet the standards, as illustrated in Fig. 1, 2 and 3. These labels should not close marking specified in paragraphs 6.46-6.52.

Fig. 2. The labeling of category II-YELLOW (za056-06). The background color of the upper half of the label - yellow, bottom half - white, the color of the main radiation hazard sign (Shamrock) and inscriptions - Black color stripes denoting category - red.

Specifying information about radioactive contents on signs danger

6.41. Each label corresponding to samples as illustrated in Fig. 1, 2 and 3 (za056-06), should be specified the following information:

a) content:

i) the name (s) of the radionuclide (s) taken (i) from the table. 1, The recommended symbol there, except material LSA-I. When a mixture of radionuclides must be specified how This allows the size of the line, radionuclides, for which there are major restrictions. After the name of the radionuclide (s) should be specify a group of LSA or SCO. You must use the terms "LSA-II", "LSA-III", "SCO-I" and "SCO-II";

ii) for LSA-I material need only the term "LSA-I", the name of the radionuclide is not required;

b) Activity: The maximum activity of the radioactive contents during carriage expressed in becquerels (Bq) with the appropriate prefix CI (annex). For fissile material instead activity can be specified weight fissile material in grams (G) or multiples thereof units;

c) For overpacks and freight containers in records boxes "content" ("contents") and "activity" ("activity") to sign danger must contain the information required under

provisions accordingly sub 6.41a and 6.41b, and that summed across content overpack or freight container; but to label transport packages or freight containers containing mixed loading of packages different radionuclides may be made entry "See. transportation documents "(" See Transport Documents ");

d) transport index: see. paragraphs 6.29 and 6.30 (Transport index for the category "I-WHITE" is not stamped).

Fig. 3. The labeling of category III-YELLOW (za056-06). The background color of the upper half of the label - yellow, bottom half - white, the color of the main radiation hazard sign (Shamrock) and inscriptions - Black color stripes denoting category - red.

Designation of information on safety criticality on signs danger

6.42. Each label corresponding to the sample, shown in Fig. 4 (za056-06), should be specified index criticality safety (CSI), specified in the certificate approval for special arrangement or the certificate approval of the package design issued competent authority.

Fig. 4. The labeling of the criticality safety index (Za056-06). The background color of the label - white, color labels - black.

6.43. For transportation of packages and freight containers criticality safety index (CSI) on the label should be available the information required under the provisions of § 6.42, prosumovana around the fissile content of transport package or cargo container.

Putting warning signs

6.44. Large freight containers, which are transported packaging, except excepted packages, and tanks must have four warning signs that correspond to the sample Fig. 5 (za056-06). Signs must be attached vertically on each side as well as front and rear walls of the great cargo container or tank. Any signs that are not related with content should be removed. Instead of using a parallel labels and warning signs are allowed apply only increased labels under sample shown in Fig. 1, 2, 3 and 4, with a minimum size, listed in Fig. 5.

Fig. 5. Warning sign (za056-06). Except cases specified in paragraph 7.20, the minimum should the dimensions shown on the figure; using other size to keep appropriate proportions. Height digits "7" must be at least 25 mm. The background color of the upper half mark - yellow, lower half - white, the color of the main plate Radiation risk (shamrock) and inscriptions - black. The use of the word "RADIOACTIVE" ("RADIOACTIVE") at the bottom not required that allows an option to use the mark for image corresponding UN number for the goods.

6.45. If the load in the cargo container or tank is unpacked LSA-I material or SCO-I or the goods that transported under exclusive use in freight container is packed with radioactive material with one number The UN, the UN number corresponding to this load (see. Table. 11) you must also put down a black figures a minimum height of 65 mm:

a) either on a white background in the lower half of the label shown in Figure 5 (za056-06);

b) or the mark shown in Fig. 6 (za056-06).

If you use the option "b" additional sign attached next to the main sign on all four sides cargo container or tank.

Fig. 6. marker individual image UN number (za056-06). The background color of the sign - orange frame and UN number - black. The "****" indicates the place where it should placed appropriate UN number for radioactive material according to Table. 11.

Labeling

6.46. Each package shall be on the outside the packaging is clearly and indelibly marked with the indication or consignor or consignee, or both of them.

6.47. Also excepted packages, the outer surface the packaging must be clearly and indelibly labeling stating the number of the UN (see. Table. 11), to which the letters "UN" (UN), as well as proper vehicle name (see. Table. 11). In the case of excepted packages except those accepted for international mailing should be only the UN number preceded by the letters "UN" (UN). To packages accepted for international mailing, should apply the requirements set out in paragraph 7.30.

6.48. Each package of gross mass exceeding 50 kg shall have on the outside of the packaging clear and indelible marking with indication of its permissible gross mass.

Table 11 - Excerpt from the list of UN numbers stating the appropriate transport items, descriptions of goods and subsidiary risk

Number UN	a) GOOD TRANSPORT name and description	More danger
2910	Radioactive material, excepted package - Limited number of materials	
2911	Radioactive material, excepted package - INSTRUMENTS or ARTICLES	
2909	Radioactive material, excepted package - Products manufactured from natural uranium or Depleted uranium or natural thorium	
2908	Radioactive material, excepted package - BLANK packaging	
2912	Radioactive material, low specific ACTIVITY (LSA-I), or indivisible b) Fissile-fired	
3321	Radioactive material, low specific ACTIVITY (LSA-II), or indivisible b) Fissile-fired	
3322	Radioactive material, low specific ACTIVITY (LSA-III), or indivisible	

| | b) | |
	Fissile-fired	
2913	Radioactive material, objects with surface	
	Radioactive contamination (SCO-I or SCO-II),	
	b)	
	Indivisible or fissile-fired	
2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE,	
	Non-exclusive forms, or indivisible	
	b)	
	Fissile-fired	
3332	RADIOACTIVE MATERIAL, TYPE A PACKAGE,	
	Special form, or indivisible	
	b)	
	Fissile-fired	
2916	radioactive material, package Type B (U),	
	b)	
	Indivisible or fissile-fired	
2917	radioactive material, package Type B (M),	
	b)	
	Indivisible or fissile-fired	
3323	RADIOACTIVE MATERIAL, TYPE C PACKAGE,	
	b)	
	Indivisible or fissile-fired	
2919	Radioactive material carried in	
	Special conditions, indivisible or	
	b)	
	Fissile-fired	
2978	radioactive materials, uranium hexafluoride,	corrosion
	b), c)	(Class 8
	Indivisible or fissile-fired	UN)
3324	Radioactive material, low specific	
	ACTIVITY (LSA-II), fissile	
3325	Radioactive material, low specific	
	ACTIVITY (LSA-III), fissile	
3326	radioactive material objects with
-3327	RADIOACTIVE MATERIAL, TYPE A PACKAGE,	
	Divisible, non-exclusive form	
3333	RADIOACTIVE MATERIAL, TYPE A PACKAGE,	
	Special form, divisible	
3328	radioactive material, package Type B (U),	
	Fissile	
3329	radioactive material, package Type B (M),	
	Fissile	
3330	RADIOACTIVE MATERIAL, TYPE C PACKAGE,	
	Fissile	
3331	Radioactive material transported in	
	Special conditions, divisible	
2977	radioactive materials, uranium hexafluoride,	corrosion
	c)	(Class 8

| | Fissile | UN) |----------

a) proper transport TITLE indicated only in the
of the column "proper transport name and description" that
typed in CAPITAL LETTERS. In the case of UN 2909 N, N UN 2911, N 2913
3326 N UN and the UN in respect of which the specified alternative appropriate
transport name, separated by the conjunction "or"
is only acceptable proper transport
name.

b) The term "fissile-excepted" applies only if
packages containing fissile-released material
the requirements of paragraph 4.31.

c) In the case of unchallenged or fissile-released
2978 N uranium hexafluoride UN proper carrier name,
and the description "Radioactive material, uranium hexafluoride
indivisible or fissile-excepted "have priority over other
UN numbers used for undivided and
fissile-released material. If unchallenged, or
fissile uranium hexafluoride, released in 2977 N UN proper
carrier name, and a description of "radioactive material
Uranium hexafluoride, fissile "have priority over other
UN numbers applicable to fissile material.

6.49. Each package corresponding to:

a) the packaging design type IP-1, IP-2 or
IP-3 should be on the outside of the packaging
clear and indelible marking under "TYPE IP-1" ("TYPE IP-1"),
"TYPE IP-2" ("TYPE IP-2") or "TYPE IP-3" ("TYPE IP-3");

b) the packaging design type A, should be on
the outside of the packaging clear and indelible
marking "Type A" ("TYPE A");

c) the packaging design type IP-2, IP-3 or
Type A, should be on the outside of the packaging
clearly and indelibly marked with the indication of the international
registration code of the vehicle (code VRI) countries
origin of design and either the name of the manufacturer or other
identification of the packaging specified by the competent
authority of the country of origin of the design.

6.50. Each package corresponding to structures that
approved in accordance with paragraphs 9.5-9.14 or 9.16-9.17 should
be on the outside of the packaging clear and indelible
marked with:

a) the identification mark issued by the competent authority
for the design;

b) the serial number for each individual label
packaging, relevant data structures;

c) for the design of the packaging type B (U) or
packaging type B (M) - the inscription "Type B (U)" ("TYPE B (U)")
or "Type B (M)" ("TYPE B (M)");

d) for the design of the packaging Type C - inscription
"Type C" ("TYPE C").

6.51. Each package corresponding to the design of packaging
sets of type B (U), Type B (M) or type C, should be on
the outer surface of the outer tank, resistant to fire and
water, clear labeling method applied embossing, stamping and
others resistant to fire and water ways, depicting
sign of radiation danger in the form of trefoil (Fig. 7
(Za056-06).

Fig. 7. The main sign of radiation hazard according to GOST 17925-72
in a shamrock around the central circle of radius X
(Za056-06). The minimum allowable size of X equal to 4 mm.

