UKRAINE

NATIONAL REPORT

On Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

KYIV 2017

FOREWORD

Ukraine signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (hereinafter the Joint Convention) on 29 September 1997 and was one of the first countries to ratify it by the Law of Ukraine on 20 April 2000.

After the Joint Convention came into force, Ukraine became an active participant of all processes and events under the Joint Convention in order to fulfill its tasks. The First, Second, Third, Fourth and Fifth National Reports of Ukraine were presented to the Contracting Parties of the Joint Convention at Review Meetings. The comments and recommendations of the review processes are incorporated in national action plans in the area of nuclear energy as regards improvement of spent nuclear fuel and radioactive waste management system.

The Sixth National Report has been developed by the State Nuclear Regulatory Inspectorate of Ukraine in full compliance with requirements of the Joint Convention and Guidelines Regarding the Form and Structure of National Reports INFCIRC/604/Rev.3 with amendments, as well as the Summary Report of the Fifth Review Meeting of the Contracting Parties (JC/RM5/04/Rev2).

By submission of National Reports, Ukraine fulfills its obligations according to Article 32 of the Joint Convention.

This Report, as well as the previous ones, is based on legislative and regulatory documents in force in Ukraine and official reports of state executive bodies responsible for the national policy in nuclear energy use and regulation and radioactive waste management as well as operating organizations (operators).

The key objective of this Report is to provide objective information to the Contracting Parties of the Joint Convention and to the public of Ukraine regarding the safety of spent fuel management and the safety of radioactive waste management and actions taken to protect personnel, the public and the environment against hazardous effects of radiation. The Report highlights the changes and progress in the legislative and regulatory framework since the Fifth Review Meeting and identifies prospects and plans for further development and issues to be resolved.

Based on this Report and according to the powers entrusted by the Cabinet of Ministers of Ukraine, the Acting Chairman of the State Nuclear Regulatory Inspectorate of Ukraine declares the following:

Ukraine adheres to the principle of priority to safety of people and the environment at all stages of spent fuel and radioactive waste management in the area of nuclear energy and radiation safety.

In this regard, *Ukraine completely fulfills its obligations under the Joint Convention*, which is proved by:

- establishment and development of the legislative and regulatory framework of safety in the area of nuclear energy;
- functioning of the state nuclear regulatory body with relevant competence, which establishes safety requirements and criteria, develops and approves standards and regulations on nuclear and radiation safety, conducts licensing and state supervision and applies legislative enforcement measures in case of incompliance;
- independence of the state nuclear regulatory body from other state authorities, establishments, enterprises and officials that deal with nuclear energy and independence from local authorities and public associations;

– safety assessments and reviews of existing and new spent fuel and radioactive waste management facilities and measures to improve safety and security;

– development of the emergency preparedness and response system;

– full responsibility of the licensee for safety and measures intended to protect people and the environment;

– development of safety culture and implementation of safety self-assessment practices.

The actual data in this Report, except for those specially stated, are provided as of 1 July 2017. The changes to take place by May 2018 will be additionally reported by the Ukrainian Delegation at the Sixth Review Meeting.

Kyiv, September 2017

Borys Stolyarchuk
Acting Chairman
State Nuclear Regulatory Inspectorate of Ukraine

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

Baryer	State Enterprise *Baryer*
CCMEZ	State Specialized Enterprise for Capital Construction Management of the Exclusion Zone
ChNPP	State Specialized Enterprise *Chornobyl Nuclear Power Plant*
CLTSF	Centralized Long-Term Storage Facility for Radiation Sources
CRME	State Specialized Enterprise *Centralized Radioactive Waste Management Enterprise*
CSFSF	Centralized Spent Fuel Storage Facility for RNPP, KhNPP, SUNPP
DRS	Disused Radiation Sources
DSFSF	Dry Spent Fuel Storage Facility
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIA	Environmental Impact Assessment
Energoatom	National Nuclear Energy Generating Company *Energoatom*
ENSDF	Engineered Near-Surface Disposal Facility for Solid Radioactive Waste on *Vektor* Site
HLW	High-Level Waste
IAEA	International Atomic Energy Agency
ICSRM	Industrial Complex for Solid Radioactive Waste Management at ChNPP
INSC	European Commission Instrument for Nuclear Safety Cooperation
IRRS	Integrated Regulatory Review Service
ISF	Interim Spent Fuel Storage Facility
KhNPP	Khmelnitsky Nuclear Power Plant
LRSF	Liquid Radioactive Waste Storage Facility
LRTP	Liquid Radioactive Waste Treatment Plant at ChNPP
LRW	Liquid Radioactive Waste
LSRSF	Liquid and Solid Radioactive Waste Storage Facility
MECI	Ministry of Energy and Coal Industry of Ukraine
MENR	Ministry of Environment and Natural Resources of Ukraine
MHU	Ministry of Health of Ukraine
NPP	Nuclear Power Plant
NRI	Nuclear Research Institute, National Academy of Sciences of Ukraine
NRU	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)
NSC	Shelter New Safe Confinement
PChP	Industrial Association *Prydniprovsk Chemical Plant*
Radwaste	Radioactive Waste
RBMK	Light-Water Graphite-Moderated Channel-Type Reactor
RICS	Radioactive Waste Interim Confinement Site in the Exclusion Zone
RL	Reference Level
RNPP	Rivne Nuclear Power Plant
RWDS	Radioactive Waste Disposal (Storage) Site
SAEZ	State Agency of Ukraine on Exclusion Zone Management
SAR	Safety Analysis Report

SFA	Spent Fuel Assembly
SFP	Spent Fuel Pool
SIP	Shelter Implementation Plan
SISP	State Interregional Specialized Plant for Radioactive Waste Management of UkrDO *Radon*
SkhidGZK	State Enterprise *Eastern Ore Mining and Processing Plant*
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SRSF	Solid Radioactive Waste Storage Facility
SRTP	Solid Radioactive Waste Treatment Plant included into ChNPP ICSRM
SRW	Solid Radioactive Waste
SRW-1, SRW-2	Near-Surface Radioactive Waste Disposal Facilities on *Vektor* Site
SSR	Storage Site for Radwaste Resulting from Decontamination and Sanitary Treatment of Vehicles
SUNEI	Sevastopol National University for Nuclear Energy and Industry
SUNPP	South Ukraine Nuclear Power Plant
UkrDO *Radon*	Ukrainian State Association *Radon*
USCPS	Unified State Civil Protection System
Vektor	Industrial *Vektor* Site for Decontamination, Transport, Treatment and Disposal of Radioactive Waste in Chornobyl Exclusion Zone
VTS	Vehicle Sanitary Treatment Site
VVER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

EXECUTIVE SUMMARY

Radioactive Waste Management

Ukraine has the Strategy for Radioactive Waste Management[1] that was developed for 50 years. The status of radwaste management in Ukraine was analyzed and best international practices and IAEA and European Union safety standards were taken into account in developing the Strategy.

Specific tasks under the Strategy are performed according to:

- National Target Environmental Program for Radioactive Waste Management[2] to be implemented by 2017;
- National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System[3].

In the period after the Fifth Meeting of Contracting Parties to the Joint Convention, a number of tasks and measures were implemented under the Strategy and national programs.

Radioactive waste treatment plants are under construction at operating NPPs in order to minimize waste amounts and reach the state acceptable for disposal or long-term storage in central storage facilities at the Vektor site:

- at Zaporizhzhya and Rivne NPP, a significant part of equipment for the treatment plants has already been supplied, mounting and acceptance tests are underway, and plant lines are to be put into trial commercial operation in 2017;
- at Khmelnitsky and South Ukraine NPPs, buildings for future location of the plants have been inspected and plant designs have been developed, subjected to state review and, upon review results, have been approved according to the established procedure;
- a search for safe technologies for immobilization of salt fusion cake generated at liquid radwaste deep evaporation facilities into a solid matrix is underway;
- selection of a technology for processing of evaporation bottoms without production of salt fusion cake is ongoing.

Chornobyl NPP:

- decommissioning of units 1, 2, 3 and dismantling of systems and equipment are underway;
- construction of the New Safe Confinement for the Shelter is in its final stage;
- radwaste management infrastructure is under development;
- temporary storage facility for packages with high-level and long-lived waste is in operation within ICSRM;
- solid radioactive waste treatment plant within ICSRM is under commissioning;
- liquid radioactive waste treatment plant is under commissioning;
- line for fragmentation of high-level long-length components retrieved from the reactor compartments is being mounted;
- plant for manufacture of metal drums and reinforced concrete containers for radioactive waste is in operation;
- additional ChNPP radioactive waste treatment facilities are being designed: facility for liquid radwaste treatment to remove organic compounds and transuranium elements, areas for storage, fragmentation and decontamination of dismantled structures, facilities for release of dismantled materials from regulatory control.

[1] Agreed by Cabinet Resolution No. 990-r of 19 August 2009
[2] Approved by Law of Ukraine No. 516-VI of 17 September 2008
[3] Approved by Law of Ukraine No. 886-VI of 15 January 2009

Vektor site: (15 km south-west from ChNPP):

- engineered near-surface disposal facility for ChNPP radwaste packages is in operation;
- construction of two near-surface disposal facilities for solid radwaste, SRW-1 and SRW-2, is in its final stage;
- development of the infrastructure required to ensure safe operation of the disposal facilities is under completion;
- centralized facility for long-term storage of disused radiation sources has been completed and is under commissioning;
- storage facility for vitrified high-level radwaste resulting from reprocessing of spent fuel from Ukrainian NPPs to be returned from the Russian Federation and radwaste treatment facility are being designed.

Chornobyl Exclusion Zone (not considering ChNPP and Vektor site):

- measures on radiation monitoring and monitoring of the environment within the exclusion zone are taken on a permanent basis according to the agreed procedure;
- near-surface radwaste disposal facilities of RWDS *Buryakivka* are under operation, this RWDS is planned to be expanded;
- projects have been implemented to stabilize and improve safety of facilities where radwaste was placed in the first years after the Chornobyl catastrophe, namely RWDS *Pidlisny*[4] and *ChNPP Stage III*[5];
- survey of the radioactive waste interim confinement sites (RICS)[6] is ongoing to find/specify locations of trenches and pits with radwaste, effect of RICS has been reassessed to optimize further decisions on their remediation, radwaste retrieval from the most hazardous trenches and pits is underway.

Measures are under implementation at UkrDO *Radon* SISPs to:

- convert and reequip specialized plants into facilities for collection and temporary storage of radwaste;
- reassess and improve safety of operating and shut down legacy storage facilities;
- create new radwaste management facilities;
- renovate the fleet of vehicles and containers;
- upgrade radiation monitoring and physical protection systems.

Spent Fuel Management

There are VVER-1000 (13) and VVER-440 (2) reactors in operation at Ukrainian NPPs. The spent fuel management systems of these reactors includes handling equipment for reactor loading and unloading and transport containers, as well as spent fuel pools.

[4] RWDS *Pidlisny* was constructed within the emergency mitigation measures after the Chornobyl accident. From the end of 1986 to the end of 1988, the most hazardous high-level and long-lived waste was placed in modules A-1 and B-1 of this RWDS.

[5] RWDS *ChNPP Stage III* was constructed within the emergency mitigation measures after the Chornobyl accident in the partially constructed facility for solid radioactive waste of non-completed ChNPP *Stage III*. From the end of 1986 to the end of 1988, low- and intermediate-level waste was placed in reinforced concrete modules of this facility and bunding was constructed.

[6] RICS includes territories adjacent to ChNPP with a total area of 10 ha, where trenches and pits for radwaste confinement were constructed within the emergency mitigation measures after the Chornobyl accident. The estimated number of RICS trenches and pits is from 800 to 1000, accurate locations of some of them should be specified.

The Energy Strategy of Ukraine until 2035 "Safety, Energy Efficiency, Competitiveness" (Energy Strategy), which was approved by Cabinet Resolution No. 605-r of 18 August 2017, establishes both design procedure for spent fuel management (transport of spent fuel for reprocessing to the Russian Federation) and procedure that envisages long-term storage of spent fuel with subsequent approval of the final decision on its reprocessing or disposal.

The following efforts are planned for VVER spent fuel management:

- transport of spent fuel from Rivne, Khmelnitsky and South Ukraine NPPs for temporary storage and processing until the centralized spent fuel storage facility is commissioned in Ukraine;
- safe operation of the dry spent fuel storage facility at Zaporizhzhya NPP;
- construction and safe operation of the centralized dry storage facility for spent fuel of VVER-440 and VVER-1000 of operating NPPs and spent fuel of new nuclear units.

Since Zaporizhzhya DSFSF Stage I, which was put into commercial operation in 2004, was filled in accordance with the design (100 containers), DSFSF Stage II with design capacity of 280 containers was commissioned in December 2011.

Construction of the centralized dry spent fuel storage facility:

- on 4 February 2009, Cabinet Resolution No. 131-r approved the Feasibility Study for the centralized spent fuel storage facility (CSFSF) for storage of 16,529 spent fuel assemblies for 100 years;
- on 9 February 2012, the Verkhovna Rada of Ukraine approved the Law of Ukraine "On Spent Fuel Management for Siting, Design and Construction of the Centralized Dry Storage Facility for Spent Fuel of Ukrainian NPPs with VVER Reactors". The Law also defines the territory of its location in the exclusion zone;
- design and exploration efforts were completed to construct CSFSF and access roads;
- on 07 June 2017, Cabinet Resolution No. 380-r approved the project "Construction of the Centralized Storage Facility for Spent Nuclear Fuel of VVER of National Nuclear Power Plants"
- on 29 June 2017, the SNRIU provided the *Energoatom* Company, as an operating organization, with license No. EO 001060 to perform activities on a lifecycle stage "construction and commissioning" of the nuclear installation the centralized storage facility for spent nuclear fuel of VVER of national nuclear power plants (CSFSF).

Energoatom is the operating organization of CSFSF.

Energoatom continues efforts to upgrade spent fuel management systems at NPPs in order to include containers envisaged by the CSFSF design into transport flow charts for spent fuel management.

Management of Chornobyl NPP RBMK spent fuel:

- construction of dry spent interim fuel storage facility ISF-2 is underway at ChNPP;
- measures to upgrade and improve safety of existing wet interim spent fuel storage facility ISF-1 are implemented.

Stress tests

After the Fukushima-1 accident in Japan, the European Council offered to hold targeted safety reassessment of nuclear power plants in European Union member states

using stress tests. The operating organization implemented the following measures in the area of spent fuel management in the light of the lessons learnt from Fukushima-1 accident:

- analysis of effects from external natural hazards on reactors and spent fuel pools of each Ukrainian NPP site;
- additional safety assessment of ZNPP DSFSF.

In addition, natural hazards peculiar to the CSFSF site and their potential impact on safety of its storage facility were analyzed in the CSFSF design. The analysis showed that these impacts would not challenge the limits of CSFSF safe operation preliminary identified in the CSFSF Feasibility Study.

Information on stress tests at Zaporizhzhya DSFSF, ChNPP, CSFSF and operating NPPs is provided in Subsections B.2.1, G.2.1, G.3.1 and K.3 of this Report.

Section A

A.1. Introduction

The safe management of spent fuel and radioactive waste is one of the most important factors in sustainable development of nuclear energy in the State according to the Energy Strategy of Ukraine by 2035, including application of nuclear technologies in medicine, science and industry.

Ukraine, as a Contracting Party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, ensures implementation of provisions under the Joint Convention according to its objective and IAEA safety fundamentals.

The years that passed since the previous Fifth Review Meeting of the Contracting Parties were full of events that will have an impact on the nuclear and radiation safety of our state not only in the coming years. They will also have long-term effects.

The signing of the Association Agreement between Ukraine and the European Union significantly promoted activities on the adaptation of the Ukrainian legislation to the European legislation on the safe nuclear energy use. The SNRIU developed and at the beginning of 2015 the Government of Ukraine approved the plans for implementation of EU legislative acts on nuclear and radiation safety: Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel, and Council Directive 2014/87/Euratom establishing a Community framework for the nuclear safety of nuclear facilities.

The main step towards Ukraine's transfer to EU standards in the regulation of nuclear and radiation safety occurred on 26 March 2015, when the State Nuclear Regulatory Inspectorate of Ukraine obtained a full membership in the Western European Nuclear Regulators Association (WENRA). Participation in WENRA allows Ukraine to improve national nuclear and radiation safety legislation in accordance with EU standards (WENRA reference levels), and to participate in their development.

Efforts are ongoing on the improvement of authorizing procedures, bringing them in compliance with Ukrainian laws considering international documents and best practice of other countries. A number of draft laws aimed at reducing regulatory pressure and eliminating problems that arose as a result of ignoring the peculiarities of the nuclear industry in the deregulation process were developed.

The existing practice to ensure the safety of spent fuel and radioactive waste management, national strategies, plans and programs for further development of the system for spent fuel and radioactive waste management and major events and changes that took place after the Fifth Meeting of the Contracting Parties to the Joint Convention are highlighted in the relevant sections of this Report.

The Report includes information on the improvement of the legislative and regulatory system of spent fuel and radioactive waste management, system for administration of spent fuel and radioactive waste management, emergency preparedness, personnel training, financial resources, quality assurance, decommissioning, international cooperation and improvement of safety in spent fuel and radwaste management.

Annexes to the Report also present:

- list of existing spent fuel and radwaste management facilities, and nuclear facilities being decommissioned;
- inventories of spent fuel and radioactive waste subject to the Joint Convention;.
- dynamics of radiation safety indicators;

- list of regulations approved in the reporting period;

- information on Shelter safety and implementation of measures to transform the Shelter into an environmentally safe system, including construction of the New Safe Confinement;

- data on waste from uranium mining and milling industry.