6.52. If materials LSA-I or SCO-I contained in containers or

in packing materials and transported under exclusive
under the provisions of paragraph 6.8, the outer surface
these containers or packaging materials applied in accordance
marking "RADIOACTIVE LSA-I" ("RADIOACTIVE LSA-I") or
"RADIOACTIVE SCO-I" ("RADIOACTIVE SCO-I").

Preparation of transport documents

Freight information

6.53. The consignor should Introduce to transport
documents attached to each cargo identification
consignor and consignee, which includes their
name and address, and relevant information in the following
sequence, namely:

a) proper carrier name as it appears in line
the provisions of paragraph 6.27;

b) Class UN number of dangerous goods "7";

c) assigned to this material UN number listed under
the provisions of paragraph 6.27, preceded by the letters "UN" (UN);

d) the name or symbol of each radionuclide or, in the case of mixtures
radionuclides, an appropriate general description or a list
radionuclides for which there are major limitations;

e) description of the physical and chemical form of the material or
recording that
that the material is special form radioactive material or
radioactive material, low dispersible. For
chemical form acceptable overall chemical description;

f) the maximum activity of the radioactive contents during
carriage expressed in becquerels (Bq) with the appropriate prefix CI
(addition). For fissile material in place of activity can be
Set fissile material mass, expressed in grams (g) or
appropriate multiples thereof units;

g) category of the package, that "I-WHITE" ("I-WHITE"), "II-YELLOW"
("II-YELLOW"), "III-YELLOW" ("III-YELLOW");

h) the transport index (for categories "II-YELLOW" and
"III-YELLOW");

i) criticality safety index - for loads containing
fissile material, other than cargo containing fissile-released
material;

j) token for each certificate
approval of the competent authority (radioactive material
special form radioactive material with a low capacity for
scattering, special conditions or package design
transportation), which is applicable to the given load;

k) information specified in paragraph 6.53a-j, which should
available for each package - for loads containing more
one package. For packages that are contained in the transport
package, freight container or vehicle traffic, you
provide a detailed description of contents of each package in transport
package, freight container or vehicle traffic and,
necessary, details contents of each overpack,
cargo container or vehicle traffic. If the point
interim relief package will extract it from
overpack, freight container or vehicle
transportation, they must be prepared in accordance transport
documents;

l) note: "Carriage under exclusive use"
("EXCLUSIVE USE SHIPMENT"), if the goods required to carry
under exclusive use;

m) All cargo activity as a value multiple of A -

for LSA-II, LSA-III, SCO-I and SCO-II.

The declaration of the shipper

6.54. A shipper must include transport
Declaration of the documents or equivalent wording:
"These state that the contents of the load completely and accurately reflected in the above proper transport
naming it classified, packaged, labeled,
provided with labels in all respects aligned
proper condition for transportation (indicated (yutsya) corresponding (i) Type (s) of transport) in accordance with applicable international and national governmental regulations. "

6.55. If the content of the declaration are included in the conditions transportation, defined by some international
Convention, the shipper is not required to provide such
Declaration on the part of the carriage covered
this convention.

6.56. The declaration must be signed by the consignor of
stating the date. Fax signatures are allowed in cases
when the relevant laws and regulations of recognized validity
facsimile signatures.

6.57. The declaration must be in the same transport
document containing information about the goods listed in
Paragraph 6.53.

Information for Carriers

6.58. A shipper must uklyuchaty in transport
Documents indication of actions that are needed are obliged
implement carrier. This indication must be made by the languages
carrier or relevant authorities deem necessary, and should
include at least the following elements:
a) additional requirements to boot, making,
transportation, processing, packaging and unloading, transport
package or container, including any special
regulations regarding conclusion for the safe removal
heat (see. § 7.14), or notification that such requirements
not expected;
b) restrictions on the type of vehicle or means of transportation and any necessary instructions concerning the route;
c) measures in case of accident for the cargo.

6.59. Existing certificates issued by the competent authority,
not necessarily bound together with the load. Consignor
must provide them available to the carrier (s) to download
and unloading.

Message to competent authorities

6.60. The first carriage of any package requiring
approval of the competent authority, the shipper must
ensure that copies of each applicable certificate that
issued by the competent authority package design,
the competent authority of each country through or into
territory of which goods are transported. The consignor is not
obliged to wait for confirmation from the competent authority
a certificate and the competent authority is not obliged to give
a confirmation.

6.61. On each carriage, which is specified in paragraphs "a",
"B", "c" or "d" below shipper inform the competent
authority of each country through or into which
transported goods. Such notification must be received every
the competent authority before the transport, preferably not less than
7 days before it starts:

a) packaging type C, containing radioactive material
activity greater than 3000 A or 3000 A, depending on
February 1
case, or 1000 TBq - depending on what value less;
b) package Type B (U), containing radioactive material
activity greater than 3000 A or 3000 A, depending on
February 1
case, or 1000 TBq - depending on what value less;
c) package Type B (M);
d) transportation in special circumstances.

6.62. The report of the goods must be:
a) information sufficient to identify this package or
packages including all applicable certificate numbers and
identifying marks;
b) information about the date of carriage, and the expected date of arrival
route that is expected;
c) the names of radioactive material, or radionuclides;
d) a description of physical and chemical forms of the radioactive material
or write that it is a special radioactive material
form radioactive material or low ability to
scattering;
e) information about the maximum activity of the radioactive contents
the carriage expressed in becquerels (Bq) with an appropriate
prefix CI (annex). For fissile material instead
activity can be specified fissile material mass, expressed in
grams (g) or multiples thereof units.

6.63. The consignor is not required to send a separate
notification if the required information has been included in the application
for
shipment approval (see. § 9.22).

Availability of certificates and instructions

6.64. The shipper before starting transportation
under the terms of the certificates must have a copy of each
the certificate required under section 9 of the Regulations, and
a copy of the instructions for proper packaging and closure
other measures to prepare for transportation.

Section 7. Requirements for dispatch transportation, storage in transit packaging

Terms

7.1. Tanks and containers Intermediate
Bulk cargoes used for transportation
radioactive material shall not be used for
storage or transport of other goods unless they
cleared of beta and gamma emitters and alpha-emitters
low toxicity lower than 0.4 Bq / cm, and all
other alpha emitters below 0.04 Bq / cm.

7.2. Allowed to transport other items with
goods transported under exclusive use,
if the organization that controlled traffic only
shipper and not prohibited by other regulations.

7.3. Loads during transport should be separated
from other dangerous goods in compliance with the relevant rules
transportation of dangerous goods of each of the countries through
or into which the materials will be transported,
and, where applicable, in compliance with international rules
transport organizations and these Rules.

Requirements and controls for radioactive
pollution and leakage from packages

7.4. Non-fixed contamination on the external surfaces
any package must be maintained at the lowest practical
achievable level, and under normal conditions of carriage it should not
exceed the following limits:

a) 4 Bq / cm for beta and gamma emitters and
Alpha emitters of low toxicity;

b) 0,4 Bq / cm for all other alpha emitters.

These limits apply when averaged over any area
300 kv.sm any part of the surface.

7.5. Except as provided in paragraph 7.10 level
non-fixed radioactive contamination and outdoor
Surface transport packages, freight containers,
tanks, containers, intermediate bulk
cargo and any means of transportation should not exceed
limits specified in paragraph 7.4.

7.6. If it appears that the packaging is damaged or has
leaking or if there is reason to believe that packaging has leakage
or been damaged, access to such packaging should be
limited and specialist as soon as possible should assess the
radioactive contamination and radiation level of the package,
resulting from leakage. Assessment must be subject to
packaging, means of transportation, loading and surrounding area
unloading and, if necessary, all other materials transported
by the same means of transport. In order to overcome and reduce to
minimize the consequences of such leakage or damage must be taken
additional measures to protect people, property and the environment
environment in accordance with emergency plans, and approved
agreed in due course.

7.7. Packages damaged or leaking radioactive
content that exceed the allowable limits for normal conditions
transportation, can be removed to fit the intermediate object
which is under control, but should not go further,
before they will be repaired or brought in due
state and deactivated.

7.8. Means of transportation and equipment permanently
used for the transport of radioactive material shall
periodically checked to determine the level of radioactive
pollution. The frequency of such inspections should depend
the probability of radioactive pollution and traffic volume
radioactive materials.

7.9. Except as provided in paragraph 7.10, any means
transport or equipment, or part of them that during
transport of radioactive materials were contaminated above the limits
referred to in paragraph 7.4, or the radiation level from which
than 5 mSv / h at the surface should be as soon as possible
Deactivated specialist and should not be used again until,
unfixed until contamination is reduced to the level
limits specified in paragraph 7.4, and the level of radiation
creating a fixed surface contamination after
decontamination not be less than 5 mSv / h at the surface.

7.10. Cargo container tank container medium
bulk or means of transportation,
designed to transport unpackaged radioactive materials
under exclusive use shall be exempt from the requirements
7.5 and 7.9 points only on their interior surfaces and
just as long as they are in these exceptional circumstances

using.

Separation during transport and transit storage

7.11. Packaging, shipping packages and freight containers containing radioactive material and unpacked radioactive material during transport and storage in transit must be separated:

a) for the staff (Category A, B [NRBU- 97 (v0062282-97)]) in working areas of permanent residence distances calculated from using a dose criterion of 5 mSv in a year and conservative model parameters;

b) from members of the critical groups (category B [97 NRBU-(V0062282-97)]) in public places open access distances calculated using a dose criterion of 1 mSv a year and conservative model parameters;

c) from undeveloped photographic film distances calculated from using criteria radiation undeveloped photographic film due to the transport of radioactive material 0.1 mSv per consignment of such film;

d) from other dangerous goods in accordance with paragraph 7.3.

7.12. Packaging or overpack category "II-YELLOW" or "III-YELLOW" should not be carried in compartments engaged passengers, except for places intended solely for persons specifically authorized to accompany such package or overpack.

Stowing cargo durng the carriage And transit storage

7.13. Cargo must be securely stowed.

7.14. Packaging or overpack provided that the average heat flow at the surface does not exceed 15 W / m and the load, that directly surrounds them, not in sacks or bags, may be carried among packaged general cargo without compliance with any specific provisions on the conclusion, in addition to where the competent authority in the relevant certificate Approval may be due to special requirements.

7.15. Placement of cargo containers and storage packages, overpacks and freight containers must control as follows:

a) except exclusive use and transport material LSA-I, the total number of packages, transport packages and cargo containers on board a means of transport limited so that the total sum of the transport indexes on board means of transport does not exceed the values shown in Table. 12;

b) the level of radiation in normal conditions of carriage exceed 2 mSv / h at any point on the outside surface transportation means, and 0.1 mSv / h at 2 m from it, except goods transported under exclusive use by road or rail, for which the limits of radioactivity around the vehicle set in paragraph 7.22b, c;

Table 12 - Limits transport index (TI) for transport containers and means of transportation, not in the exclusive use

Type of freight container or means of transport	Limit the amount of transport index for freight container or on board means of transport

Cargo container - small	50
Freight containers - large	50
Vehicle	50
Aircraft	
Passenger	50
Cargo	200
Vessel for inland waterways	50
a) Ship	
(1) hold, or compartment marked Of decks:	
Packaging, transportation packages, small Freight containers	50
Large freight containers	200
(2) A ship in general:	
Packaging, transportation packages, small Freight containers	200
Large freight containers	Not limited

a) Packages or overpacks carried on board
Vehicles that comply with the provisions of paragraph 7.22,
can be transported on board, provided they do not
unloaded from the vehicle during the time
stay on board the vessel.

c) the total sum of the criticality safety indexes in a freight container and aboard a means of transportation should not exceed values given in the table. 13.

7.16. Any package or any transport package transport index is over 10, or any consignment having criticality safety index over 50, must be transported only under exclusive use.

7.17. Total activity in a single hold or compartment for vehicles inland waterways or other means of transportation for transport of LSA material or SCO in packages type IP-1, type IP-2, Type IP-3 or without packaging shall not exceed the limits, indicated in the table. 14.

Table 13 - Limits of criticality safety index (CSI) for transport containers and means of transportation, containing fissile material

Type of freight container or vehicle transportation	Limit the amount of codes criticality safety for cargo container or on board the vehicle transportation	
	out terms	in terms exceptional

	Exceptional	use
	Use	
Cargo container - small	50	No
		Applicable
Freight containers - large	50	100
Vehicle	50	100
Aircraft		
Passenger	50	No
		Applicable
Cargo	50	100
Vessel for inland waterways	50	100
a)		
Ship		
(1) hold, or compartment marked		
Of decks:		
Packaging, transportation packages, small	50	100
Freight containers		
Large freight containers	50	100
(2) A ship in general:		
Packaging, transportation packages, small	b)	c)
Freight containers	200	200
Large freight containers	No	c)
	b)	Not limited
	limited	

a) Packages or overpacks carried on board
vehicle and which comply with the provisions of paragraph 7.22,
can be transported on board, provided they do not
unloaded from the vehicle during the time
stay on board the vessel. This shall apply
value specified in the "under exclusive use".

b) The cargo should be handled and stowed so that
the total sum of CSI in any group does not exceed 50 to
loading / unloading and making each group were conducted
division groups at a distance of at least 6 m.

c) The cargo should be handled and stowed so that
the total sum of CSI in any group does not exceed 100, and that
loading / unloading and making each group were conducted
division groups at a distance of at least 6 m. The space between groups
You can fill in other cargo in accordance with paragraph 7.2.

Table 14 - Limits on the means of transport activity
for LSA material and SCO in industrial
packaging or without packaging----------

The nature of the material	Limit activity for means of transport, other than vehicles	Limit activity for hold or compartment vehicles for transportation
	Inland waterways	inland ways
LSA-I	Not limited	Not limited

| ----------------- + ---------------------- + ------ -------------- |
LSA-II and LSA-III	Not limited	100 A
(Flammable solids		2
Substances)		
----------------- + ---------------------- + ------ --------------
LSA-II and LSA-III	100 A	10 A
(Flammable solids	2	2
Substance and all		
Liquids and gases)		
----------------- + ---------------------- + ------ --------------
SCO	100 A	10 A
	2	2

Separation packages containing fissile material, during transport and storage in transit

7.18. Any group of packages, transport packages and freight containers containing fissile material, which are in transit storage in any particular place Storage should be limited so that the total the criticality safety indexes of these packages, transport packages or freight containers does not exceed 50. Each group such packages, overpacks or freight containers should be stored in a way that ensured separation at least 6 m from other such groups.

7.19. If the total sum of the criticality safety indexes on board means of transport or cargo container 50 as permitted under the table. 13, the storage must be organized in a way that ensured separation at least 6 m from other groups of packages, transport packages or freight containers containing fissile material or other means of transportation, which made transportation radioactive materials.

Additional requirements relating to the carriage Rail and road transport

7.20. Rail and road vehicles, which shipped the package, overpack or freight containers, Bearing any sign of danger, as illustrated in Fig. 1, 2, 3, 4 (za056-06), or goods transported under conditions exclusive use should be shown in Fig. 5 warning sign on each:

a) the two external lateral walls in the case of rail vehicle;

b) the two external lateral walls and the external rear wall in the case of motor vehicle.

If the vehicle has side walls, Warning signs can be applied directly on the module, which carries the weight, provided that they are easily distinguished; concerning tanks or cargo containers large enough the presence of warning signs on most of these subjects. If the configuration of the vehicle does not cause signs larger, the size of the warning sign shown in Fig. 5 (za056-06), may be reduced to 100 mm. Any Signs not related to content, should be removed.

7.21. If the cargo on board the vehicle is materials unpacked LSA-I or SCO-I or the goods that transported under exclusive use, is packed radioactive material with a single UN number, the corresponding number UN (see. Table. 11) in the form of black digits minimum height of 65 mm also be marked:

a) either on a white background in the lower half warning sign, shown in Fig. 5 (za056-06);

b) or the mark shown in Fig. 6 (za056-06).

When you use the options provided in the above paragraph "b", assigned additional mark next to the main sign two side walls of a railway vehicle or two side and rear walls of the motor vehicle.

7.22. For goods carried under exclusive use, the radiation level shall not exceed the following values:

a) 10 mSv / h at any point of the external surface of any packaging or overpack, and may exceed 2 mSv / h only provided that:

i) the vehicle is equipped with fencing that for normal conditions of carriage prevent access by unauthorized persons inside the enclosed area;

ii) provides for measures to consolidate the package or overpack so that their position within vehicle under normal conditions of carriage remained unchanged;

iii) not performed or no boot unloading during transport;

b) 2 mSv / h at any point of the outer surface vehicle, including the upper and lower surfaces, or if open vehicle - at any point vertical planes passing through the outer limits vehicle load on the upper surface and the bottom the outer surface of the vehicle;

c) 0,1 mSv / h at any point 2 m from vertical planes formed by the outer lateral surfaces vehicle, or if the load is carried in the open vehicle - at any point 2 m from vertical planes passing through the outer limits vehicle.

7.23. In the case of motor vehicles no one but the driver and his helpers (attendants) must not be at board vehicles carrying packages, transport packages or cargo containers filled with labels category "II-YELLOW" or "III-YELLOW."

Additional requirements related with the carriage on board vessels

7.24. Packaging or overpack having a level radiation on the surface of more than 2 mSv / h, unless transported in a vehicle under exclusive use in accordance with the requirements specified in the footnote "a" to Table. 12 shall be carried on board under special conditions.

7.25. Transportation of cargo on board a special purpose, constructed or freight conditions specially designed for the transport of radioactive materials exempt from the requirements of paragraph 7.15 the following conditions:

a) radiation protection program for transport should be approved by the competent authority of the country of registration of the vessel and, if appropriate, the competent authority of each port of call;

b) must be predefined conditions for making Only flight, in that those in respect of any goods that loaded at ports of call en route;

c) loading, transportation and unloading of cargo should be carried out by qualified professionals the transport of radioactive materials.

Additional requirements related with the transportation by air

7.26. Packaging Type B (M) and goods under exclusive use not permitted to carry on board passenger aircraft.

7.27. Packaging Type B (M) of the ventilation or discharge pressure, packaging, requiring external cooled by additional cooling, packaging, require operational controls during transport, and packages containing liquid pyrophoric materials are not allowed transport by air.

7.28. Packaging or overpack having a level radiation on the surface of more than 2 mSv / h, are not permitted transport by air, except transportation for special conditions.

Additional requirements associated with sending by mail

7.29. Freed packaging activity radioactive contents which does not exceed one tenth of the limits indicated in Table. 3, can be taken by national postal authorities to internal transfer, subject to the following additional requirements that can be set by those authorities.

7.30. Freed packaging activity radioactive contents which does not exceed one tenth of the limits indicated in Table. 3, can be taken to an international mailing subject to, inter alia, the following additional requirements attributed Acts of the Universal Postal Union:

a) the administration should be transmitted only email service shippers, licensed for conducting activities transportation of radioactive materials;

b) sending want to forward the fastest route as usually by air;

c) the administration should have a clear outside and securely label with the words "RADIOACTIVE MATERIAL - NUMBER OF ALLOWED FOR mailing "(" RADIOACTIVE MATERIAL - QUANTITIES PERMITED FOR MOVEMENT BY POST "); these words must be crossed the return of empty packaging;

d) outside of the administration should be given the name and address of the consignor marked the return of the goods if it will not be delivered to the addressee;

e) in the domestic the packaging should be given name and address of the consignor and the contents of the cargo.

Requirements and controls for carriage empty packagings

7.31. Empty packaging which previously contained radioactive material may be carried as excepted package for provided that:

a) it is in good condition and securely closed;

b) the outer surface of any details of the uranium or thorium in its design is closed inactive sheath made from metal or any other durable material;

c) the level of internal non-fixed radioactive Pollution does not exceed more than a hundred times the levels specified in Paragraph 7.4;

d) Any labels that can be applied to

the outer surface of the packaging according to
§ 6.38 is no longer visible.