In the period after submission of the previous National Report, from 2014 to September 2017, the following major events and measures took place:

- on 01 July 2014, the first Swedish-Norwegian-Ukrainian consultations were conducted on launching of a trilateral initiative aimed at improving nuclear and radiation safety in Ukraine, which was proclaimed during the Nuclear Safety Summit held in March 2014 in the Hague;

- on 02 August 2014, Cabinet Resolution No. 363 approved the Provision on the State Nuclear Regulatory Inspectorate of Ukraine;

- on 13 August 2014, Cabinet Resolution No. 336 defined competent national authorities on emergency preparedness and response;

- on 09 September 2014, the Ministry of Justice of Ukraine registered SNRIU order on the approval of a new revision of Safety Conditions and Requirements (Licensing Conditions) for Conducting Activities on Radioactive Waste Management;

- on 16 September 2014, the Verkhovna Rada of Ukraine and the European Parliament ratified the Association Agreement between Ukraine, on the one hand, and European Union, the European Union, the European Atomic Energy Community and their Member States, on the other hand;

- on 11 December 2014, the SNRIU provided Chornobyl NPP with an individual permit OD No. 000040/7 for the operation of LRTP;

- on 29 December 2014, the SNRIU made a positive decision on the possibility of further operation of research reactor VVR-M of the Institute for Nuclear Research of the National Academy of Sciences of Ukraine till 31 December 2023;

- on 18 February 2015, Cabinet Resolution No. 110-r approved the plans for implementation of EU legislative acts on nuclear and radiation safety: Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel, and Council Directive 2014/87/Euratom establishing a Community framework for the nuclear safety of nuclear facilities;

- on 26 March 2015, Ukraine and WENRA (Western European Nuclear Regulatory Association) member states signed the guideline document of the Association and on this day the State Nuclear Regulatory Inspectorate of Ukraine became a full member of WENRA;

- on 31 March 2015, the SNRIU provided Chornobyl NPP with an individual permit OD No. 000040/8 to conduct activities on the stage of final closure of ChNPP-1, 2, 3;

- on 11-12 May 2015, the National Report of Ukraine was presented during the Fifth Review Meeting of Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;

- on 01 June 2015, the Central Analytical Laboratory of the Ecocenter and Mobile Laboratory Unit of CRME were opened;

- on 24 July 2015, activities were completed on the construction and mounting of systems and equipment of the centralized long-term storage facility for radiation sources (CLTSF);

- on 19 August 2015, SNRIU amended Dnipropetrovsk SISP license OV No. 000948 for the right to conduct activities on radioactive waste processing and storage, which allowed operation of the mobile units of equipment for the safe removal of disused radiation sources from shielding of BGI and E types;

- on 01 January 2016, new revision of the branch "Concept for Decommissioning of Operating Nuclear Power Plants of Ukraine" approved by Order of the Ministry of Energy and Coal Industry of Ukraine No. 798 of 10 December 2015 came into force;

- on 04 February 2016, the SNRIU provided Chornobyl NPP with an individual permit OD No. 000033/10 for operation of the integrated automated control system of the Shelter;

- on 25 March 2016, the SNRIU provided CRME with license No. OV 001050 for the right to conduct activities on processing and storage of radioactive waste, namely, operation of the centralized long-term storage facility for radiation sources with regard to comprehensive hot tests;

- on 14 April 2016, the SNRIU provided Chornobyl NPP with an individual permit series OD No. 000040/9 to perform activities and operations on unloading of damaged spent nuclear fuel from Units 1 and 2 and its transfer to ISF-1 for safe placement and storage;

- on 04 May 2016, Order of the Ministry of Coal Industry of Ukraine No. 294 approved the project "Construction of Processing Plant for Rivne NPP Radioactive Waste (Correction)";

- on 01 July 2016, Order No. 81 of the State Agency of Ukraine on Exclusion Zone Management approved the Feasibility Study for Construction of the Interim Storage Facility for Vitrified HLW Returned from the Russian Federation after Processing of Spent Nuclear Fuel of Ukrainian NPPs;

- on 28 July 2016, the SNRIU approved results of periodical safety review of dry spent fuel storage facility at Zaporizhzhya NPP (DSFSF);

- on 22 November 2016, a new agreement on cooperation between the State Nuclear Regulatory Inspectorate of Ukraine and Swedish Radiation Safety Authority on the nuclear and radiation safety cooperation was signed;

- on 29 November 2016, the New Safe Confinement was transferred from the mounting zone and put into the design position above Chornobyl NPP Shelter;

- on 06 December 2016, the SNRIU approved Chornobyl NPP decision "On the Recognition of Chornobyl NPP Units 1, 2, 3 in the Decommissioning Process as Radioactive Waste Management Facilities";

- on 02 February 2017, Order No. 93 of the Ministry of Energy and Coal Industry of Ukraine approved the project "Construction of the Solid Radioactive Waste Processing Plant (Correction) of SUNPP";

- on 05 April 2017, Cabinet Resolution No. 239-r approved the project "Zaporizhzhya NPP. Creation of Radioactive Waste Processing Plant. Reconstruction. Correction";

- on 05 April 2017, Cabinet Resolution No. 240-r approved the project "Construction of Radioactive Waste Processing Plant for KhNPP of the *Energoatom* Company";

- on 07 June 2017, Cabinet Resolution No. 380-r approved the project "Construction of the Centralized Storage Facility for Spent Nuclear Fuel of VVER of National Nuclear Power Plants";

- on 29 June 2017, the SNRIU provided the *Energoatom* Company with license No. EO 001060 for the right to conduct activities on the lifecycle stage "construction and commissioning" of a nuclear facility (centralized storage facility for spent nuclear fuel of VVER of national nuclear power plants);

- on 11 July 2017, Law of Ukraine "On Amendments to Article 4 of the Law of Ukraine "On Radioactive Waste Management" on Improving Mechanism for Financing of

Radioactive Waste Management" and Law of Ukraine "On Amendments to the Budget Code of Ukraine on Improving Mechanism for Financing of Radioactive Waste Management Activities" were adopted;

- on 25 July 2017, Order No. 98 of the State Agency of Ukraine on Exclusion Zone Management approved the project on construction of the interim storage facility for HLW returned from the Russian Federation after processing of spent nuclear fuel of Ukrainian NPPs;

- on 22 August 2017, the Ministry of Justice of Ukraine registered the SNRIU Order "On Approval of General Safety Provisions on Predisposal Radioactive Waste Management".

A.2. Basic Conclusions from the Fifth Review Meeting

During the Fifth Review Meeting, the Contracting Parties noted the progress of Ukraine for the time since the Fourth Review Meeting regarding the development of infrastructure for safe spent nuclear fuel and radioactive waste management.

First of all, the following issues were covered:

- improve infrastructure of radioactive waste management at operating NPPs, including design and construction of solid radioactive waste processing plants;
- implement the project on the New Safe Confinement of Chornobyl NPP Shelter (NSC): demonstrated performance of a significant amount of activities related to the construction and mounting of NSC structures, systems and components;
- complete construction of Chornobyl NPP ISF-2;
- implement projects related to safety improvement of RWDS Pidlisny and planning of a similar project for RWDS ChNPP Stage III;
- construct the centralized long-term storage facility for disused radiation sources at the *Vector* site;
- complete commissioning and start operation of a number of facilities intended for radioactive waste management at Chornobyl NPP;
- enhance potential and improve qualification of personnel of the state nuclear regulatory body – SNRIU;

conduct efforts on the retrieval of disused radiation sources from the sites of bankrupt enterprises and their transport to specialized radioactive waste management enterprises for safe storage.

The following challenges were defined for Ukraine:

- completion of the New Safe Confinement for the Chornobyl NPP Shelter;
- construction of first-priority facilities for radwaste and spent fuel management in the exclusion zone, including design and construction of the CSFSF and design and construction of the facility for long-term storage of vitrified HLW resulting from VVER-440 spent fuel reprocessing.

Based on review of the National Report of Ukraine (NRU-2014), the Contracting Parties proposed for the next three-year period to pay special attention to measures planned and ongoing under national and departmental programs and adopted decisions, in particular:

- complete construction of the New Safe Confinement for the Chornobyl NPP Shelter;
- construct first-priority facilities for radwaste and spent fuel management in the exclusion zone, including design and construction of the CSFSF and design and construction of the facility for long-term storage of vitrified HLW resulting from VVER-440 spent fuel reprocessing in the Russian Federation;

- develop conceptual plans for future use and status of the exclusion zone and define need for consideration of other countries' opinion in further development of the conceptual plans for the exclusion zone, such as countries that suffered from the Chornobyl catastrophe, particularly Belarus;

- continue safety reassessment of UkrDO *Radon* SISPs and implement improvement measures if needed.

Information on the progress reached on these challenges and recommendations is summed up in Subsection K.1 of this Report.

In addition, NRU-2017 took into account issues common for the Contracting Parties defined in the Final Summary Report of the Fifth Review Meeting (JC/RM5/04/Rev2.), in particular:

- - staffing, advanced training of personnel, funding reliability and other issues related to human resources;
- provision and extension of public participation in radioactive waste management activities and involvement of the public in such an activity in order to secure the trust of the society and guarantee the social acceptance of the stated activity;
- development and implementation of the comprehensive and stable strategy of radioactive waste and spent nuclear fuel management at an early stage;
- management of disused sealed radiation sources.

Section B. POLICES AND PRACTICES (Article 32, Para. 1)

In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

i) spent fuel management policy;
ii) spent fuel management practices;
iii) radioactive waste management policy;
iv) radioactive waste management practices;
v) criteria used to define and categorize radioactive waste.

B.1. Spent Fuel Management Policy

The principles of state policy for spent fuel management are set forth in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" (outlined in Subsection B.1 of NRU-2003).

The Energy Strategy of Ukraine until 2035 "Safety, Energy Efficiency, Competitiveness" (Energy Strategy), which was approved by Cabinet Resolution No. 605-r of 18 August 2017 establishes the so-called deferred decision for spent fuel of Ukrainian NPPs, involving long-term (50 years and more) storage of spent fuel and subsequent definition and approval of the final decision on fuel reprocessing or disposal.

The design procedure for spent fuel management (transport of spent fuel for reprocessing to the Russian Federation) and the procedure that envisages storage of spent fuel with subsequent approval of the final decision on fuel reprocessing or disposal are both implemented for Ukrainian NPPs.

Strategic areas for spent fuel management at Ukrainian NPPs include

- for VVER reactors:

- temporary storage of spent fuel in on-site spent fuel pools;

- transfer of Ukrainian spent fuel (except ZNPP) for long-term storage and reprocessing;

- operation of on-site dry spent fuel storage facility at Zaporizhzhya NPP;

- study on diversification of spent fuel supply and reprocessing services;

- construction, commissioning and operation of CSFSF for spent fuel of RNPP, KhNPP and SUNPP power units;

- activities on developing the Concept of the state spent fuel management program, including spent fuel of Ukrainian NPPs taking into account defining possible areas of nuclear fuel cycle development for a long-term perspective and determining the final stage of nuclear fuel cycle, selection of a method for spent fuel safe management after the period of its long-term storage.

- for Chornobyl NPP RBMK reactors:

completion of construction, commissioning and safe operation of ISF-2 for storage of all amounts of ChNPP spent fuel;

measures to upgrade and improve safety of the existing wet interim spent fuel storage facility, ISF-1.

The following efforts are planned:

- transport of spent fuel from Rivne, Khmelnitsky and South Ukraine NPPs to the Russian Federation for temporary storage and reprocessing until the CSFSF in Ukraine is commissioned;

- safe operation of the dry spent fuel storage facility at Zaporizhzhya NPP;

- construction and safe operation of CSFSF for spent fuel of VVER-440 and VVER-1000 of operating NPPs and spent fuel of new nuclear units;

- solving the issue of long-term storage and reprocessing of spent nuclear fuel produced by Westinghouse Electric Sweden AB;

- development of regulatory and procedural issues on return of waste resulting from reprocessing of spent fuel from Ukrainian NPPs and their approval by the Russian Federation;

- development of a national program for spent fuel management to identify the objectives, strategies and scenarios for spent fuel management and define the key provisions of scientific and technical policy and implementation of the main stages of spent fuel management.

B.2. Spent Fuel Management Practices

Spent fuel is managed in Ukraine at the facilities listed in Annex 1 to this Report. The inventory of spent fuel is presented in Annex 2 of this Report.

B.2.1. Spent Fuel Management at Operating NPPs

At Zaporizhzhya NPP, spent fuel storage racks in spent fuel pools were compacted to increase capacity of the ZNPP spent fuel pools.

According to the Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs regarding the management of nuclear fuel, including spent fuel, the operating NPP units are equipped with mast sipping systems to monitor the integrity of fuel claddings. As of 1 July 2017, mast sipping systems have been introduced into commercial operation at RNPP units 1, 2, 3, 4, KhNPP units 1, 2, SUNPP unit 1 and ZNPP units 1, 2.

Trial operation of nuclear fuel produced by Westinghouse Electric Sweden AB is underway at SUNPP units 2, 3 and ZNPP unit 5. By the end of 2017, trial operation is to be extended to ZNPP units 1, 3, 4.

Energoatom holds negotiations with the French company *AREVA* to solve the issue of Westinghouse Electric Sweden AB spent fuel management and diversify suppliers of services related to transport and reprocessing of NPP spent fuel.

Dry Spent Fuel Storage Facility at ZNPP (DSFSF)

Starting from 2005, ZNPP spent fuel is unloaded for storage to the dry spent fuel storage facility at ZNPP for not less than 50 years. As of 1 April 2017, there are 139 containers with 3330 SFAs on the DSFSF site. The design capacity of DSFSF is 380 containers, each for 24 SFAs.

Fig. 1 ZNPP dry spent fuel storage facility (DSFSF)

Starting from 2005, ZNPP spent fuel is unloaded for storage to the dry spent fuel storage facility at ZNPP for not less than 50 years. As of 1 April 2017, there are 139 containers with 3330 SFAs on the DSFSF site. The design capacity of DSFSF is 380 containers, each for 24 SFAs.

A remote temperature control system (RTCS) was put into commercial operation for Stage I containers to improve storage safety. RTCS for Stage II containers is installed in accordance with the design.

The results of operation indicate that DSFSF complies with the safety criteria presented in SAR. The DSFSF design was modified to consider operating experience and implement components produced in Ukraine. The safety of design modifications was justified in a series of technical decisions agreed upon by the SNRIU. The ventilated concrete containers and multi-place sealed baskets for spent fuel storage are currently manufactured at national enterprises using Ukrainian materials and technologies.

After the Fukushima-1 accident in Japan, within the targeted safety reassessment of NPPs using stress tests according to the European Council and WENRA proposal, extraordinary target safety reassessment (stress tests) of Zaporizhzhya DSFSF was carried out. More detailed information is provided in Subsection B.2.1 of NRU-2014.

During 2015-2016, *Energoatom* performed a regular safety reassessment of DSFSF, whose results were presented in the periodic safety review report. In August 2016, this report was approved by the SNRIU based on the state nuclear and radiation safety review. The next reassessment will be performed in 2025.

CSFSF

The Law of Ukraine "On Spent Fuel Management for Siting, Design and Construction of the Centralized Spent Fuel Storage Facility for Ukrainian NPPs with VVER Reactors" establishes a legislative framework for the decision to construct the CSFSF and defines the territory of its location in the Chornobyl exclusion zone.

In the reporting period, development of the CSFSF construction project was completed. The project was approved by all interested executive bodies, positive conclusions of the Comprehensive State Review and Environmental Review on the possibility of its implementation were obtained. Due to this, the Cabinet of Ministers of Ukraine approved the CSFSF construction project.

The SNRIU issued license EO No. 001060 of 29.06.2017 to the *Energoatom* operator of CSFSF (to perform activities at life stages: construction and commissioning of CSFSF nuclear facility.

At the same time, the *Energoatom* operator continues efforts on upgrading spent fuel management systems at Ukrainian NPPs to include containers envisaged by the CSFSF design into transport flow charts for spent fuel management.

Further plans include:

- hold a tender in 2017 to select a contractor for construction activities at CSFSF,
- commission the first startup stage in 2019 and supply of 4 containers with spent fuel by the end of 2019,
- supply 90 containers from 2019 to 2022 that will allow refusing from spent fuel transport from Ukraine.

Equipment for spent fuel management is manufactured and supplied in accordance with the contract with Holtec International and scheduled for 2017-2018, with a view to timely CSFSF commissioning.

Energoatom carried out significant informational and explanatory work in order to inform the public of Ukraine on safety issues during the CSFSF construction and operation, in particular:

- a statement was published on the intentions and environmental consequences of CSFSF construction, documents on CSFSF were presented in mass media, information on the selected spent fuel storage technology, construction and operation of the storage facility, information and analytical review of the feasibility study for CSFSF construction investment, etc. was posted on the *Energoatom* web-site;
- public meetings (briefings, round tables with representatives of the public and mass media), public discussion in Ivankiv (with the participation of the public of Polissya region) and Slavutych of the Kyiv region were held; informational support of public hearings in Slavutych conducted with the participation of the public of Slavutych, Ivankiv and Polissya regions was ensured, an excursion was arranged for representatives of the public of the abovementioned regions to ZNPP where a similar spent fuel storage facility is operated to cover CSFSF design safety issues;
- results of events, issues of the public were processed, responses to them were developed and posted on *Energoatom*'s website.

The conducted activities with the public of Ukraine on CSFSF safety are reflected in the "Report on Public Consultations on Establishing a Centralized Storage Facility for VVER Spent Fuel of Ukrainian NPPs".

B.2.2. Spent Fuel Management at Chornobyl NPP

At present, the ChNPP in accordance with the conditions of license EO No. 000040 is at the decommissioning stage, namely at the stage of final closure and temporary storage.