Customs operations

7.32. Customs operations, including the control of radioactive content of the package, should be done only in places equipped appropriate means of control over radiation exposure, and the presence of qualified staff. Any packaging open at the request of the customs, before its subsequent departure consignee should be reduced to the previous state.

Undelivered goods

7.33. If the goods can not be delivered to the addressee, his should be placed in a safe place, and this quickly inform the State Nuclear Regulatory Committee of Ukraine and ask user for further action.

Умови перевезення матеріалів LSA та SCO
у 30-кілометровій зоні відчуження
та безумовного (обов'язкового) відселення

7.34. Матеріали LSA та SCO можуть перевозитися автомобільним транспортом без упаковки при дотриманні таких умов:

a) усі неупаковані матеріали повинні транспортуватися таким чином, щоб за звичайних умов перевезення не було витоку або розсіювання радіоактивного вмісту із засобу перевезення або погіршення захисту;

b) кожний засіб перевезення повинен перебувати в умовах виняткового використання;

c) рівень випромінювання не повинен перевищувати таких значень:

i) 2 мЗв/год у будь-якій точці зовнішньої поверхні транспортного засобу, уключаючи верхню й нижню поверхні, або, у разі відкритого транспортного засобу, - у будь-якій точці вертикальних площин, що проходять через зовнішні межі транспортного засобу, на верхній поверхні вантажу та на нижній зовнішній поверхні транспортного засобу;

ii) 0,1 мЗв/год у будь-якій точці на відстані 2 м від вертикальних площин, утворених зовнішніми боковими поверхнями транспортного засобу, або, якщо вантаж перевозиться на відкритому транспортному засобі, - у будь-якій точці на відстані 2 м від вертикальних площин, що проходять через зовнішні межі транспортного засобу.

1411/5000
Umovy perevezennya materialiv LSA ta SCO
u 30-kilometroviy zoni vidchuzhennya
ta bezumovnoho (obov'yazkovoho) vidselennya

7.34. Materialy LSA ta SCO mozhut' perevozytysya avtomobil'nym transportom bez upakovky pry dotrymanni takykh umov:
a) usi neupakovani materialy povynni transportuvatysya takym chynom, shchob za zvychaynykh umov perevezennya ne bulo vytoku abo

rozsiyuvannya radioaktyvnoho vmistu iz zasobu perevezennya abo pohirshennya zakhystu;
b) kozhnyy zasib perevezennya povynen perebuvaty v umovakh vynyatkovoho vykorystannya;
c) riven' vyprominyuvannya ne povynen perevyshchuvaty takykh znachen':
i) 2 mZv/hod u bud'-yakiy tochtsi zovnishn'oyi poverkhni transportnoho zasobu, uklyuchayuchy verkhnyu y nyzhnyu poverkhni, abo, u razi vidkrytoho transportnoho zasobu, - u bud'-yakiy tochtsi vertykal'nykh ploshchyn, shcho prokhodyat' cherez zovnishni mezhi transportnoho zasobu, na verkhniy poverkhni vantazhu ta na nyzhniy zovnishniy poverkhni transportnoho zasobu;
ii) 0,1 mZv/hod u bud'-yakiy tochtsi na vidstani 2 m vid vertykal'nykh ploshchyn, utvorenykh zovnishnimy bokovymy poverkhnyamy transportnoho zasobu, abo, yakshcho vantazh perevozyt'sya na vidkrytomu transportnomu zasobi, - u bud'-yakiy tochtsi na vidstani 2 m vid vertykal'nykh ploshchyn, shcho prokhodyat' cherez zovnishni mezhi transportnoho zasobu.
Conditions of Carriage LSA material and SCO
a 30-kilometer exclusion zone
and unconditional (obligatory) resettlement

7.34. LSA and SCO materials can be transported by road transport unpackaged under the following conditions:
a) all unpacked materials must be transported in way that under normal conditions of carriage there was no leakage or dispersion of the radioactive contents of a means of transportation or deterioration of protection;
b) each way traffic should be in terms of exclusive use;
c) the radiation level shall not exceed the following values:
i) 2 mSv / h at any point of the outer surface vehicle, including the upper and lower surfaces, or, if open vehicle - at any point vertical planes passing through the outer limits vehicle load on the upper surface and the bottom the outer surface of the vehicle;
ii) 0,1 mSv / h at any point 2 m from vertical planes formed by the outer lateral surfaces vehicle, or if the load is carried in the open vehicle - at any point 2 m from vertical planes passing through the outer limits vehicle.

Chapter 8. Test Procedure

Homologation

8.1. Conformity performance requirements set out in sections 4 and 5 should be any of the methods listed below or their combination:
a) testing on samples that are material LSA-III or radioactive material special form or radioactive material with low dispersible or prototypes, or models packagings, provided that the content of the sample or packaging for tests simulating as closely as possible the expected range of radioactive contents and sample the tested packaging or prepared in the form in which they are offered for transport;
b) reference to previous satisfactory confirmation

similar nature;

c) testing on models of appropriate scale, Bearing that elements essential to the sample, which tested if the technical experience has shown results such tests suitable for construction purposes. At the use of scale models should take into account the need to adjusting certain test parameters, such as diameter punch or compression load;

d) calculation, or reasoned argument when reliable or conservative calculation methods and parameters acknowledged.

8.2. After the test sample, prototype or model should apply appropriate evaluation methods to confirm execution set out in this section in accordance with requirements acceptable norms and operating characteristics listed in section 4 and 5.

Tests on leaching LSA-III material and radioactive material, low dispersible

8.3. The sample material in the solid state, which is full of contents Packaging must dive for 7 days in water at a temperature environment. The volume of water testing should be sufficient to ensure that at the end of 7-day residual test free volume of water that was not absorbed and unreacted was at least 10% of the volume of solid sample, tested. Initial pH of water should be 6-8, and a maximum conductivity - 1 mS / m at 20 hrad.C. After immersion 7 Nights sample under test measured total activity free volume of water.

Tests radioactive special form material

Terms

8.4. Samples are special form radioactive material or mimic, to be tested for collision the impact test, bending test and thermal testing, provided for in paragraphs 8.5-8.9. For each of these tests can be used by a single sample. After each test should evaluate sample leaching and determining the volume of leakage using method no less sensitive than the methods specified in paragraph 8.10 for solid material that is not scattered or in paragraph 8.11 to material in the capsule.

test methods

8.5. Tests on collision. The sample looks like a target with height of 9 m. The target must meet the requirements of paragraph 8.17.

8.6. The impact test. The specimen shall be placed on lead plate lying on a smooth solid surface and the It is performed hit a flat surface with a mild steel billets a force that is equal to strike a mass of 1.4 kg at free falling from a height of 1 m. The lower part must have a diameter ingots 25 mm from the edges with a radius of curvature (3.0 + -0.3) mm. Plate of 3.5-4.5 lead hardness for Vickers scale and thickness no more than 25 mm should be slightly larger surface area than support model. For each test must blow

used a new surface lead. Beat the sample disc must be performed so as to cause maximum damage.

8.7. The bend test. This test must apply only to thin and elongated sources with length of 10 cm and the ratio of the width to the minimum at least 10. The sample should be rigidly fixed in horizontally so that half its length appeared outside space clamp. Regulation sample shall be such that He received the maximum damage when hitting a flat surface steel ingots on the free end of the sample. Shot Power blanks on the sample shall be equal to the strength strike a mass of 1.4 kg, free fall from a height of 1 m. The flat surface of the ingots must be 25 mm diameter with the edges with a radius of curvature (3.0 + -0.3) mm.

8.8. Thermal tests. The specimen shall be heated to Air temperature to 800 ° C, during this last for temperature for 10 minutes and then freely cool.

8.9. Samples radioactive material in a sealed capsule, or mimic may be exempted from:

a) tests are specified in paragraphs 8.5 and 8.6, provided the mass of radioactive material special form:

i) less than 200 g and they instead be tested the effect of impact for 4th class, specified in the document ISO 2919 [1] "Sealed Radioactive Sources - Classification";

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1) Similar requirements are contained in document GOST 25926-90 "Sources of radiation yonyzyruyuscheho radyonuklydnые Closed. Norms zhestkosty degree at klymatycheskyh and mechanical impact. Classes and methods prochnosty trials. "

ii) less than 500 g and they instead be tested the effect of impact for the 5th grade, specified in the document ISO 2919 "Sealed Radioactive Sources - Classification";

b) test, which states in paragraph 8.8, provided that they instead be tested for the effect of temperature 6th grade referred to in the document ISO 2919 "Sealed Radioactive Sources - Classification ".

Methods of assessment and evaluation leaching volumetric leakage

8.10. For samples that are solid material that is not scattered, or mimic, the assessment of leaching should held as follows:

a) the specimen shall be immersed for 7 days in water at the temperature of the environment. The volume of water for tests has be sufficient to ensure that at the end of 7-day trial remaining free volume of water that was not absorbed reacted, was at least 10% of the volume of solid sample being tested. The initial pH of the water should be 6-8, and maximum conductivity - 1 mS / m at 20 ° C;

b) the sample water heated to be (50 + -5) ° C, and the design must last for at this temperature 4 hours;

c) thereafter should be measured water activity;

d) on the sample should last for at least 7 days without blowing air at a temperature of at least 30 ° C with relative humidity of at least 90%;

e) further sample should be immersed in water with parameters

listed in paragraph a) above water with the sample should be heated to a temperature (50 + -5) ° C and maintained at this sample temperature for 4 hours;

f) should be measured after water activity.