Due to the delay in the construction and commissioning of dry ISF-2, in order to reduce risks during decommissioning and transformation of the Shelter into an ecologically safe system, as well as to reduce the costs to maintain ChNPP-1, 2, 3 in a safe condition, from 2006 to 2016 spent fuel was transferred from the units into ISF-1 (including damaged spent fuel).

Activities and operations on damaged spent fuel unloading from units No. 1, 2 and its transfer to ISF-1 for safe placement and storage were carried out by Chornobyl NPP in 2016 based on separate permit OD No. 000040/9.

Interim Spent Fuel Storage Facility 1 (ISF-1)

ISF-1, located on the Chornobyl NPP site and intended for interim storage of RBMK-1000 spent fuel, has been in operation since 1986. ISF-1 is a wet storage facility.

As of 31 March 2017, 21,284 SFAs are in storage in the ISF-1 spent fuel pools.

Safety justification for SFA storage in ISF-1 SFP is presented in the "Safety Analysis Report for Spent Fuel Storage Facility (ISF-1)" Inv. No. 06 of 24 June 2015. To load compartments 1-5 of ISF-1 SFP, K_{eff} neutron multiplication factor is calculated taking into account fuel burnup.

Fig. 2 ChNPP interim spent fuel storage facility 1 (ISF-1)

Efforts are continued in the exclusion zone on construction of ISF-2 intended for preparation for storage and storage of ChNPP RBMK spent fuel.

A significant scope of activities has been performed on the ISF-2 construction project:

- majority of equipment, systems and components was supplied at ISF-2 site, other equipment is under supply;
- plant of the general contractor for the project (U.S. Holtec International Company) continues to manufacture two-sided shielded casks;
- general contractor and subcontractors perform construction and mounting activities in accordance with the schedule;
- acceptance individual testing is performed for the equipment whose mounting and adjustment is completed.

ISF-2

ISF-2 site

Fig. 3 ChNPP interim spent fuel storage facility 2 (ISF-2)

B.2.3. Spent Fuel Management for Research Reactors

Spent fuel management on the NRI site is described in Subsection B.2.3 of NRU-2011. In 2009-2010, spent fuel from the NRI VVR-M research nuclear reactor was transported to the Russian Federation for reprocessing. As of 1 July 2017, NRI has no spent fuel on its site.

B.3. Radioactive Waste Management Policy

The major principles of state policy for radioactive waste management are defined by Ukrainian legislation and are presented in Subsection B.3 of NRU-2011.

The state policy for radioactive waste management is implemented in compliance with the Strategy for Radioactive Waste Management in Ukraine, National Target Ecological Program for Radioactive Waste Management and National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System.

The Strategy for Radioactive Waste Management in Ukraine identifies major areas and tasks for development of the radioactive waste management system for a 50-year period in Ukraine (described in NRU-2014).

The following tasks are underway until 2017 in compliance with the National Target Ecological Program for Radioactive Waste Management:

- improve radioactive waste management system at NPPs;
- reassess safety, reequip and convert the UkrDO *Radon* SISPs into sites for radwaste collection and interim storage in containers;
- commission and operate near-surface radioactive waste disposal facilities on the *Vektor* site for centralized radwaste disposal;
- design and construct facilities for long-term storage of long-lived and high-level waste at the *Vektor* site, including disused radiation sources, vitrified radwaste to be returned from the Russian Federation after spent fuel reprocessing, other long-lived and high-level waste;
- design radwaste processing facilities at the *Vektor* site;
- ensure safety of Chornobyl-origin radwaste;
- conduct surveys and research efforts to select a site for a geological repository;
- ensure personnel training and professional development;
- improve state system for radwaste accounting and control;
- ensure regulatory framework and international cooperation.

The deadline for implementing the National Targeted Ecological Program for Radioactive Waste Management is 2017. The State Agency of Ukraine on Exclusion Zone Management performs activities to update the measures of the national program and extend their deadline for the next period by development and agreement of the relevant draft law with the interested parties.

The main area in the technical policy of *Energoatom*, the operator of all acting NPPs, for radioactive waste management is to develop a state-of-the-art infrastructure to ensure management of radwaste from generation to collection of radwaste packages for disposal, which shall comply with acceptance criteria for appropriate facilities. Interrelation of all radwaste management stages shall be ensured.

In 2016, the current *Energoatom'*s Comprehensive Program for Radioactive Waste Management was reviewed, the main activity areas and measures were defined for the next five-year period (2017-2021). They include:

- continue construction of solid radwaste processing plants at NPP sites to minimize the scope of radwaste temporary storage at NPPs and to prepare conditioned radwaste for transfer for disposal;
- perform a number of activities to characterize different NPP radwaste flows using current models and calculation methods;
- select and implement optimal technology for processing of NPP liquid radwaste without salt fusion cake;
- ensure functioning of an appropriate radwaste accounting and control system;
- train competent personnel in radwaste management;
- improve corporate regulatory and methodological framework in radwaste management and international cooperation.

Energoatom's report on radioactive waste management during NPP operation as of 31 December 2016 can be found at www.energoatom.kiev.ua.

State policy for management of radwaste accumulated and generated in ChNPP decommissioning and Shelter transformation is implemented through tasks and measures identified in the National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System.

According to this National Program, the Radioactive Waste Management Program at Chornobyl NPP is in force and kept updated. The Program objective is to develop and ensure an integrated optimized procedure for radwaste management at ChNPP, taking into account existing radwaste management facilities those planned to be constructed.

B.4. Radioactive Waste Management Practices

B.4.1. Radioactive Waste Management at Operating NPPs

A list of facilities designed for radwaste management at operating NPPs is provided in Subsection 3.1 of Annex 3 to this Report. Information on radwaste stored in facilities at operating NPP sites is provided in Subsection 4.1 of Annex 4 to this Report.

The on-site management of radioactive waste generated in NPP operation includes collection, transport, treatment and interim storage in design facilities for liquid and solid waste.

The system for management of NPP operational radwaste is to be improved to ensure treatment to minimize waste amounts and obtain radwaste packages acceptable for disposal or long-term storage in centralized facilities designed and constructed at the *Vektor* site. For this purpose, *Energoatom*'s Comprehensive Program for Radioactive Waste Management

defines the main activities and a list of measures to improve management of radwaste resulting from NPP operation, in particular:

- construct and commission complex lines for radwaste treatment to prepare NPP waste for transfer for long-term storage/disposal to centralized facilities at the *Vektor* site;
- implement efficient and economically feasible technologies for treatment of solid and liquid radwaste;
- upgrade existing and construct new facilities for treatment of solid and liquid radwaste;
- create a system for characterization of radwaste in predisposal treatment and transfer for disposal;
- improve a fleet of containers for radwaste collection, transport, storage and disposal;
- implement a transport and handling procedure for NPP radwaste transport to special enterprises for radwaste management;
- participate with the operator of storage facilities in developing and justifying the acceptance criteria for long-term storage and/or disposal of NPP radwaste at the *Vektor* centralized storage facilities, in justifying storage/disposal safety of salt fusion cake at the *Vektor* facilities;
- continue implementing measures to minimize generation of radioactive environments and radwaste.

Liquid Radwaste Management

Liquid radwaste is stored in relevant storage facilities. Liquid radwaste is collected into stainless steel tanks equipped with a system for automated liquid waste level monitoring and alarm in case of leaks. To avoid emergency leakage of liquid radwaste, all tanks are located in concrete rooms lined with stainless steel sheets. The designs of the liquid radwaste storages provide for a redundant empty tank to be used in case of damage and repair of other tanks.

Fig. 4,5 On-site storage of liquid radwaste at NPPs

To minimize waste volumes, evaporation bottoms are additionally evaporated to the state of salt fusion cake (except for South Ukraine NPP). The salt fusion cake is stored in

200-liter KRO-200 containers placed into special compartments in SRSF.

Consideration of salt fusion cake as solid radwaste gives the possibility to perform activities on safety justification of its disposal in existing CRME disposal facilities.

In order to solve the issue on liquid radwaste accumulation, the activities on developing formulations and technology to immobilize still residue by direct cementation were performed. The studies and tests of samples (forms) of still residue immobilized according to the developed formulations proved compliance of the developed formulations with the requirements of regulatory documentation for the final product of processing. The advisability of implementing this technology will be determined by the results of the feasibility study on the optimization of liquid radwaste management procedure.

Spent filters and sludge are collected and stored under a layer of water in SRSF tanks. Efforts have been initiated to select technology for conditioning of spent filters through immobilization of spent filters and sludge in an inorganic geopolymer matrix using mobile facilities. Research and experimental efforts are planned at the Zaporizhzhya NPP to adapt the formulation and approve a batch of filters.

Solid Radwaste Management

Solid waste is collected in situ, sorted into groups (by gamma dose rate) and transported for interim storage to SRSF.

The on-site SRSF represent reinforced concrete structures including individual compartments for radwaste depending on activity. The compartments are equipped with a fire alarm system, automated fire-extinguishing system and exhaust ventilation with air purification. Some SRSF compartments are additionally equipped with a moisture detection and removal system.

Low-level waste is treated at ZNPP and SUNPP prior to placement for interim storage: preliminary compaction (ZNPP and SUNPP) and incineration (ZNPP).

Fig. 6 Radwaste incineration facility at ZNPP

Fig. 7 Radwaste compaction facility at SUNPP

The systems for solid radioactive waste treatment are in the final construction stage at NPPs in the framework of European Commission TACIS projects:

- Zaporizhzhya NPP: fully completed supply, mounting and testing of all equipment (incineration facility, release monitoring system, facilities for fragmentation, supercompaction, radwaste retrieval from storages and activity measurement), construction and finishing works are underway at;

- Rivne NPP: completed supply and testing of equipment of the cementation facility and equipment supplied under the TACIS program (facilities for solid radwaste retrieval, sorting and fragmentation, supercompaction and activity measurement for characterization of radwaste packages). Efforts are ongoing on the supply of equipment for metal-containing radwaste decontamination facilities. Construction, installation and finishing activities are under completion.

The completion of construction and trial commissioning of the systems for solid radioactive waste treatment at ZNPP and RNPP is planned for 2017.

Relevant projects for the construction of radwaste treatment facilities at KhNPP and SUNPP were approved to prepare radwaste to be transferred for disposal.

The Comprehensive Program for Radioactive Waste Management provides for development a system for solid radioactive waste treatment at KhNPP in 2017-2021 and at SUNPP in 2019-2023.

All systems will be provided with facilities for radiation monitoring and characterization of radwaste packages. The prepared packages will be transferred for disposal to *Vektor* centralized facilities. Commissioning of the systems for solid radioactive waste treatment will allow processing of solid radwaste accumulated on-site to the state acceptable for disposal and will permit emptying of existing on-site radwaste storages in the context of NPP lifetime extension.

For interim storage of conditioned radioactive waste in universal protective reinforced concrete containers, there is a concept for creation of light facilities at NPPs for storage of such containers. Efforts are ongoing on the development of design documentation on the light storage facility on ZNPP site.

Activities are underway to manufacture universal reinforced concrete containers. The containers will be used for both radwaste management processes at NPPs and long-term storage or disposal of solid radwaste in the *Vektor* facilities.

In the reporting period, the experts revised and developed a number of new regulations, in particular, documents of the operating organization regulating the reporting on NPP radwaste management and establishment of reference levels for radwaste generation and radwaste acceptance to the on-site NPP storage facilities.

According to the Agreement between the Government of Ukraine and the Government of the Russian Federation on Scientific, Technical and Economic Cooperation in the Field of Nuclear Energy of 14 January 1993 and the contractual obligations of *Energoatom* Company, spent fuel of VVER reactors is transferred for process storage and reprocessing to the enterprises in the Russian Federation (Industrial Association *Mayak* and Mining and Chemical Plant). Radioactive waste generated after spent fuel reprocessing and valuable reprocessing products shall be returned to Ukraine. The return of radioactive waste to Ukraine will be carried out according to terms and conditions defined by contractual documents on the return of spent fuel reprocessing products.

The amount of vitrified HLW that will be returned to Ukraine shall be calculated according to the document SOU-N YaEK 1.027:2010 “Methodology for Calculating the Amount of High-Level Waste Returned to Ukraine after Process Storage and Reprocessing of a VVER-440 SFA Batch” agreed by the regulatory authorities of Ukraine and Russia.

At present, the following documents are under agreement by the parties: Technical Conditions for vitrified HLW from reprocessing spent fuel of Rivne NPP VVER-440 reactors to be returned to Ukraine, Certification Procedure and Program of Quality Assurance in Spent Fuel Reprocessing.

Construction of the facility on the *Vektor* site for long-term (up to 100 years) storage of vitrified HLW from the reprocessing of VVER-440 spent fuel is envisaged by Task 3 of

the National Targeted Environmental Program for Radioactive Waste Management. The progress is presented in Subsection B.4.3 of this Report.

Spent fuel of VVER-1000 NPPs, except for ZNPP, is transported to the Russian Federation for process storage and reprocessing. At present, VVER-1000 spent fuel is not reprocessed in the Russian Federation, as the reprocessing technology is under testing. The technical specifications for VVER-1000 spent fuel reprocessing products and methodology for calculating the amount and activity of reprocessing products of VVER-1000 spent fuel from Ukrainian NPPs, including radwaste, to be returned to Ukraine are under agreement.

B.4.2. Radioactive Waste Management at Chornobyl NPP

Detailed information on the existing radwaste management system at ChNPP is presented in Subsection B.4.2 of NRU-2008.

A list of facilities for ChNPP radwaste management is provided in Subsection 3.2 of Annex 3 to this Report. Information on radwaste stored in facilities on the ChNPP site is presented in Subsection 4.2 of Annex 4 to this Report.

Detailed information on the Shelter activities and NSC construction is presented in Annex 9 to this Report.

Liquid radwaste at ChNPP is collected by the design piping system.

Low- and intermediate-level solid radwaste is collected in accumulating containers. Low- and intermediate-level short-lived solid radioactive waste is reloaded into special vehicle and is transported for disposal to RWDS *Buryakivka*.

Interim storage of radwaste is performed into design storage facilities (liquid radwaste – in stainless steel containers, solid radwaste – in reinforced concrete containers). Radwaste is stored until the completion of radwaste retrieval and its transfer to LRTP and SRTP for processing.

High-level solid radwaste is collected in special containers that are transported by a special vehicle to the storage facility for interim storage of HLW. Such a waste is stored into transport protective containers KTZV-0.2.

Radwaste storage facilities are equipped by protective systems: special ventilation, active drains, physical protection and alarm, radiation monitoring systems. There is a network of observation wells on the perimeter of the storage facilities for groundwater monitoring.

According to the National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System, the priority measures in the development of the system for treatment of ChNPP radwaste that was accumulated in the period of operation and that will be generated in activities on decommissioning of ChNPP units and activities at the Shelter cover commissioning of radwaste treatment facilities within liquid radioactive waste treatment plant (LRTP) and facilities of the industrial complex for solid radioactive waste management (ICSRM) constructed under the international technical assistance projects.

ICSRM

ICSRM combines a series of radwaste management facilities[7].

[7] **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 in sorting at the SRTP and in preparation for construction of 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;

The interim storage facility for low- and intermediate-level long-lived and high-level radwaste that was commissioned in 2010 is currently under operation.

According to conditions of an individual permit series OD No. 000040/6, activities were completed within the second stage of SRTP hot tests using radwaste with known radiation characteristics. The final safety analysis report according to documents on the second stage of hot tests was developed.

Activities are ongoing to prepare for the third stage of hot tests of SRTP and solid radwaste retrieval facility according to the agreed "Decision on the Third Stage of Hot Tests and Initial Stage of SRTP Commercial Operation". It is envisaged to take efforts on the characterization of radwaste located in compartments of existing SRSF, from which solid radwaste will be retrieved in the process of operation to be transferred to SRTP for processing.

The main problematic issues in commissioning of SRTP and solid radwaste retrieval facilities are significant uncertainties in characteristics of radwaste stored in the existing SRSF. This radwaste partially consists of operational (pre-emergency) radwaste of ChNPP and partially of emergency radwaste generated after Chornobyl accident. There was no proper characterization performed during its loading into SRSF compartments.

Fig. 8 Solid radwaste treatment plant (SRTP) at Chornobyl NPP site

LRTP

In March 2014, ChNPP obtained an individual permit for commissioning of liquid radioactive waste treatment plant. Within commissioning, comprehensive testing of LRTP using active products was completed (5.1 m^3 of liquid radwaste was processed; 63 radwaste packages (200-l drums) were received). Four packages were transferred to ENSDF on the *Vektor* site for disposal. The remaining packages are stored in the premises for buffer storage of radwaste packages at LRTP before being transferred for disposal.

Solid radwaste retrieval facility is designed for retrieval of solid radwaste from the existing ChNPP solid waste storage and transfer of waste for treatment to SRTP;

SRTP is a solid radioactive waste treatment plant for sorting of solid radioactive waste of all categories and treatment (fragmentation, incineration, compaction, cementation) of low- and intermediate-level short-lived solid radioactive waste retrieved from the solid radwaste storage facility, and waste resulting from ChNPP decommissioning and Shelter transformation into an environmentally safe system. SRTP also envisages packaging of long-lived and high-level waste that will result from sorting and transport of these packages to temporary storage.

Fig. 9 Liquid radwaste treatment plant (LRTP) at Chornobyl NPP site

The SNRIU issued an individual permit series OD No. 000040/7 dated 11 December 2014 for LRTP operation on condition of receiving certificate on completed construction project. For this purpose, ChNPP initiated activities on insulation of the building, reconstruction of fire protection and lightning protection systems.

Currently, ChNPP personnel maintain operating condition and perform maintenance of LRTP equipment.