8.11. For samples of radioactive material a sealed capsule or mimic, or should be done leaching assessment or volumetric leakage assessment as follows:

a) leaching assessment shall consist of the following stages:

i) the design must dive into the water at environment. The initial pH of the water should be 6-8 and a maximum conductivity - 1 mS / m at 20 ° C;

ii) the water and specimen must be heated to (50 + -5) ° C, and the sample is kept at this temperature for 4 hours;

iii) thereafter should be measured water activity;

iv) further sample shall be kept for at least 7 days without blowing air at not less 30 ° C with a relative humidity of at least 90%;

v) must repeat the steps in points i, ii and iii;

b) volumetric leakage assessment conducted instead, shall include any appropriate competent authority test with those provided document ISO 9978: "Radiation Protection - Sealed Radioactive Sources - Leakage Test Methods "or GOST 27212-87" Sources of radiation yonyzyruyuscheho Closed radyonuklydnыe. General specifications Requirements ".

Tests of radioactive material low dispersible

8.12. Samples which radioactive material is low dispersible or mimic, subjected to enhanced thermal test specified in paragraph 8.36, and test on collision that specified in paragraph 8.37. For each of these Test can be used a separate sample. each the test sample should be subjected to the test leaching that specified in paragraph 8.3. After each test it is necessary to establish whether relevant requirements have been met specified in paragraph 4.28.

Testing of packagings

Preparation of samples for testing

8.13. To test all samples should be tested for the purpose of identification and registration of malfunctions or damage, including:

a) Divergence from the design;

b) defects in manufacture;

c) corrosion or other defects that impair quality;

d) strains.

8.14. It must be clearly marked containment system packaging.

8.15. External parts of the sample must be clearly defined, in order to be able to simply and clearly to any of its part.

Test system integrity and shielding

and evaluating criticality safety

8.16. After each of the applicable tests specified in
Points 8.18-8.37:
a) must be detected and fixed problems and
damage;
b) must be established or continued integrity of
containment and protection to meet the requirements of section 5
the package under test;
c) for packages containing fissile material shall be
determined whether the assumptions and conditions used in the
assessments required under paragraphs 5.67-5.77 concerning
one or more packages.

The target for the drop tests

8.17. The target for the drop tests specified in
Points 8.5, 8.22, 8.25a), 8.27, 8.35, to be flat,
and a horizontal surface such that any increase in resistance
displacement or deformation of the surface in the fall by the specimen is
not
led to a significant increase damage to the specimen.

Testing of packagings intended to
uranium hexafluoride

8.18. Samples are either mimic packaging
Kits are designed to contain 0.1 kg or more
uranium hexafluoride, subjected to hydraulic test at
the internal pressure of at least 1.4 MPa, but if a trial
pressure is less than 2.8 MPa, the design required
multilateral approval. For packagings that
subjected to repeated tests, can be used any
other equivalent non-destructive testing method provided
multilateral approval.

Tests for demonstrating ability to withstand
normal traffic conditions

8.19. These tests include:
water spray;
Free drop test;
test for making a stack;
penetration test (penetration).
Samples must be subjected packagings
Free drop test, making the stack and penetration,
and before each of these tests should be conducted
water spray. For all tests can be used
one sample, provided that the requirement of paragraph 8.20.

8.20. The time interval between the end of trial
water spray and the next test should be such
that the water has absorbed most visible without drying
the outer surface of the sample. In the absence of any contraindications
this interval is assumed to be about two hours if the water
fed simultaneously from four directions. However, if the water
sprayed sequentially on each of the four directions, no
interval should not be.

8.21. Water spray test
The specimen shall be subjected to the test method
water spray that simulates stay for at least

one hour rainfall of approximately 5 cm per hour.

8.22. Free drop test

The specimen shall drop onto the target so that zavdavalasya Maximum security measures sorry packaging, tested:

a) drop height from the lowest point of the specimen to the top target surface must be at least the distance specified in Table 15 for the appropriate weight. The target must meet the requirements of paragraph 8.17;

b) For rectangular fibreboard or wood packages weighing not 50 kg, a separate specimen shall be subjected to the test free fall from a height of 0.3 m on each corner;

c) For cylindrical fibreboard packages not exceeding 100 kg a separate specimen shall be subjected to the test of free fall a height of 0.3 meters per quarter edge of the cylinder at each base.

Table 15 - Height of free fall during testing packages to normal conditions of carriage

Package mass (kg)	Free fall height (m)
Package mass <5000	1,2
5000 <= Package mass <10000	0,9
10000 <= Package mass <15000	0,6
15000 <= Weight Packaging	0,3

8.23. Tests on the conclusion stack

If the shape of the packaging does not preclude the conclusion stack, the sample is subjected to 24 hours of compression efforts, equal to or greater than:

a) The equivalent of 5 times the mass of the packaging;

b) The equivalent of 13 kPa vertical Square projection packaging.

The load must be distributed evenly to two opposite sides of the specimen, one of which must be the basis on which is packaging.

8.24. Penetration testing

The sample must be installed on a rigid horizontal flat surface that does not move during the test:

a) 3.2 cm diameter rod with a hemispherical end and a mass 6 kg dropped in free fall in the upright position its longitudinal axis towards the center of the weakest part sample so that if it penetrates sufficiently deep hit the containment system. In conducting test rod shall not be significantly deformed;

b) the height of drop of the bar measured from its lower end to the intended point of impact on the upper surface of the sample must be 1 m.

Additional tests for packagings of Type A, designed for liquids and gases

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8.25. A specimen or separate specimens shall be subjected to each of tests listed below, except when you can

prove that one of the tests are more difficult to sample, studied than the other; in which case one specimen to more difficult challenge:

a) Free drop test.

The specimen shall drop onto the target so that was inflicted maximum damage containment. The height of drop measured from the lowest part of the specimen to the upper surface target shall be 9 m. The target must meet the requirements § 8.17;

b) penetration test.

The sample should be subjected to the test, as provided for in paragraph 8.24, with the difference that the height of fall increases 1 m to 1.7 m.

Tests to verify the ability to withstand emergency conditions of carriage

8.26. The specimen shall be subjected to cumulative exposure testing in accordance with paragraph 8.27 and paragraph 8.28 in specified sequence. After these tests, the same or a different pattern shall be subjected to the test at ducking, as indicated in paragraph 8.29, and, if applicable, as set out in paragraph 8.30.

8.27. Tests for mechanical damage

Tests for mechanical damage consists of three various drop tests. Each specimen shall be subjected to corresponding drop test in accordance with paragraph 5.52 or § 5.77. Falls sample sequence should be such that after the test sample was mechanical damage caused such damage that would lead to the maximum damage in the thermal test which follows:

a) I like the fall must drop onto the target so that he received the maximum damage, and the height of the drop measured from the lowest point of the specimen to the upper surface target shall be 9 m. The target must meet the requirements § 8.17;

b) in the fall II design must fall to the pin, hard mounted vertically on a target so that sample suffer maximum damage. The height of drop measured from the intended point of impact specimen to the upper surface the probe must be 1 m. Pin must be made of mild steel and circular section diameter (15.0 + -0.5) cm 20 cm long unless at greater length probe will zavdavatysya more severe damage; in this case should used pin of sufficient length for the job maximum damage. The upper surface of the probe should be flat and horizontal radius of curvature of the edge is not more 6 mm. Target, which set the probe must meet the requirements of paragraph 8.17;

c) the fall III specimen shall be subjected to the test the dynamic destruction by placing the specimen on the target so so that it got maximum damage on the fall his body weight 500 kg from a height of 9 m. The body should be made of mild steel as a solid plate size 1x1 m and fall horizontally. The height of drop be measured from the bottom of the plate to the highest point of the sample. The target, which established pattern should comply with the requirements of paragraph 8.17.

8.28. Thermal tests. It shall be in heat balanced state at ambient

38 ° C environment in terms of solar insolation listed in
Table. 6, and with a maximum design speed of formation
internal heat inside the package from the radioactive contents.
Alternatively allowed to any of these options had other
importance to the trial and during it, provided that they are
properly taken into account in assessing the behavior of the next package.

The thermal test shall further include:

a) placing the sample in 30 minutes in the thermal environment in
which heat flow is at least equivalent to the heat
flow in the hearth burning hydrocarbon fuel in air
environment in which there are quite constant external conditions
environment for the average emission factor
flame of at least 0.9 with an average temperature of at least 800 ° C;
flame completely covers the sample, and the coefficient of surface
Acquisitions set equal to or 0,8 or that value which may
be confirmed for the packaging, which is located in
appointed burning cell and then

b) placing the sample in thermal environment with value
38 ° C in the solar insolation conditions specified in Table 6, and
at the maximum design speed of the internal allocation
Heat radioactive contents within the package at a time, sufficient
in order to make sure that the temperature in the sample
all places are reduced and / or close to initial conditions
steady state. Alternatively allowed to any of these
parameters have different values following cessation of heating provided
they will be properly taken into account at the next assessment
behavior of the package.

During and after the test specimen shall not be
artificially cooled and any combustion of materials of the specimen shall
occur naturally.

8.29. Tests immersion

It shall be under water of at
at least 15 m for at least eight hours at a position that
causes maximum damage. For demonstration purposes
it is assumed that these conditions external gauge pressure
at least 150 kPa.

Power immersion test packaging

5

sets of type B (U) and Type B (M), containing more than 10 A and

2

Type C packagings

8.30. Power immersion test

It shall be under water of at
at least 200 m for at least one hour. With demo
vvzhayetsya purpose that these conditions external gauge
pressure of at least 2 MPa.

Waterproof packaging test kits,
containing fissile material

8.31. From these tests should be exempt packing
kits for which to assess conformity with the provisions
listed in paragraphs 5.72-5.77, there was an assumption on the flow
Water leak inside her and in volume, which leads to
most of reactivity.

8.32. Before being subjected to the test provided below
to the water sample must be subjected to the tests
listed in paragraph 8.27b and or paragraph 8.27a, or 8.27c, according
the requirements of paragraph 5.77, and the test specified in

Paragraph 8.28.