Plant for production of metal drums and radwaste is operated at ChNPP to ensure radwaste management. The plant will ensure necessary amount of reinforced concrete 3 m^3 containers and metal 200 liter drums.

Fig. 10 Plant for production of metal drums and containers for ChNPP radwaste

The Feasibility Study for Design and Construction of *New Additional Facilities* for Radioactive Material and Radioactive Waste Management was agreed in 2013 to create conditions for safe and efficient management of all types of radioactive waste that will be generated during decommissioning of Units 1, 2, 3 in Shelter transformation into an environmentally safe system.

According to this document, activities on the creation of the following additional facilities for radwaste management were performed in the reporting period:

– facility for removal of organic compounds and transuranium elements from Shelter liquid radwaste and preparation of Shelter liquid radwaste for treatment at LRTP;

– line for cutting of long-length components from reactor compartments to allow removal of radioactive waste from them and further safe enclosure;

– facility for release of materials from regulatory control, together with the development of standards, methodologies and procedures for release of materials from regulatory control considering the best international practice.

B.4.3. Radioactive Waste Management in Exclusion Zone

A list of facilities for management of radioactive waste located in the exclusion zone (except for ChNPP site) is presented in Subsection 3.3 of Annex 3 to this Report. Data on radwaste disposed of in CRME in the exclusion zone are provided in Subsection 4.4 of Annex 4 to this Report. Data on radwaste stored/confined in the storage facilities of the exclusion zone are presented in Subsection 4.5 of Annex 4 to this Report.

The main activities on radwaste management in the exclusion zone (except for ChNPP site) are conducted by CRME appointed as the operating organization for all operating and closure stages of radwaste disposal facilities. The CRME also conducts individual activities on radwaste treatment and transport.

The CRME deals in the exclusion zone with:

- operation of two parallel modules of ENSDF on the *Vektor* site;
- operation of the centralized storage facility for radiation sources on the *Vektor* site regarding comprehensive (hot) tests using radwaste as disused radiation sources of different types;
- operation of near-surface disposal facilities of RWDS *Buryakivka*;
- maintenance, upgrading and safety improvement of RWDS *Pidlisny* and *ChNPP Stage III*;
- maintenance, inspection, monitoring and closure of RICS trenches and pits;
- operation of the station for decontamination of overalls and individual protection means and the point for decontamination of special vehicles and equipment;
- radwaste transport.

Efforts on design, construction and repair of facilities for radwaste management in the exclusion zone (except for ChNPP site) are made by CCMEZ appointed as the operating organization for siting, design and construction of radwaste disposal facilities on the *Vektor* site.

CCMEZ deals in the exclusion zone with completion of radwaste disposal facilities SRW-1 and SRW-2 on the *Vektor* site with a total capacity of 19,200 m^3 and infrastructure facilities to ensure operation of the radwaste disposal facilities (vehicle wash, radiological laboratory, changing rooms etc.)

Radiation dose and environmental monitoring in the exclusion zone is conducted by the are performed by the State Specialized Enterprise *Ecocenter* in compliance with the agreed procedure.

RWDS *Buryakivka*

RWDS *Buryakivka* has been in operation since 1987. RWDS consists of 30 near-surface radwaste disposal facilities (trenches). The main engineering barrier is a compacted clay layer one meter thick to confine radwaste from the environment. RWDS *Buryakivka* is one of the main elements to manage large amounts of radwaste resulting from the Chornobyl accident. The facility was constructed within priority measures for mitigation of the Chornobyl catastrophe. Until now, operation of this RWDS ensures disposal of large amounts of low-level radwaste resulting from efforts at ChNPP site and contaminated areas in the exclusion zone. RWDS *Buryakivka* has practically exhausted its capacities.

During 2014-2016, according to the register of radwaste in the exclusion zone, RWDS *Buryakivka* accepted 6963 radwaste batches for disposal with a total volume of 31.276.3 m^3 and an activity of 8.21 E + 12 Bq. Radwaste is stored in the last disposal facility (trench) No. 21, which is filled up by 99%.

Possible solutions for reconstruction of RWDS *Buryakivka* are under consideration to increase capacity for the disposal of low-level radwaste. In this regard, the operating organization improves the safety justification taking into account safety assessments and recommendations provided by European experts by industrial project INSC U4.01/08-B and regulatory project INSC U3.01/08 (UK/TS/39).

To expand production capacities of RWDS *Buryakivka*, CRME developed and submitted project "Construction of 21A RWDS *Buryakivka* Disposal Facility", which envisages construction of an additional disposal facility (trench) to the state review.

Fig. 11
RWDS *Buryakivka*

ENSDF

The engineered near-surface disposal facility (ENSDF) for solid radwaste was constructed on the *Vektor* site within ICSRM for disposal of radwaste packages from ChNPP LRTP and SRTP. The design capacity of the disposal facility is 50,210 m^3. ENSDF consists of two parallel sections, each with eleven reinforced concrete compartments (modules). The disposal facility is equipped with a central drainage gallery, two mobile frame structures with bridge cranes for loading of modules, a radiation monitoring system and a system of environmental monitoring. Within operation of the disposal facility, measures are taken to ensure functioning of the central drainage gallery under the disposal facility, monitor structures of the modules and study and implement up-to-date methodologies for ENSDF safety assessment and review to increase the number of radwaste suppliers and update radwaste acceptance criteria for this disposal facility. Placement of ChNPP radwaste packages in ENSDF was started on 26 April 2014.

During 2014-2015, additional justifications were made and a decision was taken on the disposal of radwaste packages from the UkrDO *Radon* Kharkiv SISP in ENSDF. The activities on transport and disposal of 74 radwaste packages (66 m^3) from the Kharkiv SISP were completed.

Fig. 12 Engineered near-surface disposal facility (ENSDF) for solid radwaste at the Vektor site

Fig. 13 Loading of radwaste packages into ENSDF compartment

RWDS and RICS

RWDS and RICS in the exclusion zone, as well as the existing SRSF on the ChNPP site are elements of the system for managing large amounts of radwaste resulting from the Chornobyl accident. These facilities so far ensure confinement and isolation of radwaste from the environment. However, they require more active measures on maintenance, monitoring, inspection, stabilization, safety improvement, remediation, safety reassessment etc. International cooperation with EC and IAEA, in particular, is involved for their implementation.

RWDS *Pidlisny* was constructed within priority measures after the Chornobyl accident. From the end of 1986 to the end of 1988, the most hazardous high-level and long-lived radwaste was placed in modules A-1 and B-1 of this RWDS. The project for closure of RWDS *Pidlisny* aimed at stabilization and safety improvement of this facility was completed in 2012. Process covers over RWDS modules, new bunding around the perimeter of modules, new water drainage system and eight additional observation wells for groundwater monitoring were constructed.

Fig. 14 Modules A-1 and B-1 of RWDS Pidlisny after implementation of safety improvement project

RWDS *ChNPP Stage III* was constructed within priority measures after the Chornobyl accident in the partially constructed facility for solid radioactive waste of non-completed ChNPP Stage III. From the end of 1986 to the end of 1988, low- and intermediate-level radwaste was placed in the reinforced concrete modules of this facility and bunding was constructed. Over the years, the bunding degraded and required measures for repair and maintenance on a permanent basis.

In 2016, the project for closure of RWDS *ChNPP Stage III* for its stabilization and safety improvement was completed. In the framework of the project, additional engineered barriers (new multi-layer upper protective screen over existing modules with radwaste) were constructed and drainage system and monitoring system were upgraded.

The implementation of the mentioned projects on RWDS safety improvement will allow ensuring protection against degradation and support of confining functions of engineering barriers, improving information content of monitoring systems. In the course of industrial project INSC U4.01/10-D and INSC U3.01/10 (UK/TS/46), safety assessment of RWDS *Pidlisny* and RWDS *ChNPP Stage III* was performed involving European experts and current safety assessment methodologies, which confirmed that at present taking into account the implemented safety improvement and stabilization projects, these facilities ensure safe radwaste storage. Looking forward, the issue on radwaste retrieval from these RWDS and its redisposal in appropriate disposal facilities should be solved.

RICS are territories adjacent to ChNPP with a total area of about 10 ha, where trenches and pits for radwaste confinement were constructed within priority measures after the Chornobyl accident. This radwaste mostly represented contaminated structures, household items, upper layer of soil etc. Nine RICS are located in the exclusion zone: *Yaniv Station*, *Naftobaza*, *Pischane Plato*, *Rudyy Lis*, *Stara Budbaza*, *Nova Budbaza*, *Prypiat*, *Kopachi* and *Chystohalivka* with a total area of 10 ha, where trenches and pits with radwaste are located. The estimated number of RICS trenches and pits is from 800 to 1000, accurate location of some of them must be specified. The RICS territories in the exclusion zone are continuously investigated, trenches and pits are maintained in safe state. The objective of investigations is to search for and specify locations of trenches and pits and specify inventory and activity of the placed radwaste.

CRME performs efforts on retrieval and redisposal of radwaste from RICS trenches and pits that may have the most negative impact on personnel of the exclusion zone and the environment. As of the end of 2016, 7698.8 m^3 radwaste was retrieved and transferred for

disposal to RWDS *Buryakivka*. Radwaste was retrieved from trenches of RICS *Naftobaza* with a risk of flooding and from RICS *Nova Budbaza* located in places where active construction of NSC and ISF-2 is underway.

At the same time, it is now clear that retrieval of all radwaste located in RICS is inappropriate. Such decisions need to be optimized taking into account the assessment of risks related to specific RICS, their comparison with the risks of other radiation and nuclear facilities in the exclusion zone, definition of long-term status of the exclusion zone as a strict access area for the population and the implementation of economic activities.

INSC Project U4.01/10-D covered the implementation of large-scale activities on survey, collection and systematization of data, safety assessment and ranking of RICS in terms of risk degree. This safety assessment can be used as a basis for identifying and optimizing priority measures to maintain and improve RICS safety and make decisions on partial/complete retrieval and redisposal of radwaste from the most potentially hazardous RICS sites.

Information on safety assessment of RICS and RWDS is presented in Subsection H. 2.2 of this Report.

CLTSF

In 2015, the construction of the Centralized Long-Term Storage Facility for Radiation Sources (CLTSF) and installation of systems and equipment for this facility were completed with the support of the Department of Energy and Climate Change of Great Britain.

CLTSF is a facility, which today has no analogues in the world, and it is a key element in improving the entire system for the management of radiation sources in Ukraine. CLTSF shall ensure centralized location of the main volumes of radwaste in the form of disused radiation sources of different types and structures that are currently accumulated on sites of UkrDO *Radon* specialized radwaste management facilities and radiation sources used in medicine and industry after being transferred into a category of radioactive waste.

The management of disused radiation sources includes their acceptance, identification of sorting, conditioning and long-term storage (during 50 years).

According to license OB No. 001050 issued on 25 March 2016 for the right to perform radwaste processing and storage, CRME carries out comprehensive hot tests of CLTSF. During these tests, CRME shall confirm protective features of facility structures, work out the technological processes for processing of disused radiation sources, process regulations and procedures, interaction with suppliers of radioactive waste in form of disused radiation sources, functioning of the system for accounting and control of such radwaste during the whole technological process of its processing from acceptance from suppliers to placement of prepared packages for long-term storage, management of secondary radioactive waste.

Since the beginning of hot tests, technological processes for processing of spent gamma-radiation sources were worked out, radiation survey was performed related to reliability of biological protection of CLTSF structures, the procedures of radioactive waste transfer and receiving in the form of disused radiation sources from suppliers -UkrDO Radon SISPs are worked out, a nuclear material accounting and control system was developed.

Fig. 15 Centralized long-term storage facility for disused radiation sources (CLTSF)

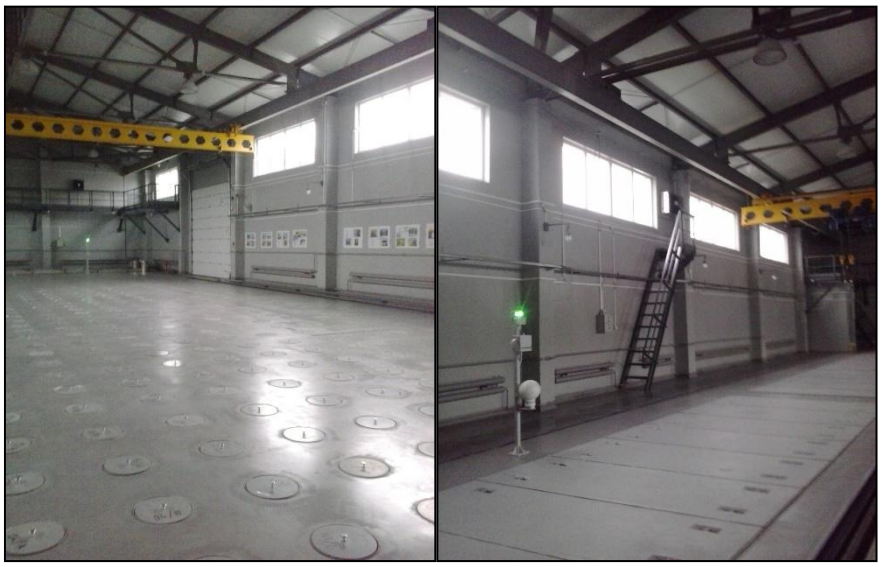


Fig. 16 Area for storage of disused radiation sources at CLTSF

Design of New Facilities for Radioactive Waste Management on the Vektor Site

According to the Strategy for Radioactive Waste Management in Ukraine and National Target Ecological Program for Radioactive Waste Management, design of facilities for long-term storage of radwaste and radwaste treatment is underway on the *Vektor* site in order to further develop the radwaste management system, including:

- facility for long-term storage of vitrified HLW to be returned from the Russian Federation after VVER-440 spent fuel reprocessing;
- facility for long-term storage of HLW and facility for long-term storage of long-lived radwaste. High-level and long-lived radwaste to be stored in these facilities is to be generated in retrieval of radwaste and fuel-containing materials from the Shelter and RWDS *Pidlisny*, ChNPP decommissioning and NPP operation;
- process building for the centralized processing of radwaste of small producers and radwaste flows. The design is carried out in the framework of industrial project INSC U4.01/11A. The process building envisages implementation of radwaste management technologies that include acceptance, sorting and fragmentation of radioactive waste; incineration; compaction; processing of secondary radioactive waste; cementation; radioactive waste placing in containers; certification.

Facilities for long-term storage at the *Vektor* site will ensure centralized long-term storage (100 years) of radwaste prior to its disposal in a geological repository.

"Feasibility study for construction of the interim spent fuel storage facility for vitrified HLW returned from the Russian Federation after reprocessing of spent nuclear fuel from Ukrainian NPPs" was approved by Order of the State Agency of Ukraine on Exclusion Zone Management No. 81 dated 01 July 2016.

The design of this facility obtained a positive conclusion of the state review including nuclear and radiation review and was approved by the Order of the State Agency of Ukraine on Exclusion Zone Management No. 98 of 25 July 2017 (see also Subsections H. 1.1, H. 4 of this Report).

B.4.4. Radioactive Waste Management at UkrDO *Radon* SISPs

Radioactive waste originating from the use of radiation sources in medicine, science and different industries in Ukrainian regions is collected and placed for interim storage by State Interregional Specialized Plants for Radioactive Waste Management (SISP) of UkrDO *Radon*: Kyiv SISP, Kharkiv SISP, Dnipropetrovsk SISP, Odesa SISP and Lviv SISP.

In view of the impossibility to transfer Donetsk SISP to the territory controlled by the Ukrainian authorities, SAEZ Order No. 33 dated 24 March 2015 temporarily suspended enterprise activities until the end of military actions and restoration of state control over territories that are currently beyond control of the Ukrainian authorities. At the same time, the scope of services in the Donetsk Oblast that remained beyond control of the Ukrainian authorities was transferred to Dnipropetrovsk SISP. The relevant changes to the constituent and organizational documents were made.

A list of radwaste facilities located at UkrDO *Radon* SISPs is presented in Subsection 3.4 of Annex 3 to this Report. Data on radwaste and disused radiation sources located in UkrDO *Radon* SISP facilities are presented in Subsection 4.6 of Annex 4.6 to this Report. Disused radiation sources declared as radwaste are the main type of radwaste managed by SISPs.

SISP deal with:

- operation of facilities for solid radwaste storage in containers;
- maintenance, inspection and monitoring of closed radwaste disposal facilities that were filled in the previous period (to 1996);
- collection, conditioning and transport of radwaste to relevant facilities;
- operation of decontamination stations for overalls, underwear, and individual protection means.

Containers with radwaste and disused radiation sources are stored in hangar-type storage facilities. These buildings were constructed at SISP sites in the 1990s after making a decision on SISP transfer to the radwaste storage technology.

Fig. 17 Container storage of radwaste in hangar-type SISP storage facilities

The closed radwaste disposal facilities filled by 1996 are a system of near-surface reinforced concrete module-type facilities with a capacity of 200 m^3. They were constructed according to standard designs in the 1960s–1970s. SISPs are responsible for maintenance, monitoring and safety reassessment to make decisions on the safety of each facility, periods during which these facilities can ensure reliable radwaste isolation and process decisions on radwaste retrieval and closure of facilities.

First of all, it is planned to retrieve radioactive waste from Kyiv SISP facilities No. 5, 6, 7 according to the developed retrieval plan, which received a positive conclusion of the comprehensive state review. According to the design decisions, radwaste after preliminary sorting will be placed into protective containers, which will allow further storage of retrieved radwaste until they are sent for processing, long-term storage or disposal at *Vektor* facilities.