8.33. It shall be under no water column less than 0.9 m at least eight hours in a position where expected maximum flow.

Test Type C packagings

8.34. Samples must be exposed to each of the following series tests conducted in the order listed:

a) the tests specified in paragraphs 8.27a, 8.27c, 8.35 and 8.36;

b) test specified in paragraph 8.37.

For each of the series "a" and "b" are permitted to use Various samples.

8.35. Test puncture / tear

The specimen shall be subjected to the ravages of solid probe made of mild steel. The provisions regarding probe sample surface must be such as to cause maximum damage at the conclusion of a series of tests listed in paragraph 8.34a:

a) on the target should position like that is packing weighing less than 250 kg, and on it from a height of 3 m above the intended point blow pin falling weight of 250 kg. For this test the probe shall be in the form of a cylindrical rod with a diameter of 20 cm, stroke end of which forms a truncated right circular cone with dimensions: height 30 cm and a diameter of 2.5 cm from the top radius rounded edge of 6 mm. The target, which is located sample must meet the requirements of paragraph 8.17;

b) For packages weighing 250 kg or more base probe attached to the target, and the sample falls on the probe. The height of the fall, measured from the point of impact to the upper surface of the sample probe, should be at 3 m. For this test properties and dimensions the probe must meet the requirements of paragraph "a", except the length and weight of the probe should be such that nanosylosya maximum damage to the specimen. The target, which is fixed basis of the probe must meet the requirements of paragraph 8.17.

8.36. Enhanced thermal test

The conditions of this test must meet the requirements § 8.28, except that of the sample in the heat environment should take 60 minutes.

8.37. Tests on collision

The specimen shall be subjected to contact with the target at a speed at least 90 m / s, and in a position to suffer maximum damage. The target must meet the requirements § 8.17, except that the target surface may be present in any position, but it should be perpendicular to the trajectory of the sample.

Chapter 9. Approval and administrative requirements

Terms

9.1. For laid-off construction of packagings are does not require the issuance of a certificate SCNS Ukraine approval shipper shall provide on request to SCNS inspection documentation of Ukraine design meets all of the packaging

applicable requirements.

9.2. Approval required SCNS Ukraine concerning:

a) structures:

i) special form radioactive material (see. paras 9.3, 9.4 and 9.18);

ii) radioactive material with a low capacity for scattering (see. paragraphs 9.3 and 9.4);

iii) packagings containing 0.1 kg or more uranium hexafluoride (see. § 9.5);

iv) All packagings containing fissile material (except fissile-released) (see. paras 9.12-9.14, 9.16 and 9.17);

v) packaging sets type B (U) and Type B (M) (see. paras 9.6-9.11, 9.16 and 9.17);

vi) packaging sets of type C (see. paragraphs 9.6-9.8);

vii) packaging sets type IP-1, Type IP-2, Type IP-3 (See. Paragraphs 9.6-9.8);

viii) packaging sets of type A (see. paragraphs 9.6-9.8);

b) special conditions (see. paragraphs 9.24-9.26);

c) some traffic (see. paragraphs 9.20-9.23);

d) radiation protection program for special vehicles purpose (see. § 7.25a);

e) calculating values for radionuclides not listed in Table. 1 (see. § 4.3).

Reconciliation of Ukraine SCNS necessary regarding:

technical specifications on the packaging, radioactive material special form radioactive material with low dispersible;

programs and testing methods packagings special form radioactive material, radioactive material low dispersible.

Approval of special radioactive material Forms and radioactive material low dispersible

9.3. The design of the special form radioactive material requires unilateral approval. The design of radioactive material with low dispersible requires multilateral approval. In both cases the application shall also include:

a) A detailed description of the radioactive material or, if capsule and its contents; particularly should be specified as the physical, and chemical status;

b) a detailed description of the design of any capsule to be used;

c) A statement of the tests and their results or results based on calculations that radioactive material able to meet accepted standards, or other data that the radioactive material, or special form radioactive material with low dispersible satisfy the requirements of these Regulations;

d) detailed description of the quality assurance used required under paragraph 3.6; and

e) a description of any measures taken to transportation, the cargo of radioactive material special form radioactive material or low ability to scattering.

9.4. Nuclear Regulatory Committee of Ukraine shall issue a certificate of
approval stating that the design meets
requirements for special form radioactive material or
radioactive material, low dispersible, and
assigns this design an identification mark.

Approval of construction of packagings

Approval for construction of packagings
uranium hexafluoride

9.5. Approval for construction of packagings that
containing 0.1 kg or more of uranium hexafluoride, you need the following:

a) Each design that meets the requirements of paragraph 5.81,
require multilateral approval;

b) Each design that meets the requirements
5.78-5.80 points, requires unilateral approval
the competent authority in the home design if
multilateral approval in other cases not required
compliance with these provisions;

c) The application shall include all information
necessary to the competent authority that the
design meets the requirements of paragraph 5.78, and detailed
description appropriate quality assurance program as required in
Paragraph 3.6;

d) Nuclear Regulatory Committee of Ukraine shall issue a certificate of
approval stating that the design meets
the requirements of paragraph 5.78, and assigns this design identification
sign.

Approval of designs of packaging sets type IP-1,
Type IP-2, Type IP-3, Type A, Type B (U) and Type C

9.6. For each design packaging type IP-1,
Type IP-2, Type IP-3, Type A, Type B (U) and Type C is required
unilateral approval, except for the fact that:

a) to design the packaging type IP-2, type
IP-3, Type A, Type B (U), Type B (M) and Type C for fissile
material, which is also subject to the requirements of paragraphs 9.12-9.14,
require multilateral approval;

b) to design the packaging type B (U) to
radioactive material, low dispersible
require multilateral approval.

9.7. The application shall include:

a) A detailed description of the intended radioactive contents
indicating its physical and chemical composition and nature
radiation;

b) a detailed description of the design, including complete set
engineering and technical documentation (drawings), lists of materials,
used and methods of manufacture;

c) A statement of the tests and their results or
based on calculations or other data showing that
design adequately meets the applicable requirements;

d) the instruction manual and its packaging
service during use;

e) if the packaging is designed for maximum
Normal pressure gauge pressure greater than, equal
100 kPa - detailed structural materials systems
containment samples are to be taken, and the tests
Proposed;

f) If the radioactive content that is assumed is irradiated fuel, the applicant must specify and justify any assumptions concerning the characteristics of the fuel, made during analysis security, and a description of any measurement front carriage required under paragraph 5.69b;

g) a description of any special conditions making needed to safe dissipation of heat from the package considering using different modes of transport and the type of vehicle or transportation cargo container;

h) a reproducible illustration, not larger more than 21x30 cm, illustrating the layout of the packaging;

i) detailed description of the quality assurance used required under paragraph 3.6.

9.8. Nuclear Regulatory Committee of Ukraine shall issue a certificate of approval stating that the design meets requirements for packaging sets type IP-1, Type IP-2, Type IP-3, Type A, Type B (U) or Type C, and assigns this design identification mark.

Approval of designs of packaging sets type B (M)

9.9. Each packaging design type B (M) including construction, designed for fissile material, which also fall under the force requirements of paragraphs 9.12-9.14 and for radioactive material, low dispersible, require multilateral approval.

9.10. In addition to the information required in paragraph 9.7 for packaging sets type B (U), an application for approval packaging design type B (M) should include:

a) a list of the requirements specified in paragraphs 5.27, 5.49, and 5.50 5.53-5.60 how this packaging is not responsible;

b) details of any proposed supplementary operational controls to be applied during transportation, which, although not provided for in these Rules the usual way, but nevertheless required for security package or to compensate for shortcomings above in paragraph "a";

c) a statement of any restrictions on the type of transport and of any special procedures for loading, transportation, unloading or handling;

d) The range of ambient conditions (Temperature, solar radiation) expected during transportation and taken into account in the design.

9.11. Nuclear Regulatory Committee of Ukraine shall issue a certificate of approval stating that the design meets applicable requirements for packaging sets type B (M) and assigns this design an identification mark.

Approval for construction of packagings fissile material

9.12. For each design of the packaging, designed for fissile material requires multilateral approval.

9.13. The application shall include all information necessary to the competent authority that the

design meets the requirements of paragraph 5.67, and detailed description appropriate quality assurance program required in accordance with paragraph 3.6.

9.14. Nuclear Regulatory Committee of Ukraine shall issue a certificate of approval stating that the design meets the requirements of paragraph 5.67, and assigns this design identification sign.

Provisions for transition

Packaging for which approval is required design by the competent authority in accordance with the provisions of IAEA regulations edition 1985, edition of 1985 (revised in 1990)

9.15. Released packagings, industrial packaging sets type IP-1, Type IP-2 and IP-3 type and packing sets type A, which is not required for design approval the competent authority and which meet the requirements of the IAEA regulations Edition 1985 or Edition 1985 (revised in 1990) may continue to be used provided decision on them mandatory program of quality assurance accordance with paragraph 3.6 and compliance mentioned in Section 6 activity limits and restrictions on materials. Any packing kit that modified unless it was done to improve safety, or manufactured after December 31, 2003, must fully meet the requirements of this Edition Rules. Packaging prepared for transport no later than 31 December 2003 in accordance with the requirements of the IAEA regulations Edition 1985 or Edition 1985 (revised in 1990) may continue to be used for transportation. Packages prepared for transport after this date shall satisfy the requirements of this edition of the Rules.

Packaging approved under the provisions of IAEA regulations editions 1973, 1973 (revised) 1985 and 1985 (revised in 1990)

9.16. Packaging made pursuant to design approved by the competent authority in accordance with the provisions of the IAEA regulations edition 1973 or 1973 edition (Corrected) can remain in service provided: multilateral approval of design of the packaging, decision against them mandatory program of quality assurance accordance with the applicable requirements of Section 3.6; compliance specified in Section 6 activity limits and restrictions on materials and for packaging containing fissile material and transported by air transport - compliance with the requirements of paragraph 5.75. Production of new packagings are not permitted. With this modification or design of the packaging and features the number of authorized radioactive contents which, according to the competent authority, would significantly affect safety must completely fulfilled the requirements of this edition of the Rules. Each the packaging must be serialized in accordance with the requirements of paragraph 6.50, which is applied to the outer each surface of the packaging.

9.17. Packaging made pursuant to
design approved by the competent authority in accordance with
provisions of the Rules Edition 1985 or Edition 1985
(Revised in 1990) could be in operation by
Conditions: multilateral approval of design packaging
set, making them concerning the mandatory
quality assurance in accordance with the requirements of paragraph 3.6;
compliance
mentioned in Section 6 activity limits and restrictions on materials and
packaging containing fissile material and transported
air - compliance with paragraph 5.75. With this
modification or design of the packaging and features
the number of authorized radioactive contents which, according to
the competent authority, would significantly affect safety must
fulfilled the requirements of this edition of the Rules. All packaging
kits, production of which will begin after December 31, 2006
must satisfy the requirements of this edition of the Rules.

Radioactive material is a special form approved
according to IAEA regulations editions 1973, 1973
(Revised), 1985 and 1985 (revised in 1990)
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9.18. Radioactive material is a special form made
in accordance with the design for which was received unilateral
approval of the competent authority in accordance with IAEA regulations
Edition 1973 Edition 1973 (revised) edition 1985
year or edition of 1985 (revised in 1990) may
continue to be used subject to the decision against him
mandatory program of quality assurance in accordance with the
applicable requirements of paragraph 3.6. Any radioactive material
special form, made after December 31, 2003, should
satisfy the requirements of this edition of the Rules.

Notice of serial numbers and their registration

9.19. By SCNS Ukraine should be sent
message serial number of each packaging,
manufactured under construction, approved in accordance with
paragraphs 9.6, 9.9, 9.12 and 9.16-9.17.

Approval of transport

9.20. Multilateral approval is required for:

a) transport packaging type B (M), which does not comply
§ 5.27 or design which provides an opportunity
controlled periodic aeration;

b) transport packaging type B (M), containing radioactive
material with activity as the case of 3000 A or more
1
3000 A, or 1000 TBq, depending on which of the smaller quantities;
2

c) transportation of packages containing fissile material if
The sum of the criticality safety indexes in a freight packages
container or in a single vehicle traffic over 50. The exception in
this requirement is marine transportation vehicles, if the amount of codes
criticality safety does not exceed 50 in any of the holds, compartments
or on the deck of marked and the distance of 6 m between groups
packages or overpacks as required in Table. 13,
follows;

d) Radiation protection programs for shipments on vessels
Special purpose under paragraph 7.25a.

9.21. The competent authority may authorize transport to
through or into the country without approval
transportation, uklyuchyvshy special provision in this paper on
design approval (see. § 9.27).

9.22. An application for shipment approval shall include the following
data:
a) duration of transport for which approval is sought;
b) The actual radioactive contents, modes of transport,
provided, type of vehicle and the probable or transportation
to get;
c) a detailed statement of the exercise precautions
activities, and administrative or operational controls
referred to in the design approval certificates
packages issued in accordance with paragraphs 9.8, 9.11 and 9.14.

9.23. In approving transportation SCNS
Ukraine shall issue a certificate of approval.

Approval of transport in special circumstances

9.24. Each cargo is transported in special
conditions should be provided multilateral approval.

9.25. An application for approval of transportation in special
circumstances
must contain all information necessary to
the competent authority that that the overall level of security
the carriage of at least equivalent to that ensured
would be if all applicable requirements of these Regulations. Application
for
Approval must also include:
a) a list of deviations from the applicable requirements specifying
reasons why traffic can not be satisfied in full
compliance with these requirements;
b) A statement of any special precautions or
special administrative or operational controls to
to be employed during transport to compensate
failure to comply with applicable requirements.

9.26. In approving transport in special circumstances
Nuclear Regulatory Committee of Ukraine shall issue a certificate of
approval.

Certificates of approval
issued SCNS Ukraine

9.27. Nuclear Regulatory Committee of Ukraine issues five types
certificates of approval for special radioactive material
form radioactive material with a low capacity for
scattering on special conditions for transportation and the design
packaging. Approval certificate
the design of the packaging and the transportation can be
combined into a single certificate.
Competent authority identification mark

9.28. Each approval certificate issued
Nuclear Regulatory Committee of Ukraine, assigned an identification mark.
This sign has the general form:

VRI / number / type code

a) except as provided in paragraph 9.29b, VRI is
international distinctive vehicle registration code
the country that issued the certificate;

b) number is SCNS Ukraine, and specific
construction or transport must have a special
individual number. Approval identification mark
transportation must have a clear link with the identification mark
Approval of the design;

c) for certificates of approval issued should
these types of codes used in the following order:

IP-1 - the packaging design type IP-1

IP-2 - the packaging design type IP-2
[IF - for fissile material]

IP-3 - the packaging design type IP-3
[IF - for fissile material]

A - the packaging design type A

AF - design the packaging for Type A
fissile material

B (U) - the design of the packaging type B (U)
[B (U) F - for fissile material]

B (M) - the design of the packaging type B (M)
[B (M) F - for fissile material]

C - the packaging design type C
[CF - for fissile material]

S - special form radioactive material

LD - radioactive material with low resolution
dispersible

T - transportation

X - special conditions.

In the case of construction of packagings for undivided
material in the form of uranium hexafluoride or
fissile-material released in the form of uranium hexafluoride,
When not used any of the codes listed above,
codes, the following types:

H (U) - unilateral approval;

H (M) - multilateral approval;

d) certificates of design approval
packaging and special radioactive material
form, other than those issued under paragraphs 9.16-9.18,
as well as the approval certificates for radioactive material
low dispersible type code to be added
numbers "-96".

9.29. These type codes shall be applied as follows:

a) Each certificate and each of the packaging must
have appropriate identification mark, comprising the symbols

referred to in paragraphs 9.28a, b, c and d, for the exception that
concerning the packaging following the second stroke
must affix the appropriate codes only type of construction
numbers "-96", if applicable, that indexes "T" or "X" not
are distinctive sign on the packaging. If
Approval of the construction and transportation combined into a single
, the applicable type codes are not to be repeated
required. Example:

A / 132 / B (M) F-96: the design of the packaging type B (M)
approved for fissile material, which
requiring multilateral approval, for
which the competent authority of Austria has assigned the
number
construction 132 (marked on both the
the packaging and on the certificate
design approval packing
set);

A / 132 / B (M) F-96T: The shipment approval issued for a package
having given up token
(To be marked on the certificate only);

A / 137 / X: by the competent authority of Austria
approval of special conditions which assigned
Room 137 (to be marked only
certificate);

A / 139 / IF-96: An industrial packaging
for fissile material approved
the competent authority of Austria, which assigned
packaging design number 139
(To be marked both on the packaging,
and the certificate of approval
the design of the packaging);

A / 145 / H (U) -96: approved by the competent authority of Austria
design for packaging
fissile-material released in the form of
uranium hexafluoride, which assigned number
design packaging 145
(To be marked both on the packaging,
and on the approval certificate
the design of the packaging);

b) if the multilateral approval is effected
by confirmation in accordance with paragraph 9.34, it shall
used only the identification mark issued
country in the design or performing
transportation. Where multilateral approval is effected
by issue of certificates by successive countries, each
The certificate must bear the appropriate identification mark and
the packaging, the design of which is approved this
therefore, should have all the relevant markings.
Example:
A / 132 / B (M) F-96
CH / 28 / B (M) F-96
will be the hallmark of the packaging that initially
Austria was approved, and then approved by
issuance of a separate certificate Switzerland. Additional identification
Signs affixed on the packaging the same way;
c) review of the certificate shall be indicated by a
brackets after the identification mark on the certificate. Example,

A / 132 / B (M) F-96 (Rev.2) would indicate revision 2 approved
Austria Certificate to the design of the packaging; or
A / 132 / B (M) F-96 (Rev.0) - approved the initial issuance of Austria
certificate for the design of the packaging. If
the initial issuance of the parenthetical entry is optional and instead of
"Rev.0"
can also be used by other records, such as "initial
issued "(" original issuance "). The rooms viewing certificate
can be established only country that issued the original
certificate of approval;

d) Additional symbols (as may be required pursuant to
national requirements) may be added in parentheses at the end
distinctive sign, for example: A / 132 / B (M) F-96 (SP503);

e) change the identification mark on the packaging
Each review certificate for this construction is not necessary.
This change marks made only in cases where
review certificate for the design of the packaging draws
a change in the letter type codes for design of packing
kit, following the second stroke.

The approval of radioactive material
special form radioactive material and low capacity for
scattering

9.30. Each approval certificate radioactive
material is special form radioactive material or low
dispersible shall include the following:

a) Type of certificate;

b) competent authority identification mark;

c) the date of issue and validity;

d) list of applicable national and international requirements,
including the publication of IAEA Regulations for the Safe Transport
radioactive material, under which approved
special form radioactive material or radioactive material
low dispersible;

e) identification of the special form radioactive material or
radioactive material, low dispersible;

f) description of special form radioactive material or
radioactive material, low dispersible;

g) Design specifications for radioactive material
special form radioactive material or low resolution
dispersible, which may include references to drawings;

h) specification of the radioactive contents which includes information
about the
its activity and may include a description of the physical and chemical
forms;

i) a link to the software quality,
used required under paragraph 3.6;

j) Reference to information provided by the applicant on
special measures to be taken prior to shipment;

k) at the discretion of the competent authority - the name of the
applicant;

l) Signature and identification of the certifying official.