There are also well-type facilities on SISP sites for disused radiation sources. They represent deep stainless steel tanks with a wavy reception tube for lowering the capsules with radiation sources. According to regulatory decision, disused radiation sources are no longer placed into the well-type facilities.

At present, capacities of well-type storage facilities and condition of radwaste in the form of disused radiation sources located in them are under inspection. Data of these inspections will be considered in making process decisions on the retrieval of disused radiation sources and further decommissioning.

In 2016, with the support of the Swedish Regulatory Authority (SSM) within the framework of G-7 Donor Program on improving safety in management of disused radiation sources in Ukraine, there started the development of a Standard Technical Decision on the retrieval of disused radiation sources from well-type storage facilities, which will take into account inspection results. The pilot implementation of this Technical Decision after its approval by the review results is planned at Kyiv SISP.

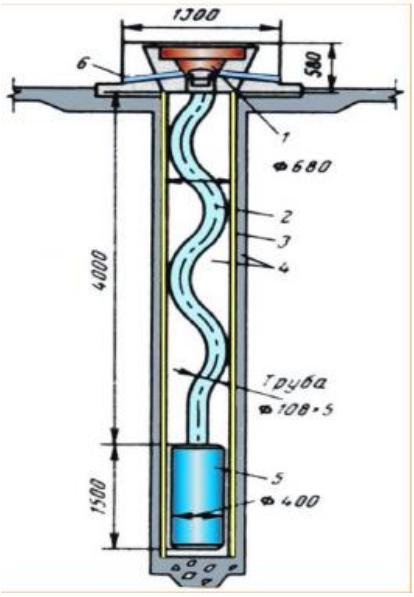


Fig. 18 Design of standard well-type facility

According to the issued licenses, SISPs carried out safety reassessments of radwaste facilities on their sites. The safety reassessments were performed for facilities operating under the technology of interim container storage of radwaste and closed legacy facilities that were operated in the previous period (see also Subsection H.2.2 of this Report).

Projects are ongoing at a number of SISPs for construction of new radwaste management facilities and introduction of radwaste treatment and conditioning technologies to improve safety of radwaste management.

Dnipropetrovsk SISP, which provides services to one of the industrial regions in Ukraine, where a substantial number of radiation sources was and continues to be used:

- operates the near-surface facility from reinforced concrete structures for container storage of solid radwaste and DRS of module type;
- conducts pilot operation of a mobile unit with equipment for safe removal of disused radiation sources from shielding blocks of BGI and E types. This unit is a facility for treatment of radwaste representing disused gamma radiation sources.

Operation of the plant developed and produced with support of the French Atomic Energy Commission is foreseen at SISP sites for the purpose of removing DRS from shielding and placing them in a protective container. This will minimize the amount of such radwaste, increase the safety of its storage, and optimize transport to the *Vektor* site (number of shipments will be reduced tenfold).

Fig. 19 Mobile unit with equipment for safe removal of disused radiation sources from shielding blocks of BGI and E types

The Kyiv SISP conducts maintenance, radiation monitoring and control of storage sites for radwaste resulting from decontamination and sanitary treatment of vehicles (SSR/VTS) after the Chornobyl accident, which are located outside the exclusion zone in the Kyiv, Zhytomyr and Chernihiv regions. These sites also require additional survey, safety assessment and decisions on their remediation. Under project INSC U4.01/12D "Remediation of Radioactive Waste Storage Sites Resulting from the Chornobyl Nuclear Power Plant Accident and Situated outside the Exclusion Zone", additional surveys and safety assessments of SSR/VTS were carried out. Information on SSR/VTS and their safety assessments is provided in Subsection H. 2.2 of this Report.

During 2015-2017, the industrial project INSC U4.01/12BCD "Infrastructure Improvement for Radioactive Waste Management, Remediation of Contaminated Sites and Decommissioning in Ukraine" was under implementation. Its components envisage international technical support to improve SISP infrastructure. The following products are supplied:

- specially equipped vehicle with a set of spectrometric, radiometric, dosimetric and other types of devices for equipping of SISP emergency crews;
- equipment to create an integrated automated system for radiation monitoring of the environment at SISP radwaste facilities, and equipment for the dispatching point in the central office of UkrDO *Radon*;
- equipment and transport vehicles to carry out additional surveys, retrieval and transport of radwaste from SSR/VTS.

B.4.5. Radioactive Waste Management for Research Reactors

Data on radwaste stored in on-site storage facilities of research reactors are presented in Subsection 4.3 of Annex 4 to this Report.

B.5. Criteria Used to Define and Classify Radioactive Waste

Detailed information on the radwaste classification system used in Ukraine is provided in Subsection B.5 of NRU-2005 and NRU-2011.

Taking into account new IAEA Safety Standard GSG-1 "Classification of Radioactive Waste", international experience and IRRS-2008 and IRRS-2010 recommendations,

Ukraine initiated revision and improvement of the radwaste classification system. This is aimed at implementing the radwaste classification system in accordance with the waste final disposal option. In 2011-2013, project INSC U4.01/08-C "Improvement of the radwaste classification system in Ukraine" was implemented. Efforts are continued to implement recommendations obtained within this project into the national legislative and regulatory framework.

Implementation of the updated classification of radioactive waste will allow optimization of its disposal and to divide radioactive waste into classes according to acceptance criteria for radwaste disposal in four types of facilities: in surface, near-surface, intermediate depth, geological repositories. Such an approach is fully harmonized with requirements of GSG-1 and best international practice.

As assessed within the mentioned project, the implementation of the updated classification will have a significant economic effect for radwaste disposal in Ukraine. SAEZ in cooperation with MHU, MECI and SNRIU developed a draft law on the legal implementation of the radwaste classification system that prescribes the compliance of radwaste classes with the envisaged disposal method.

In the transition period until the updated classification system is introduced, the existing radwaste classification is used for operating facilities.

Section C. SCOPE OF APPLICATION (Article 3)

1. This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

2. This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

3. This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

4. This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

Spent fuel and radwaste management in Ukraine is considered as defined in Article 2 of the Joint Convention.

Ukraine has no facilities for spent fuel reprocessing.

Ukraine deals with uranium ore mining and processing resulting in uranium ore waste stored in tailing pits of *SkhidGZK* and former PChP, which are registered on *Baryer* books. Waste from mining industry, as well as waste resulting from mining of other minerals, is not declared by Ukraine as radwaste. In line with recommendations of the First and Third Review Meetings of the Contracting Parties to the Joint Convention, information on uranium milling waste is provided in Annex 10 to this Report.

Ukraine does not pursue any military or defense programs that would result in the generation of spent fuel or radwaste. However, there are four radwaste disposal sites that remained from the former military programs of the USSR.

In this regard, Ukraine applies requirements of the Joint Convention to ensure the safety of radwaste originating from former defense programs if this radwaste has been finally transferred for management under civil programs.

The Strategy for Radioactive Waste Management in Ukraine and National Target Ecological Program for Radioactive Waste Management envisage safety measures to keep these facilities in safe state, carry out safety reassessment and plan measures on their subsequent closure.

To date, two such sites are under control of the Ministry of Defense of Ukraine, two radwaste disposal sites resulting from the annexation of the Crimea by the Russian Federation are located on the territory not controlled by Ukraine and *Vakulenchuk* storage facility, which was controlled by the State Border Guard Service, was closed (see Subsection H.1.1 of this Report).

Section D. INVENTORIES AND LISTS (Article 32, Para. 2)

This report shall also include:

i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

iv) an inventory of radioactive waste that is subject to this Convention that:

a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

b) has been disposed of; or

c) has resulted from past practices.

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

D.1. List of Spent Fuel Management Facilities Subject to the Joint Convention, Their Location, Main Purpose and Essential Features

A general description of facilities existing in Ukraine for spent fuel management is provided in Subsections B.2.1- 2.3 of this Report.

A list of spent fuel management facilities as of 1 July 2017 is presented in Annex 1 to this Report.

D.2. Inventory of Spent Fuel Subject to the Joint Convention

As required by the Law of Ukraine “On Nuclear Energy Use and Radiation Safety”, spent fuel is accounted for under the state system for accounting and control of nuclear materials. Nuclear materials are accounted for in compliance with the “Rules for Nuclear Material Accounting and Control”.

An inventory of spent fuel as of 1 July 2017 is presented in Annex 2 to this Report.

D.3. List of Radioactive Waste Management Facilities Subject to the Joint Convention, Their Location, Main Purpose and Essential Features

A general description of radwaste management facilities existing in Ukraine is provided in Subsections B.4.1 - 4.5 of this Report.

A list of radwaste management facilities as of 1 July 2017 is provided in Annex 3 to this Report.

D.4. Inventory of Radioactive Waste Subject to the Joint Convention

The state system for accounting of radwaste and control of its movement and location consists of two main elements: State Register of Radwaste and State Cadaster of Storages and Sites for Temporary Radwaste Storage. SAEZ, as a state authority for radwaste management, arranges and coordinates state accounting of radwaste and storage facilities and conducts state inventories of radwaste. UkrDO *Radon*, which includes the Chief Information and Analytical Center for Radwaste State Accounting System and Regional Centers for Radwaste Accounting, is responsible for the State Register and State Cadaster.

State inventories of radwaste are taken every three years. The first state inventory was taken in 1999-2000, second in 2003, third in 2007, fourth in 2010, fifth in 2013 and sixth in 2016.

Radwaste inventories as of 1 July 2017 are presented in Annex 4 to this Report.

D.4.1. List of Radioactive Waste in Temporary Storage at Nuclear Facilities and Research Reactors

Subsections 4.1–4.3 of Annex 4 to this Report provide data on radwaste accumulated in storages located at sites of *Energoatom* NPPs, ChNPP and research reactors as of 1 July 2017.

D.4.2. List of Disposed Radioactive Waste

Subsection 4.4 of Annex 4 to this Report provides information on radwaste disposed of in near-surface radwaste disposal facilities as of 1 July 207: RWDS *Buryakivka* and ENSDF on the *Vektor* site.

D.4.3. List of Radioactive Waste Resulting from Past Practices

Subsection 4.5 of Annex 4 to this Report provides data on radwaste originating from the Chornobyl accident.

Subsection 4.6 of Annex 4 to this Report contain data on radwaste placed in UkrDO *Radon* SISPs as of 1 July 2017.

D.5. List of Nuclear Facilities under Decommissioning

As of 1 April 2017, *Energoatom* has no nuclear facilities under decommissioning.

A list of ChNPP nuclear facilities being decommissioned is provided in Annex 5 to this Report.

In the reporting period, Chornobyl NPP completed the stage of operation termination and proceeded to the stage of final closure and safety enclosure of units 1, 2 and 3.

Section E. LEGISLATIVE AND REGULATORY SYSTEM

E.1. Implementing Measures (Article 18)

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

In compliance with the Joint Convention, Ukraine established and keep updated the state system for regulation of nuclear and radiation safety.

E.2. Legislative and Regulatory Framework (Article 19)

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

2. This legislative and regulatory framework shall provide for:

i) the establishment of applicable national safety requirements and regulations for radiation safety;

ii) a system of licensing of spent fuel and radioactive waste management activities;

iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;

iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;

v) the enforcement of applicable regulations and of the terms of the licences;

vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.

3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

E.2.1. National Safety Requirements and Radiation Safety Regulations

Requirements and regulations on nuclear and radiation safety of Ukraine are established in laws, Cabinet resolutions, and legal acts of central executive bodies. The system of nuclear legislation also includes international treaties of Ukraine, whose obligatory nature is appropriately acknowledged and which constitute an integral part of national legislation.

Regulatory requirements are developed by the SNRIU on a systematic basis considering regulatory experience and practices in nuclear and radiation safety in Ukraine, as well as experience of advanced countries, advances in science and technology, international standards, including European Commission documents and documents and recommendations of IAEA, WENRA and other international safety organizations.

The main priorities to develop the national regulatory and legal system in the reporting period include:

- adaptation of the Ukrainian legislation to the EU legislation in connection with the signing of the Association Agreement between Ukraine and the European Union, including Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, Council Directive 2006/117/Euratom for the supervision and control of shipments of radioactive waste and spent fuel, Council Directive 2014/87/Euratom establishing a Community framework for the nuclear safety of nuclear facilities and Council Directive 2011/70/Euratom for the responsible and safe management of spent fuel;

- implementation of strategic objectives for nuclear energy development according to the Strategy for Radioactive Waste Management and Energy Strategy;

- implementation of recommendations and suggestions of IRRS-2008 mission and IRRS-2010 follow-up mission;

- implementation of IAEA requirements and safety standards, WENRA recommendations considering SNRIU as a full member of WENRA.

In the reporting period, a series of legislative and regulatory documents in the area of energy were developed and adopted. The main documents that were put in force in 2014 – first half of 2017 are provided in Annex 6 to this Report.

E.2.2. Licensing System for Spent Fuel and Radioactive Waste Management

The major legal and organizational issues of the licensing system are set up in the Law of Ukraine "On Authorizing Activity in Nuclear Energy".

The purpose of the licensing system in the area of nuclear energy and, accordingly, spent fuel and radioactive waste management was described in Subsection E.2.2 of NRU-2008.

A list of activities that require a license and permit is set in the Law of Ukraine "On Authorizing Activity in Nuclear Energy".

Regarding spent fuel and radioactive waste management activities, a license is required to provide the following activities:

- operator's activities on individual lifetime stages of a nuclear facility (including spent fuel storage facility): construction and commissioning of the facility, operation of the facility, decommissioning of the facility;

- operator's activities at individual stages of radioactive waste disposal facilities connected with: construction of the disposal facility, operation of the disposal facility, closure of the disposal facility;

- activities of operator's officials that are in charge of management and organizational decisions for ensuring nuclear and radiation safety;

- activities of enterprises on processing and storage of radioactive waste connected with radioactive waste treatment facility construction and commissioning, operation and decommissioning; radioactive waste storage facility construction and commissioning, operation and decommissioning;

- activities on radioactive material transport.

An individual permit is required for the operator for specific activities and operations at particular stage of nuclear facilities or radioactive waste disposal facilities. These activities and operations are listed in each license.

A list of documentation to be provided by the licensee to support the license application for each type of activity is defined by regulations.

E.2.3. System of Prohibition to Operate a Spent Fuel or Radioactive Waste Management Facility without a License

The legislative provisions regarding the prohibition to operate a spent fuel or radwaste management facility without a licence indicated in Subsection E.2.3 of NRU-2008 have not changed.

E.2.4. System of Institutional and Regulatory Control and Documentation and Reporting

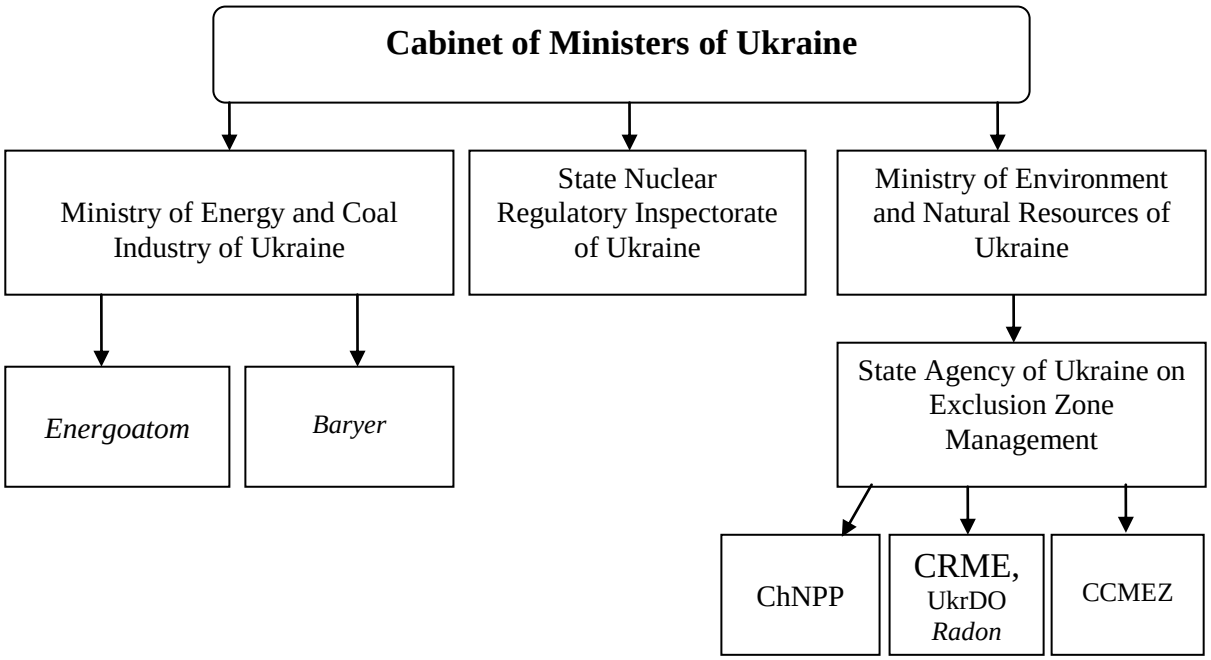
Legislative framework for regulatory control over compliance with nuclear and radiation safety remained unchanged in the reporting period (see NRU-2014).

E.2.5. Enforcement of Applicable Regulations and Terms of Licenses

In the reporting period, the procedure and criteria for enforcement of compliance with applicable regulations and licensing terms remained unchanged (see NRU-2014).

E.2.6. Allocation of Responsibilities for Bodies Involved in Different Stages of Spent Fuel and Radioactive Waste Management

According to the principles of state policy in nuclear energy use and radiation safety established in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", Ukraine separates state control in the areas of nuclear energy and state control of radwaste disposal and long-term storage.



The State Agency of Ukraine on Exclusion Zone Management (SAEZ) is entrusted with functions of state management in the area of radwaste management at the stages of long-term storage and disposal and with implementation of the state policy for radwaste management. To perform its functions, the SAEZ deals with state management of specialized radwaste management enterprises at ChNPP in decommissioning of ChNPP units 1-3 and Shelter transformation into an environmentally safe system.

The SAEZ efforts in the central executive system are coordinated by the Minister of Environment and Natural Resources of Ukraine.

The Ministry of Energy and Coal Industry of Ukraine (MECI) is in charge of the establishment and implementation of state policy for fuel and energy, including nuclear energy.

The MECI exercises state management over the operating organizations of acting NPPs (*Energoatom*) and *Baryer*.

The MECI arranges and coordinates the safe management of spent fuel and radioactive waste in operation of nuclear facilities until radwaste is transferred to specialized radwaste management enterprises for long-term storage or disposal.

In compliance with the main principles of state policy for radwaste management identified in Subsection B.3 of NRU-2011, the radwaste generators are responsible for

management of waste before its transfer to specialized radwaste management enterprises. Radwaste disposal by radwaste generators is prohibited.

Waste generators are currently operating organizations of nuclear facilities: *Energoatom* for operating NPPs, NRI (Kyiv) for the research reactor, State Specialized Enterprise ChNPP for the Chornobyl NPP and enterprises and organizations that use radionuclide sources.

The CRME is the national operating organization for radwaste management at the stages of long-term storage and disposal. Radwaste generated at enterprises that use radiation sources and at research reactors is collected and temporarily stored by UkrDO *Radon* SISPs, CRME being the main enterprise of UkrDO *Radon*.

CCMEZ is appointed the operating organization for the stages of design and construction of radwaste disposal facilities at *Vektor* site. CCMEZ serves as the main client of all construction projects in the exclusion zone, except for ChNPP and CSFSF sites.

E.3. Regulatory Body (Article 20)

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.

2. Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.

The main functions of the nuclear regulatory body are entrusted to the State Nuclear Regulatory Inspectorate of Ukraine, acting in compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine, approved by Cabinet Resolution No. 363 of 20 August 2014.

In its nuclear regulatory activities, SNRIU is independent of central executive bodies, enterprises and organizations with administrative functions in the area of nuclear energy and spent fuel and radioactive waste management in compliance with Para. 2 of Article 20 of the Joint Convention.

National legislation of Ukraine clearly separates functions of the regulatory body and any other authorities or organizations in the area of nuclear energy. At the legislative levels, this is governed by Articles 21, 23, 24 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety".

In compliance with the Law of Ukraine "On Authorizing Activity in Nuclear Energy", interference of any authorities, officials, citizens and their associations in the resolution of issues within the powers of the state nuclear regulatory body is inadmissible.

To implement one of the fundamental principles of nuclear safety, such as safety culture, the "Statement on the SNRIU Policy in Nuclear Energy Safety and Safety Culture" was adopted by the regulatory body, which is placed on the SNRIU website www.snrc.gov.ua.

The SNRIU issues annual reports on nuclear and radiation safety in Ukraine. The annual report highlights implementation of the national policy in peaceful use of nuclear energy and compliance with nuclear and radiation safety requirements in Ukraine. The annual report is published in Ukrainian and English and posted at the SNRIU official website www.snrc.gov.ua.

In order to adapt the requirements of European Directives and strengthen the independence and institutional capacity of the regulatory body, the SNRIU has developed a draft Law of Ukraine on the state nuclear regulatory body, which is consistent with other governmental authorities.

To develop recommendations on significant issues and identify the most essential areas of nuclear and radiation safety regulation, the SNRIU Board is working on a permanent basis.

Advisory functions in the SNRIU decision-making process in the area of nuclear energy use are performed by the Advisory Board on Radiation Protection, Advisory Board on Reactor Safety and Public Council.

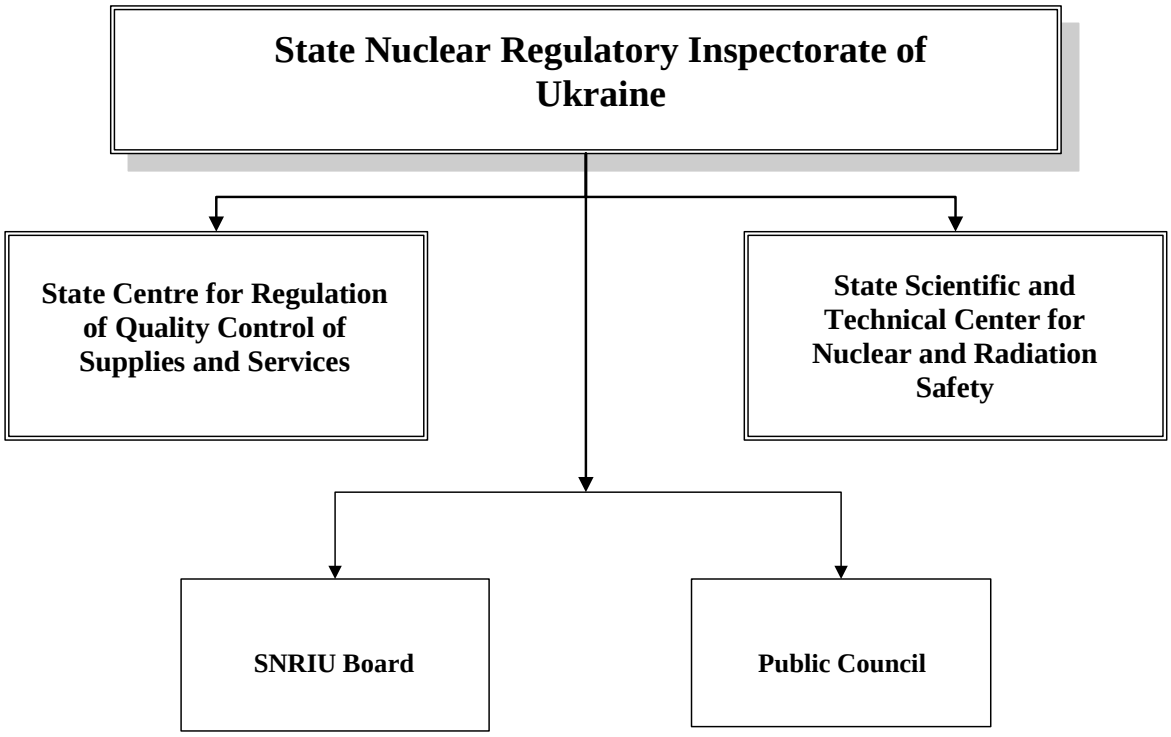
The Public Council was established to ensure that the public is involved in administration of state affairs, exercise public supervision of SNRIU activities and promote effective interaction of the SNRIU with the public, taking into consideration public opinion in the formulation and implementation of state policy. The main tasks of the Public Council are to:

- create conditions for citizens to exercise their constitutional right for participation in administration of state affairs;
- carry out public supervision over SNRIU activities;
- assist the SNRIU in considering the public opinion in the formulation and implementation of state policy.

Within the SNRIU system, there are also two technical support organizations:

1. State Scientific and Technical Centre for Nuclear and Radiation Safety, providing analytical, scientific, expert, technical, engineering, informational, consultative and methodological support to the state nuclear regulatory body;

2. State Centre for Regulation of Quality Control of Supplies and Services, providing technical support to the SNRIU as well as methodological and advisory support in updating regulatory requirements for quality assurance of equipment and services for nuclear power facilities.



The SNRIU implemented management system of activities in compliance with ISO 9001 in 2008.

The SNRIU management system allows effective performance of functions to achieve the objectives of state policy in nuclear energy use, systematically resolve the challenges faced by the regulatory body, meet the expectations of society and manage legislative changes that may influence the functions and powers of the regulatory body. The management system processes are defined and described also taking into account IAEA GS-R-3 "Safety Requirements. The Management System for Facilities and Activities".

In the framework of the certification procedure, internal and external audits are periodically conducted at the SNRIU in all areas of activity, working parameters are continuously monitored and measures are taken for continuous improvement of the results.

Compliance of the management system is periodically confirmed by auditors having international accreditation. According to the recertification audit of the management system that was conducted in 2017, it was ascertained that the SNRIU management system fully meets the requirements of international standard ISO 9001: 2015, which confirms the compliance of the management system and the regulatory approaches with the current European level.

Section F. OTHER GENERAL SAFETY PROVISIONS

F.1. Responsibility of the License Holder (Article 21)

1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

According to Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the licensee is fully responsible for radiation and physical protection and safety of nuclear facilities, radwaste management facilities and radiation sources independently of activities and responsibilities of suppliers and state nuclear regulatory authorities.

Specific responsibilities of the licensee are established in Articles 32 and 33 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and Article 11 of the Law of Ukraine "On Radioactive Waste Management", particularly:

– the licensee shall submit annual radiation safety analysis reports to the regulatory body and ensure that radwaste generation be as low as practically achievable;

– in the event of an accident, the licensee shall keep records and predict radioactive releases beyond the nuclear installation or spent fuel or radwaste management facility and appropriately inform about this respective bodies and organizations;

– the operating organization shall appropriately submit timely and complete information on operational events at nuclear facilities or radwaste disposal facilities;

– the licensee shall be responsible for informing the public, national authorities and public organizations on nuclear safety and radiation protection.

The licensee's responsibilities are also established in special terms of licenses and individual authorizations. If the licensee is deprived of the license or authorization, it is still responsible for the safety of its facilities until they are transferred to other entities or a new license or authorization is granted.

The licensee takes measures to protect personnel and the public in case of an accident at a nuclear facility or radwaste management facility.

The SNRIU verifies whether the licensee has necessary documentation, organizational structure and resources to maintain a proper safety level.

F.2. Human and Financial Resources (Article 22)

Each Contracting Party shall take the appropriate steps to ensure that:

i) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;

ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;

iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

In 2012, regulatory requirements for the management system and human factor were approved in Ukraine. These regulatory requirements comply with requirements of IAEA Safety Standards Series No. GS-R-3 "Safety Requirements. The Management System for Facilities and Activities", WENRA reference levels, consider requirements of ISO 9001 standard and GS-G-3.x series recommendations. Regulatory requirements to wide extent meet requirements of IAEA GSR Part 2. Leadership and. Management for Safety.

State regulation covers the provision of resources, safety culture, professional training of personnel, creation of a system for training and checking knowledge of nuclear and radiation safety issues. The regulatory body performs oversight of compliance with these legal and regulatory requirement, conditions of issued licenses. The regulatory body interacts with licensees on the elimination of inconsistencies revealed in oversight, formation and maintenance of safety culture.

The training and professional development system in the area of spent fuel and radwaste management, which is described in previous NRUs, was further improved in the reporting period.

F.2.1. Qualified Staff Needed for Safety-Related Activities during the Operating Lifetime of a Spent Fuel and Radioactive Waste Management Facility

According to Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the licensee establishes requirements on qualification of personnel depending on their responsibility for the safety of nuclear facilities and radwaste management facilities, their monitoring, and proper operation of safety-related equipment.

In compliance with legislation, the licensee improves skills of its personnel who perform licensed activities on a permanent basis and admits them to work after appropriate training and examination. The licensee develops procedures for examinations on nuclear and radiation safety for managers and personnel and agrees them with the SNRIU. Some categories of personnel are examined in the presence of the regulatory body's representative.

Compliance with personnel qualification requirements is also monitored under state supervision over enterprises that deal with spent fuel and radioactive waste management.

The national training system operates in cooperation with scientific organizations, enterprises, state control and regulatory bodies and other educational systems to ensure

adequate training, retraining and professional development of personnel in order to maintain knowledge, skills and professional attitude.

The following higher educational establishments in Ukraine carry out training and professional development of experts in the sphere of nuclear energy use:

- Taras Shevchenko National University of Kyiv;
- National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic University";
- Odesa National Polytechnic University;
- Odesa State Environmental University;
- Kharkiv National University;
- Kharkiv Polytechnic University "National Technical University";
- National University "Lviv Polytechnic".

Training of experts in higher educational establishments is carried out using modern equipment in specialized laboratories (radiochemical laboratories for activities with open radioactive substances, spent fuel and high-level radwaste, radiochemical and spectro-chemical laboratories, etc.).

Requirements for personnel qualification and examination are established in the relevant instructions, provisions and licenses for operation of radwaste management facilities. Radwaste and spent fuel management facilities are fully staffed with personnel of corresponding qualification.

The development of NPP training centers, serving as a basis for NPP personnel training, is underway. The centers are provided with skilled trainers. Training tools are under improvement. The NPP training centers employ simulators and include practical exercises.

Under INSC U4.1/08D project, a comparative analysis of the personnel training and monitoring systems in the area of radwaste management at Ukrainian NPPs and practices at West European NPPs was carried out, Program for Training and Professional Development of Personnel Involved in Radioactive Waste Management was elaborated, individual and group programs for initial training and further professional development were developed and personnel of different categories were trained on radwaste management and received respective certificates.

Information on training of ChNPP personnel is provided in Subsection F 6.1 of this Report.

CRME and UkrDO *Radon* SISP conduct systematic development of personnel aimed at building of a safety culture, ensuring of a relevant qualification and preparedness to perform their professional duties. Besides, international technical support is involved. Personnel of enterprises undergo training and professional development on safety assessment of radioactive waste management facilities, application of state-of-the-art safety assessment methodologies and presentation of assessment results, on operation and application of systems and components supplied to the enterprises within the international support (CLTSF process equipment, dosimetric equipment of emergency teams, devices for instrumental surveys of legacy facilities ant their territories, etc.).

There is a permanently working system for personnel training and professional development, where the following approach is used: training without leaving the production process for employees working on radioactive waste management facilities. Periodic training of the management and operational personnel of the enterprises is performed by the Ukrainian

Radiological Training Center (URTC). This training center is part of UkrDO *Radon* and is a core training establishment of the corporation, which provides periodic training and professional development of personnel.

URTC has developed and approved the long-term program for training and professional development of experts on radioactive waste management intended for 2013-2018. The specified program is aimed at periodic professional development of experts on radioactive waste management and is intended to the heads of enterprises, heads of structural subdivisions, engineering and technical employees and personnel working in the sphere of radwaste management.

According to this program, training and certification of the managers and their deputies is performed in URTC every three years. Training of experts on radwaste processing, decontamination, radwaste transport handling, dosimetry and other (category A personnel) is carried out annually. URTC also provides short-term professional development with a 72-hour long training process.

In the reporting period, 105 experts of UkrDO *Radon* improved their knowledge and successfully passed the certification in URTC, in particular: in 2014 – 30 experts; in 2015 – 29 experts; in 2016 – 46 experts.

At the enterprises that are within SAEZ management area, checking knowledge of rules, regulations and standards of nuclear and radiation safety is performed in accordance with the Procedure approved by Order No. 82 of the Ministry of Emergencies of Ukraine dated 30 January 2012. The Procedure establishes the framework for checking knowledge of regulations, rules and standards of nuclear and radiation safety and extends to:

heads of subdivisions and experts of the State Agency of Ukraine on Exclusion Zone Management;

heads and individuals of the examination boards at enterprises directly subordinated to SAEZ of Ukraine;

heads and individuals of examination boards of enterprises and organizations that are not subordinated to SAEZ of Ukraine, but which act as contractors and subcontractors at Chornobyl NPP and specialized radioactive waste management facilities in the Exclusion Zone (design, equipment production, construction, mounting, adjustment, repair of equipment and piping, etc.);

officials of operating organizations (operators) of radwaste disposal facilities and ChNPP.

At least once every three years, heads of enterprises, head and members of the enterprise examination board pass a test on the knowledge of nuclear and radiation safety rules, regulations and standards in the central commission of SAEZ with obligatory involvement of SNRIU and MHU representatives.

Examination of managers and experts of enterprises is performed as follows: primary – before the admission to independent activities, periodic (regular), extraordinary (additional).

F.2.2. Financial Resources to Support the Safety of Facilities for Spent Fuel and Radioactive Waste Management during Their Operating Lifetime and for Decommissioning

According to Article 32 of the Law of Ukraine “On Nuclear Energy Use and Radiation Safety”, the licensee shall have financial, material and other resources to keep safety at the level accepted by safety standards and regulations and requirements of the license or authorization.

According to Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the licensee shall have financial, material and other resources to keep safety at the level accepted by safety standards and regulations and requirements of the license or authorization.

Establishment and Use of State Fund for Radwaste Management

The Law of Ukraine "On Amendments to Certain Laws of Ukraine on Radioactive Waste Management" dated 17 September 2008 defines legal bases for the creation of the State Fund for Radioactive Waste Management. The Fund is an integral part of the State Budget of Ukraine and is formed at the expense of costs from the environmental tax paid by radwaste producers for the radioactive waste generation and temporary storage of radwaste beyond the established period considering safety requirements. Thus, one of the fundamental principles used in the international practice and named "polluter pays" is implemented. The Tax Code of Ukraine envisages the formation of the State Fund for Radioactive Waste Management within the State Budget of Ukraine by paying the relevant taxes. Such tax liabilities, in addition to filling the financial fund, encourage radwaste producers to transfer generated radwaste to specialized radioactive waste management facilities in order to avoid radwaste accumulation at producers site and improve radiation safety level in the state.

As part of its financial obligations, *Energoatom*, being the primary payer to the State Fund for Radioactive Waste Management, has been paying tax for radwaste generation (including already accumulated waste) since 2009. Such a tax is provided in tariffs for supply of electricity and production of thermal energy at NPPs. In total, *Energoatom* allocated 4,589 mln. UAH to the Fund for Radioactive Waste Management from 2009 to 2016.