The approval of special conditions

9.31. Each approval certificate for special conditions
shall include the following:

a) Type of certificate;

b) competent authority identification mark;

c) the date of issue and validity;
d) the type or types of transport;
e) any possible restrictions on the modes of transport, such as means of transportation, freight container and any necessary instructions;
f) list of applicable national and international requirements, including the publication of IAEA Regulations for the Safe Transport radioactive material, under which approved special conditions;
g) the following statement:
"This certificate does not relieve the consignor from compliance any requirement of the government of any country through or whose territory will be transported packaging ";
h) References to certificates for alternative radioactive contents, other competent authority validation or additional technical data or information, as deemed appropriate competent authority;
i) description of the packaging by a reference to drawing or specification of the design. At the discretion of the competent Authority should be given also eligible to play graphic images no larger than 21x30 cm, illustrating the layout packaging, along with a brief description of the packaging kit, including description of construction materials, general mass, general outside dimensions and appearance;
j) specification of the authorized radioactive content, including any restrictions imposed on radioactive content and can not be from the nature of the packaging kit. This shall include the physical and chemical form, meaning activity (including, where appropriate, various isotopes), the amount in grams (for fissile material), and whether the material is radioactive material special form radioactive material or low resolution dispersible, if applicable;
k) except in respect of packages intended for fissile material:
i) a detailed description of the authorized radioactive contents;
ii) the index of criticality safety;
iii) reference to the documentation that proves safety content criticality;
iv) any special features, on which at criticality assessment was made assumptions about the lack of water certain cavities;
v) any allowance (based on the requirements of paragraph 5.69b) for a change in neutron multiplication assumed in the criticality assessment on the basis of actual exposure;
vi) the ambient temperature range for which approved special conditions;
l) A detailed listing of any additional measures operational controls required for preparation, loading, transporting, unloading and handling, including any special conditions for the purpose of making safe dissipation of heat;
m) at the discretion of the competent authority - the base for special conditions;
n) description of the compensating measures to be taken in Due to the fact that transportation will be by special conditions;
o) reference to information provided by the applicant on the use of the packaging or specific measures to be taken prior to shipment;
p) information on environmental conditions, taken the purpose of design if they meet the conditions paragraphs 5.49, 5.50 and 5.60, depending on what is applicable;

q) indication of any emergency measures that the competent authority considers necessary;
r) a link to the software quality, used required under paragraph 3.6;
s) at the discretion of the competent authority - the name of the applicant and carrier;
t) Signature and identification of the certifying official.

The approval transportation

9.32. Each approval certificate carriage issued the competent authority shall include the following:
a) Type of certificate;
b) competent authority identification mark;
c) the date of issue and validity;
d) a list of national and international regulations, including publication of the IAEA regulations for the safe transport of radioactive materials for which transportation is approved;
e) any restrictions on the modes of transport, such as means of transportation, freight container, and any necessary instructions;
f) the following statement:
"This certificate does not relieve the consignor from compliance any requirement of the government of any country through or whose territory will be transported packaging ";
g) A detailed listing of any additional measures operational controls required for preparation, loading, transporting, unloading and handling of cargo including any special conditions for the purpose of making safe dissipation of heat or the safety of criticality;
h) Reference to information provided by the applicant regarding special measures to be taken prior to shipment;
i) refer to the corresponding (i) certificate (s) of approval the design;
j) specification of the actual radioactive contents, including any restrictions on the radioactive contents which can not be from the nature of the packaging. It should include information about the physical and chemical forms, the total activity (including, where relevant, the activity of various Isotope), the amount in grams (for fissile material), and that, whether the material is special form radioactive material or radioactive material, low dispersible if applicable;
k) indication of any emergency measures that the competent authority considers necessary;
l) a reference to the program of quality assurance used required under paragraph 3.6;
m) at the discretion of the competent authority - the name of the applicant;
n) Signature and identification of the certifying official.

Certificate of packaging design approval Kit

9.33. Each approval certificate design packaging, issued by the competent authority shall include the following:
a) Type of certificate;
b) competent authority identification mark;

c) the date of issue and validity;

d) any possible restrictions on means of transport if it is necessary;

e) a list of national and international regulations, including publication of the IAEA regulations for the safe transport of radioactive material on which the design is approved;

f) the following statement:

"This certificate does not relieve the consignor from compliance any requirement of the government of any country through or whose territory will be transported packaging ";

g) References to certificates for alternative radioactive contents, other competent authority confirmation or additional technical data or information, as deemed appropriate competent authority;

h) provisions regarding the approval of transportation when shipment approval is required under paragraph 8.20, if deemed necessary;

i) Identification of the packaging;

j) description of the packaging by a reference to drawing or specification of the design. At the discretion of the competent Authority should be given also eligible to play graphic images no larger than 21x30 cm, illustrating the layout packaging, along with a brief description of the packaging kit, including description of construction materials, general mass, general outside dimensions and appearance species;

k) data structure with reference to the drawings;

l) specification of the authorized radioactive content, including any restrictions on the radioactive contents which can not be from the nature of the packaging. It should include information about the physical and chemical forms, the activity (including, where appropriate, the different activities Isotope), the amount in grams (for fissile material), and that, whether the material is special form radioactive material or radioactive material, low dispersible if applicable;

m) description of containment;

n) Additionally, for packagings intended for fissile material:

i) a detailed description of the authorized radioactive contents;

ii) description of containment;

iii) the index of criticality safety;

iv) references to documentation that proves safety of critical content packages;

v) any special features, on which at criticality assessment was made assumptions about the lack of water certain cavities;

vi) any allowance (based on requirements § 5.69b relative change in neutron multiplication made in the criticality assessment, based on the true story exposure;

vii) the ambient temperature range for which approved packaging design;

o) for packaging sets type B (M) - indication of paragraphs 5.27, 5.49, 5.50 and 5.53-5.60, which this package is not responsible, and any additional information that may be useful to other competent authorities;

p) For packages containing more than 0.1 kg of uranium hexafluoride, specifying the provisions of paragraph 5.81 that are used, if any is, and any additional information that may be useful for other competent authorities;

q) A detailed listing of any additional measures operational controls required for preparation, loading, transporting, unloading and handling,

including any special conditions for the purpose of making
safe dissipation of heat;

r) Reference to information provided by the applicant in respect
the use of the packaging or specific measures
to be taken prior to shipment;

s) data environments taken to
design if they meet the conditions
paragraphs 5.49, 5.50 and 5.60, depending on what is applicable;

t) a link to the software quality,
used required under paragraph 3.6;

u) an indication of any emergency measures that the competent
authority considers necessary;

v) by the competent authority - the name of the applicant;

w) Signature and identification of the certifying official.

Confirmation certificates

9.34. Multilateral approval may be by
confirm the original certificate issued by the competent
authority of the country in which the design or exercises
transportation. Such evidence may take the form of approval
original certificate or the issuance of a separate endorsement, annex,
additions, etc. the competent authority of the country through
or into which the shipment is made.

Head of Security
traffic management guarantees
and transport safety V.V.Sakalo

Addition
§§ 6.41, 6.53, 6.62
nuclear Rules
and radiation safety
the carriage
radioactive materials
(PBPRM 2006)

FACTORS
CI ratio and prefixes

In these Rules the International System of units
units (CI). Below are the rates for value
Common Units.

Units of radiation

Activities in becquerels (Bq) or curie (Ci)

$$1 = 3{,}7 \times 10^{10} \text{ Bq}$$

$$1 \text{ Bq} = 2{,}7 \times 10^{-11} \text{ Key}$$

Equivalent dose in sievert (Sv) or Blessing

$$\text{March } 1 = 1{,}0 \times 10^{-2} \text{ Sv}$$

1 Sv = 100 in March

Pressure

Pressure in Pascal (Pa) or (kgf / cm)

$1\ kg / cm = 9{,}806 \times 10^{4}\ Pa$

$1\ Pa = 1{,}020 \times 10^{-5}\ kgf / cm$

Conductance

Conductivity in siemens per meter (S / m)
or inverse ohms per centimeter (mo / cm)
10 mkmo / cm = 1 mS / m, or

$1\ IU / cm = 100\ cm / m$

$1\ cm / m = 10^{-2}\ IU / cm$

Prefixes and designation of units of CI

Desyatychni and Dolni multiple units can be formed by prefixes or symbols that are put before name or in front of the unit and have The following values:

|

Начальник відділу безпеки
перевезень Управління гарантій
та безпеки перевезень В.В.Сакало

3282/5000

Mnozhnyk	Prefiks	Poznachennya
18		
1 000 000 000 000 000 000 = 10	eksa	E
15		
1000 000 000 000 000 = 10	peta	P
12		
1 000 000 000 000 = 10	tera	T
9		
1000 000 000 = 10	hiha	H
6		
1000 000 = 10	meha	M
3		
1000 = 10	kilo	k
2		

100 = 10	hekto	h
1		
10 = 10	deka	da
-1		
0,1 = 10	detsi	d
-2		
0,01 = 10	santi	s
-3		
0,001 = 10	mili	m
-6		
0,000 001 = 10	mikro	mk
-9		
0,000 000 001 = 10	nano	n
-12		
0,000 000 000 001 = 10	piko	p
-15		
0,000 000 000 000 001 = 10	femto	f
-18		
0,000 000 000 000 000 001 = 10	atto	a

Multiplier	Prefix	Designation
18		
1 000 000 000 000 000 000 = 10	exa	E
15		
1000 000 000 000 000 = 10	PETA	AP
12		
1 000 000 000 000 = 10	tera	T
9		
1000 000 000 = 10	giga	G
6		
1000 000 = 10	mega	M
3		
1000 = 10	kilo	to
2		
100 = 10	hecto	g
1		
10 = 10	deck	yes
-1		
0.1 = 10	deck	d
-2		
0.01 = 10	Santi	s
-3		
0,001 = 10	milli	m
-6		
0,000 = 10 001	micro	mK
-9		
= 0.000 000 001 10	nano	n
-12		
0,000 000 000 001 = 10	pico	n
-15		
0,000 000 000 000 001 = 10	femto	f

| -18 | | |
| 0,000 000 000 000 000 001 = 10 | Atto | and

Head of Security

traffic management guarantees

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and transport safety V.V.Sakalo