However, in December 2010, amendments were made to the nuclear legislation in terms of spending the Fund money. This led to the fact that the Fund lost its accumulative character. Besides, in 2015, Fund costs were transferred from the specialized fund of the State Budget to the general fund of the State Budget, which greatly worsened the situation: along with the loss of accumulative nature, the Fund also lost the mechanism for the targeted use of its costs.

According to the annual analysis of the implemented National Targeted Environmental Program for Radioactive Waste Management, estimated amount of financial resources from 2008 to 2016 should have made 4 781.072 million hryvnias. 498.883 million hryvnias was actually allocated from the state budget, which makes 10.4% of the estimated budget allocations.

Actual funding was sufficient only to maintain the radioactive waste management infrastructure. This did not allow full implementation of tasks envisaged by this program and the achievement of its objectives.

In order to change such a situation, to restore accumulative status and to ensure proper financing of measures in the sphere of radwaste management, SAEZ according to the established procedure developed the Law of Ukraine "On Amendments to Article 4 of the Law of Ukraine "On Radioactive Waste Management" on Improving Mechanism for Financing of Radioactive Waste Management" and the Law of Ukraine "On Amendments to the Budget Code of Ukraine on Improving Mechanism for Financing of Radioactive Waste Management Activities" adopted by the Verkhovna Rada of Ukraine on 11 July 2017 (entry into force on 01 January 2018).

Establishment and Use of Financial Reserve for Decommissioning of Energoatom Nuclear Facilities (Decommissioning Fund)

The Law of Ukraine “On Settlement of Nuclear Safety Issues” defines a legal and administrative basis for funding of operation termination and decommissioning of nuclear facilities. This law states that a special account shall be opened at the State Treasury of Ukraine to accumulate decommissioning funds.

The *Energoatom* is the payer of contributions to this Fund. The total amount of costs allocated by *Energoatom* to the Financial Reserve for Nuclear Facility Decommissioning since its creation (in 2005) as of 31 December 2016 was 2740.268 million hryvnias. Since 01 January 2017, there was an increase in contributions to the Financial Reserve for Nuclear Installation Decommissioning from 283.4 million hryvnias to 785.4 million hryvnias per year. At the expense of the Financial Reserve, it is envisaged to decommission operating nuclear facilities of the *Energoatom*, including ZNPP DSFSF.

The experience of accumulation and use of costs for decommissioning demonstrated the need to improve mechanisms of the fund in terms of protecting accumulated costs from inflation and prevention of their misuse. Efforts are conducted to address these issues within the framework of a special oversight board created by the Government.

Funding of ChNPP Decommissioning and Safety Assurance of Spent Fuel and Radioactive Waste Management Facilities in ChNPP Decommissioning

According to the legislation, financing of preparation for the decommissioning of ChNPP Units, Shelter transformation into environmental safe system, radiation safety, medical and biophysical control of personnel of ChNPP and contractors, social protection of ChNPP personnel and Slavutych residents are financed at the expense of the State Budget of Ukraine within special budget programs.

At ChNPP, maintenance of the reliable and safe functioning of spent fuel and radwaste management facilities, as well as collection, sorting, characterization and transfer of radwaste for disposal are performed from the State Budget of Ukraine.

The Law of Ukraine "On Radioactive Waste Management", as amended in 2010, establishes that management of radwaste resulting from the Chornobyl accident, shall be funded from the State Fund for Radioactive Waste Management.

In particular, the main two budget programs were completed to full extent in 2016 (868.5 million hryvnias and 601.2 million hryvnias): “Maintaining Safe State of Power Units and the Shelter and Measures on Preparing ChNPP for Decommissioning” and “Contributions of Ukraine to Chornobyl Shelter Fund and EBRD Nuclear Safety Account”.

To improve the system of ChNPP spent fuel and radioactive waste management, resources of international technical cooperation are involved. The construction of ISF-2 and LRTP is funded from the EBRD Nuclear Safety Account, and the ICSRM facilities have been constructed and almost finally commissioned within the TACIS program.

Financial Resources for Safety Assurance of Spent Fuel and Radioactive Waste Management Facilities in Their Operation

Spent fuel and radioactive waste management at operating NPP sites is funded from costs included into the electric and thermal energy tariff. Moreover, to improve the infrastructure for radwaste management at NPPs, resources of international cooperation are involved. For example, systems for solid radwaste treatment at the Zaporizhzhya and Rivne NPPs were constructed under EC technical cooperation projects.

The management of spent fuel and radwaste from research reactors during operation (including future decommissioning) is funded from the State Budget.

Radwaste management at the UkrDO *Radon* SISPs (operation and future decommissioning) is funded from costs paid by enterprises that transfer radwaste to SISPs

for storage on a contractual basis and from the State Budget of Ukraine (through the State Fund for Radioactive Waste Management).

Government also involves international technical assistance for radwaste management at UkrDO *Radon*.

The CRME activities related to operation and safety assurance of radwaste management facilities in the exclusion zone are financed from the State Budget (through the State Fund for Radioactive Waste Management).

F.2.3. Financial Provision for Appropriate Institutional Control and Monitoring Arrangements for the Period Following the Closure of a Radwaste Disposal Facility

The institutional control and supervision of disposal facilities for CRME radwaste in the post-closure period is be funded from a dedicated fund of the State Budget through the State Fund for Radioactive Waste Management.

The control of closed radwaste disposal facilities of UkrDO *Radon* SISPs is funded from the State Budget of Ukraine.

F.3. Quality Assurance (Article 23)

Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

According to Article 11 of the Law of Ukraine "On Radioactive Waste Management", the development and implementation of the quality program is the responsibility of the licensee and the condition of obtaining permits from the regulatory body at all stages of spent fuel and radwaste management.

The regulatory documents "General Requirements for the Management System in the Area of Nuclear Energy" and "Requirements for the Management System of the Operating Organization (Operator)" were put in force in 2012. These documents were developed in accordance with the structure and contents of IAEA documents GS-R-3, GS-G-3.1 and GS-G-3.5, ISO 9001 standard and WENRA reference levels (2014). Licensee compliance with requirements of these documents is confirmed during inspections.

According to requirements of these documents, licensee management system shall combine (integrate) regulatory requirements for nuclear and radiation safety, environmental protection, labor protection and others in order to implement the policy and reach the specified objectives in the safety area. Requirements for the management system cover requirements for: organization policy and objectives, safety culture and leadership, information communication management, organizational structure, personnel qualification, technological processes, arrangement of internal oversight and independent assessment, all types of resources.

Licensees shall developed and keep updated documented description of processes and functions that have impact on nuclear and radiation safety in the management of spent fuel and radioactive waste, including:

- responsibilities of the manager of the process and its executors, their duties and responsibilities in making decisions, subordination, the procedure of interaction during process performance or fulfillment of function;
- sequence of process implementation or function fulfilment;
- authorities, responsibilities and procedure for interaction with contractors, suppliers, customers (consumers) in implementation of a process or function;
- list of resources needed for carrying out this or that process;

- requirements for the final result of process implementation;
- inconsistencies, emergencies possible during process implementation and measures to control them;
- references to documents that should be used in process implementation or function fulfilment, including references to relevant safety requirements.

Licensees shall carry out independent quality control in design and construction of spent fuel and radwaste management facilities according to requirements of regulatory and technical document, namely: State Standards of Ukraine, State Building Standards.

Licensees take measures to improve the quality management system. All actions aimed at quality improvement shall be planned, clearly formulated and regulated. Their implementation shall be monitored.

The licensees that deal with spent fuel and radwaste management, *Energoatom*, ChNPP, CRME, CCMEZ, and UkrDO *Radon* SISPs ensure compliance of their management systems for activities (quality systems) with regulatory requirements and standard ISO 9001. In accordance with regulatory requirements, policy of these organizations is aimed at continuous improvement of activities in order to keep it in compliance with the specified regulatory documents and international standards.

In 2016, the *Energoatom* successfully passed the certification audit and confirmed the compliance of the integrated management system with requirements of international standards:

- ISO 9001:2008 "Quality Management System. Requirements";
- ISO 14001:2004 "Environmental Management Systems. Requirements with Guidance for Use";
- OHSAS 18001:2007 "Occupational Health and Safety Management".

Appropriate certificates to confirm compliance of the management system with international standards are issued by the TÜV NORD CERT certification body.

To coordinate activities for maintenance of safety culture, *Energoatom* established the safety culture board and working group on safety culture. Safety culture audits are periodically conducted at *Energoatom* to check, among other issues, a number of quality management aspects.

On 01-13 November 2015, the World Association of Nuclear Operators (WANO) consisting of representatives from nine countries (Bulgaria, Czech Republic, Finland, Japan, Russia, Slovakia, Sweden, Ukraine and the USA) held a corporate peer review of the *Energoatom* in Ukraine. Peer review results were found to be satisfactory and its management system was considered to be an example to follow.

F.4. Operational Radiation Protection (Article 24)

1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and

iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

F.4.1. Radiation Protection of Workers and Public

Regulatory control over limitation of radiation exposure for personnel, the public and the environment in Ukraine is ensured by laws, standards and rules, such as the Law of Ukraine "On Human Protection against Ionizing Radiation", "Radiation Safety Standards of Ukraine" (NRBU-97), including supplement "Radiation Protection against Potential Exposure Sources" (NRBU-97/D-2000), "Basic Health and Radiation Safety Rules" (OSPU-2005), health and safety standards "Levels for Exemption of Radioactive Material from Regulatory Control" (2010).

These regulations, in particular, establish regulatory values to limit routine and potential exposure for personnel and the public.

The Radiation Safety Standards of Ukraine (NRBU-97) establish the following dose limits:

Table F.4.1. Dose Limits (mSv·year^{-1})

	Category of exposed individuals		
	A [a) b)]	B [a)]	C [a)]
DL_E (effective dose limit)	20 [c)]	2	1
External equivalent dose limits:			
- DL_{lens} (for lens)	150	15	15
- DL_{skin} (for skin)	500	50	50
- DL_{extrim} (for hands and feet)	500	50	-

Notes:

[a)] dose distribution during a calendar year is not regulated;

[b)] limitations of NRBU-97 para. 5.6 apply to women of childbearing age (to 45) and pregnant women;

[c)] average for any five consecutive years but no more than 50 mSv in a single year.

The following regulatory values are established for spent fuel and radioactive waste management:

1. Limits for planned exposure during practices – dose limits and derived permissible and reference levels. These regulatory values are based on the concept of annual effective dose limitation.

2. Limits for potential exposure during practices – reference levels of doses and probabilities of critical events. These regulatory values are based on the concept of potential exposure risk limitation: 2×10^{-4} year^{-1} for personnel and 2×10^{-5} year^{-1} for the public. Accordingly, for critical events (CEs) that lead to potential exposure for a small group of people, the following reference levels to limit potential exposure are established:

– for personnel – CE probability is no higher than 1×10^{-2} $year^{-1}$ with effective dose no more than 100 mSv and no higher than 2×10^{-4} $year^{-1}$ with effective dose more than 100 mSv;
– for the public – CE probability is no higher than 1×10^{-2} $year^{-1}$ with effective dose no more than 50 mSv and no higher than 2×10^{-5} $year^{-1}$ with effective dose more than 50 mSv.

3. Limits for exposure during accidents.

Exposure for the main personnel involved in emergency measures is limited by the above dose limits for routine exposure. Given proper informing and voluntary agreement of personnel, it is permitted to increase the effective dose to 100 mSv and increase the equivalent dose to 500 mSv to an organ (including uniform exposure to the whole body) in exceptional (specifically defined) cases required to save people's lives.

In order to ensure radiation protection of the public, dose limit quotas are established for exposure from releases and discharges: they are 80 μSv/year for nuclear facilities and 40 μSv/year for radwaste management facilities in operation. Based on the dose limit quota for each individual facility, permissible releases and discharges are determined, which are not allowed to be exceeded in normal operation.

Radiation exposure for the public is limited through countermeasures taken in compliance with intervention levels and derived action levels. Intervention levels are determined in terms of averted dose due to countermeasures. NRBU-97 established criteria (intervention levels and action levels) to make decisions on justification or unconditional justification of emergency, urgent or long-term countermeasures. For example, averted dose of 50 mSv for the whole body is the lower justification boundary and averted dose of 500 mSv is the level of unconditional justification for evacuation countermeasure.

4. Regulatory values for exposure to people from radwaste disposed of in near-surface facilities following 300 years after closure include limitation of:

– annual effective dose of 0.01 mSv for routine exposure;
– reference level of 1 $mSv\cdot year^{-1}$ for potential exposure.

Upon a separate regulatory decision, the level of potential exposure may be increased to 50 $mSv\cdot year^{-1}$ provided that additional measures are taken to reduce the risk of potential exposure.

F.4.1.1. Application of the ALARA Principle

The legislation of Ukraine determines optimization as one of the main principles of radiation protection. The optimization principle obliges the licensee to keep both individual and collective exposure of personnel and the public and the probability of critical events and associated potential doses as low as reasonably achievable, social and economic factors being taken into account.

There are the following key instruments for optimization of radiation protection in Ukraine:

– application of reference levels (RLs) to decrease exposure for personnel and releases and discharges (they are RLs for exposure of personnel to radiation, releases and discharges, RLs for radiation conditions in production rooms and on site, RLs for contamination of equipment, process media etc.). Reference levels shall not exceed 70% of permissible levels and shall be as low as practically achievable;

– application of administrative technological levels (investigation levels) below RLs for additional monitoring of equipment process modes;

– improvement of radiation monitoring systems, including monitoring types, scopes and procedures, instrumentation, methodologies, metrological support and software;

– implementation of administrative and technical measures for collective and individual protection of personnel, reduction of releases and discharges, prevention of critical events and decrease of exposure, releases and discharges in case of critical events;

– planning of radiation-related hazardous activities;

– minimization of radwaste generation;

– implementation of the training system;

– implementation of the quality system for radiation protection.

Reference levels are established by the licensee based on the achieved level of radiation safety and shall be decreased as safety improves. The SNRIU makes sure that RLs are established at the level close to that of similar practices and that RLs are observed. In particular, any case of RL incompliance is investigated by the licensee, and the respective report and corrective measures are considered by the SNRIU.

Application of the optimization principle allows the plants to keep individual doses to personnel as low as reasonably achievable (70% of personnel obtained dose lower than 1 mSv/y in 2016), gradually decrease the collective dose (see Annex 8 to this Report) and ensure that plant releases and discharges be no more than percentage of permissible levels (see Annex 8 to this Report).

The licensee's compliance with the optimization principle is verified during regulatory supervision, through analysis of annual reports on nuclear and radiation safety and during periodic revisions of reference levels and regulatory values for radiation dose control and monitoring.

There are dose registries at each NPP in Ukraine to evaluate the effectiveness of the optimization principle.

According to recommendations of the IRRS-2008 Mission, the optimization principle was applied at the UkrDO *Radon* SISPs to establish RLs for individual annual doses for personnel. The reference levels of individual annual dose for category A personnel are 4-5 mSv for these enterprises.

F 4.1.2. Observation of Basic Dose Limits

Dose limitation is one of the main principles of radiation protection and safety in Ukraine.

According to radiation dose monitoring at facilities for spent fuel and radioactive waste management, the following conclusions can be made for 2014-2017:

– annual limits of individual equivalent doses for personnel of categories A and B were not exceeded in the reporting period;

– permissible airborne radionuclide concentrations in working areas were not exceeded at any enterprise;

– radiation safety of category C individuals (public) living around the respective enterprises complied with standards and rules in force according to radiation monitoring.

The average individual doses for personnel of operating NPPs, ChNPP and CRME in the reporting period are shown in Figures L.8.1, L.8.2 and L.8.3 in Annex 8 to this Report.

The collective doses for personnel involved in spent fuel storage at Zaporizhzhya DSFSF are shown in Figure L.8.4 of Annex 8 to this Report

According to data from radiation and dosimetric control at Ukrainian NPPs, there were no cases of exceeding exposure dose limits for category A and category B personnel in 2014-2016.

The analysis of distribution of individual doses of *Energoatom* NPP personnel demonstrate that the vast majority of NPP personnel receive doses of less than 10 mSv per

year. There were no individuals out of personnel who received doses above 15 mSv in 2016. Average individual doses of NPP personnel in 2014-2016 ranged from 0.34 mSv/individual per year (KhNPP, 2015) to 0.97 mSv/individual per year (SUNPP, 2015).

The dynamics of average individual exposure doses of ChNPP personnel involved into spent fuel and radwaste management in the reporting period is presented in Figures F4.1.1, F4.1.2.

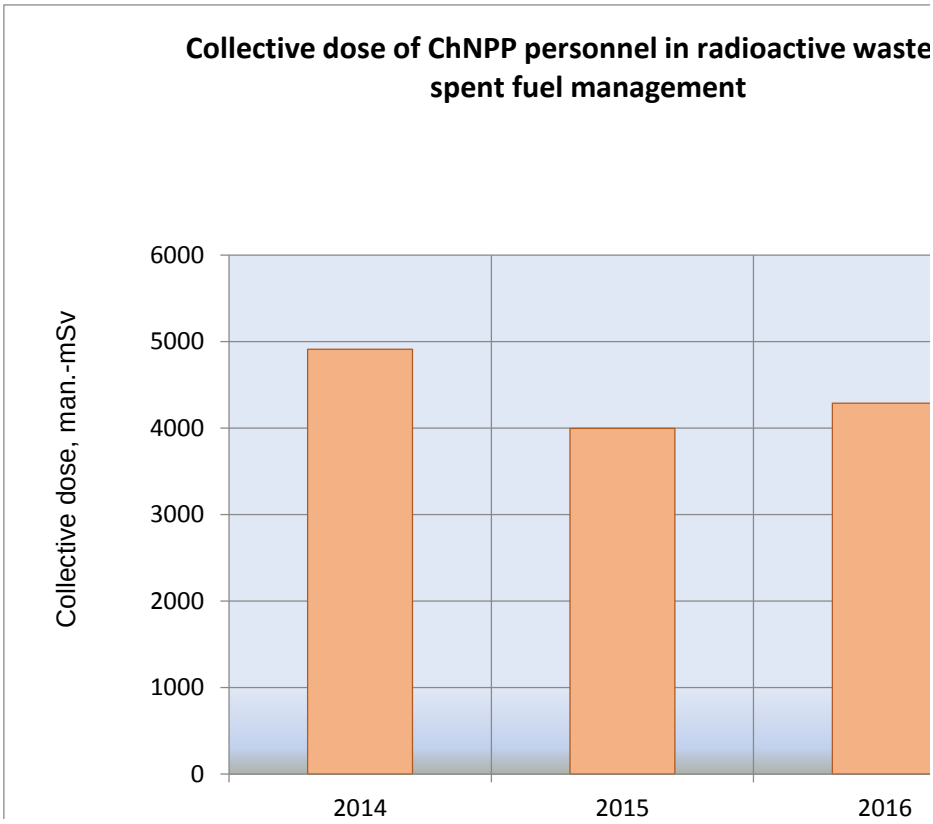


Fig. F.4.1.1 *Collective dose of ChNPP personnel in all operations with spent fuel and radioactive waste*

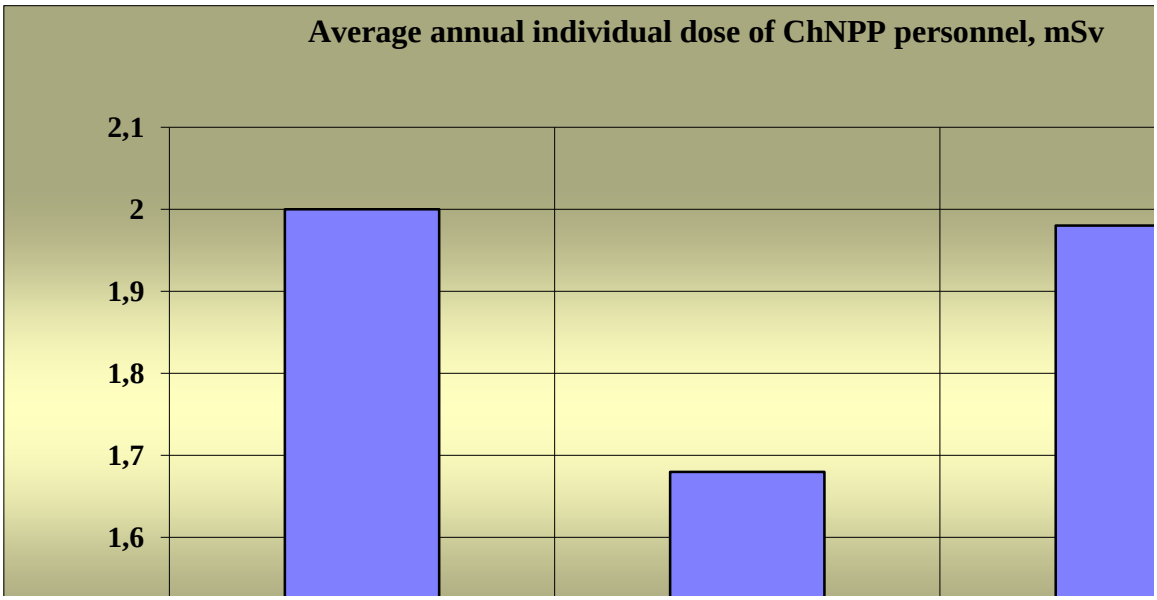


Fig. F.4.1.2 *Average annual individual doses of ChNPP personnel*

The analysis of distribution of individual doses of ChNPP personnel involved into spent fuel and radwaste management demonstrated that the vast majority of personnel receive doses of less than 10 mSv per year. Exposure doses for ChNPP personnel involved into spent fuel and radwaste management in 2014-2016 are presented in Table F 4.1.2.

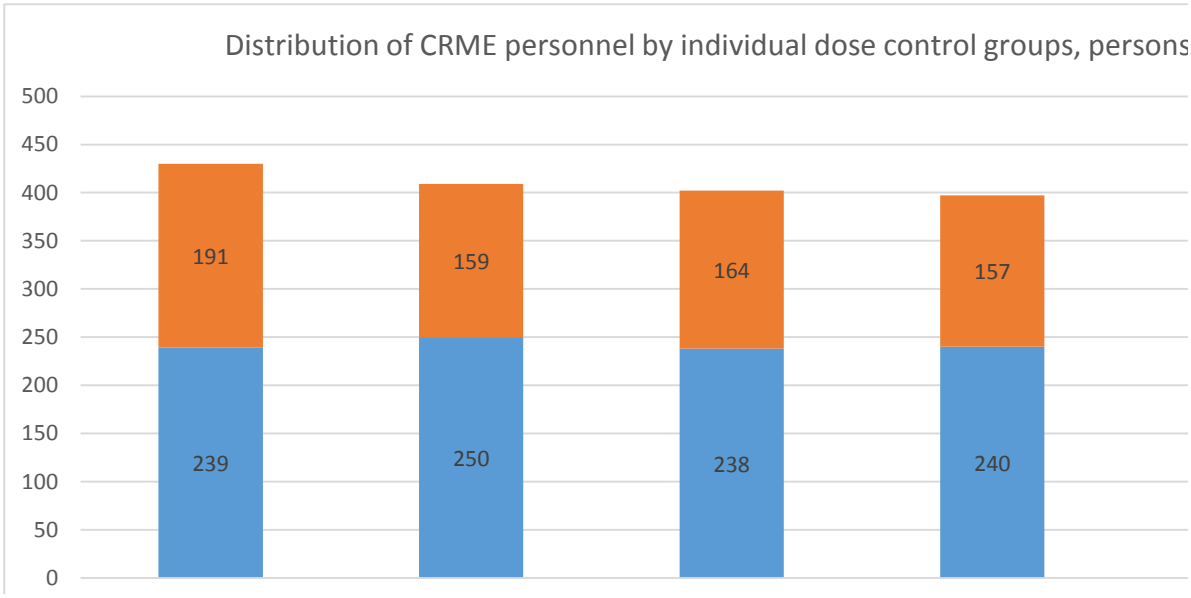
Table F.4.1.2 *Doses of ChNPP personnel involved in spent fuel and radioactive waste management in respective years*

Year	2014	2015	2016
Number of monitored persons	2456	2372	2262
Collective dose, mSv	4911.46	3996.39	4286.19
Average dose, mSv	2.00	1.68	1.98

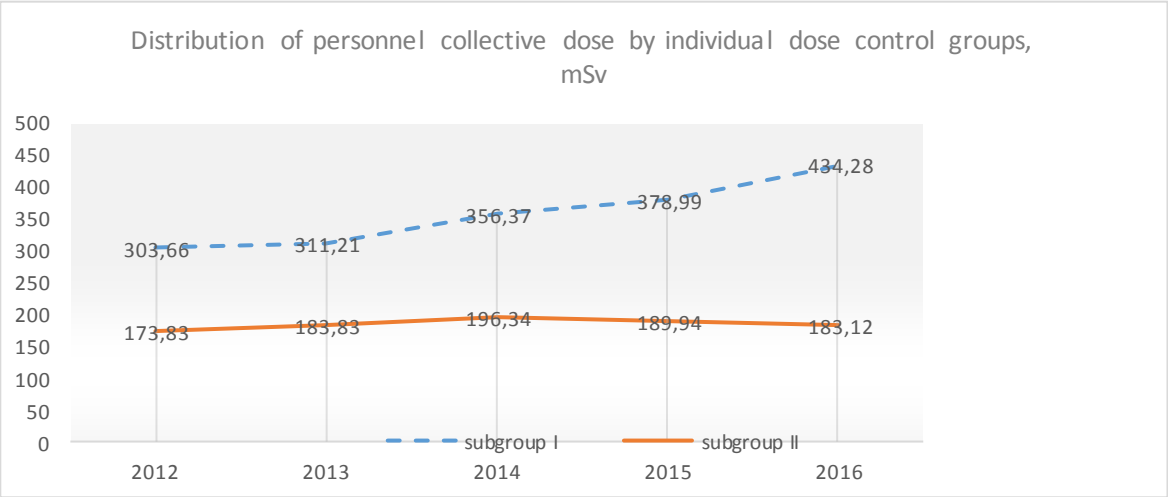
The average individual doses of category A personnel at SISPs of UkrDO *Radon* in 2014-2017 were as follows: the lowest was 0.14 mSv/individual per year at Kyiv SISP in 2016 and the highest was 3.38 mSv/individual per year at Kharkiv SISP in 2014.

According to data of radiation and dosimetric control at CRME facilities where radwaste management is carried out, individual exposure doses of enterprise personnel were within the established control levels in 2014-2017, taking into account the error in relevant measurements.

The distribution of enterprise personnel by subgroups demonstrates a decrease in a number of subgroup II personnel (individual dosimetric control) in recent years, with the sustainable number of subgroup I personnel who perform radiation hazardous activities at CRME.



The current trend of increase in the average annual individual exposure dose of CRME personnel is mostly related to the activities on liquidation of pits and trenches on RICS territories, initiation of CLTSF hot tests, survey of RWDS *Pidlisny*.



Ukraine keeps registers of doses for personnel of NPPs, specialized radwaste management enterprises, exclusion zone facilities and for medical staff.

F.4.1.3. Prevention of Unplanned and Uncontrolled Releases of Radioactive Materials into the Environment

To prevent unplanned and uncontrolled releases and discharges of radioactive materials into the environment, control and monitoring devices are used at spent fuel and radwaste management facilities. Procedures for radiation monitoring and for calibration, maintenance and repair of instrumentation are in place.

Routine radiation and environmental monitoring is conducted at NPP sites, including the 30-km area of operating NPPs, in the Chornobyl exclusion zone, including its radwaste and spent fuel management facilities, on the UkrDO *Radon* SISP territory and adjacent controlled areas and in observation areas. Threshold dose rate detectors are installed around each NPP site within a 30-km radius.

Procedures for radiation dose control and monitoring are agreed by regulatory authorities, Ministry of Health and SNRIU, and are periodically revised to take into account operating experience, improvement of monitoring instrumentation and changes in the regulatory and legal framework.

F.4.2. Limitation of Discharges and Releases

The Radiation Safety Standards of Ukraine establish dose limit quotas for the public from releases and discharges, which are 80 μSv/year for nuclear facilities and radwaste treatment facilities and 40 μSv/year for radwaste disposal facilities in the operational period. These quotas are used as the basis for determining, for each facility, permissible releases and discharges that must not be exceeded in normal operation.

According to radiation monitoring, RLs of releases and discharges at operating nuclear facilities, including spent fuel storage facilities and radwaste management facilities, were not exceeded in the reporting period.

The dynamics of releases and discharges at operating NPPs in the reporting period is shown in Figures L.8.5-L.8.12 and at the Chornobyl NPP in Figures L.8.13-L.8.14 of Annex 8 to this Report.

F.4.3. Corrective Measures to Control Unplanned or Uncontrolled Release of Radioactive Materials into the Environment and Mitigation of Its Effects

The protection of personnel and the public against unplanned or uncontrolled release of radioactive materials is governed by Articles 7 and 8 of the Law of Ukraine "On Human Protection against Ionizing Radiation" and Radiation Safety Standards of Ukraine.

The principles of justification, limitation and optimization are used for intervention in case of uncontrolled or unplanned radioactive release. Intervention levels and action levels for countermeasures are determined as quantitative criteria; unjustified, justified and conditionally justified intervention is defined; and intervention termination procedure is established (see also Subsection F.4.1 of this Report).

The Unified State Civil Protection System (USCPS) is in place in Ukraine to protect personnel and the public in case of unplanned or uncontrolled release of radioactive materials to the environment. The USCPS includes a system of emergency preparedness and response in case of nuclear and radiation accidents. The system and associated measures are described in Subsection F.5.

F.5. Emergency Preparedness (Article 25)

1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.

2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory

F.5.1. On-site and Off-site Emergency Plans. Testing of Emergency Plans

The system of emergency preparedness and response in case of nuclear and radiation accidents is an integral part of the Unified State Civil Protection System (USCPS). USCPS includes permanent functional and territorial subsystems and their links. Detailed information on the structure, objectives and functions of the USCPS is provided in NRU-2003-2015.

Requirements for the emergency plans at facilities that deal with practices involving nuclear and radiation technologies, including spent fuel and radioactive waste management facilities, are established in the Radiation Safety Standards of Ukraine, General Safety Provisions for NPPs and National Plan of Response to Radiation Accidents. Emergency planning takes into account radiation hazard categories of facilities (categories I-V), results of risk assessments, requirements of IAEA GSR Part 7 "Preparedness and Response for a Nuclear or Radiological Emergency. General Safety Requirements").

The emergency plans is one of the licensing requirements in the sphere of nuclear energy use. According to Safety Conditions and Requirements (Licensing Terms) for Radioactive Waste Management:

Licensee shall develop emergency plan and procedure of personnel actions in case of radiation accident in accordance with the established procedure taking into account analysis of accidents, emergencies and their consequences carried out during safety assessment of radwaste management facility and shall submit them to the SNRIU in a package of documents for obtaining a license to perform activities on radioactive waste management.

If the licensee is involved into mitigation of radiation accidents, limitation and mitigation of their consequences on other facilities and territories, the licensee shall develop and submit to the SNRIU relevant emergency plans and procedures to be used in such cases.

In case of a radiation accident or in case of an emergency during the conduct of the licensing activity, Licensee: within one hour shall inform SNRIU, MHU, SAEZ and start the appropriate actions envisaged by the emergency plan and emergency procedures.

Emergency plans of operating NPPs were developed based on the Standard NPP emergency plan, which establishes a single format of the structure and contents. They are revised every three years considering changes in the regulatory framework, organizational and administrative changes, results of trainings, inspections and periodical safety reviews.

Emergency response plan of the Energoatom Directorate was developed to coordinate actions, mobilize resources of the operating organization and provide assistance to NPPs, as well as to ensure *Energoatom* Directorate interaction with the state management authority on nuclear energy use, specially authorized central executive authority on civil protection, state authority for nuclear and radiation safety regulation, other central executive authorities.

NPP emergency plans and emergency response plans of the *Energoatom* Directorate are interconnected and coordinated.

Besides, each NPP has a developed and enforced system of regulatory documents (Beyond Design-Basis Accident Management Guideline, Severe Accident Management Guideline, Radiation Safety Guideline, Procedure for Personnel Actions in Case of Radiation Accident, Procedure for the Shift Supervisor when Receiving Information on Dangerous Natural and Hydrological Phenomena, etc.) that are kept updated according to the requirements of the management system.

All operating Ukrainian NPPs are serviced by the state fire and rescue units of the territorial departments of the State Emergency Service of Ukraine. At the same time, all units are completely kept at the expense of NPPs (equipment included).

Separated subdivision "Emergency and Technical Center" of the *Energoatom* has corresponding plans, technical and human resources to provide assistance to NPP in case of radiation accident and during transport of nuclear fuel and radioactive waste.

Effectiveness and consistency of emergency plans of the *Energoatom* Directorate and NPP are systematically checked during emergency trainings of different levels and during scheduled annual comprehensive checking of preparedness of NPP departments and separated subdivisions responsible for ensuring and implementation of emergency measures in the context of threat and (or) occurrence of radiation and nuclear accidents, man-made and natural emergencies.

The *Energoatom* develops and implements emergency training programs to exercise personnel actions in emergency conditions to ensure annual checking of all components of NPP emergency plan and emergency response plan of the *Energoatom*.

The operating organization conducts full-scale general plant emergency training every three years at each NPP in accordance with the "Schedule for General Plant Emergency Training jointly with the *Energoatom* Directorate and with Participation of Representatives from Relevant Ministries and Departments and Local Executive Bodies", developed by *Energoatom* for a period from 2009 to 2018 and agreed by the SNRIU.

During training, the adequacy and interrelation of emergency plans are verified, actions on coordinated prompt response of the authorities are tested, forces and means of functional and territorial subsystems of the unified state civil protection system for the public and territories are checked at all levels – facility, local, regional and national.

According to training results, actions of personnel from the affected facility with regard to protection of the public and personnel, actions to bring the conditionally affected unit to safe state, actions of the operating organization, state of emergency preparedness and

response system are assessed. Training results are thoroughly analyzed. Relevant corrective measures approved and controlled by the SNRIU are planned and implemented according to training results.

ChNPP Emergency Preparedness

ChNPP developed, agreed and apply the following emergency documents:

ChNPP Plan of Response to Accidents and Emergencies, *32P-S*, establishing a general procedure for action and allocation of responsibilities and interaction in case of emergencies on the ChNPP site;

Plan of Measures and Actions in Case of Accidents in Radioactive Material Transport, 1PL-S;

Provisions on ChNPP Emergency Teams and Groups, 11P-S;

Provisions on ChNPP Evacuation Team, 86P-S and other guidance documents.

Two protective structures with autonomous power supply and ventilation systems are kept ready at ChNPP. The emergency center whose functions are in line with requirements of NPP emergency centers is commissioned at protective building No. 1.

To implement measures to improve protection of personnel and the territory against emergencies, prevent potential emergencies and ensure actual preparedness for response in both peaceful and crisis times, ChNPP developed the Plan on Basic Civil Protection Measures at ChNPP.

Facility emergency plans of LRTP, SRTP, ISF-1, Shelter, Units No. 1, 2, 3 were developed. They are in line with document 32P-S.

Emergency Preparedness of Research Reactors

The actions of NRI research reactor personnel in case of an accident are regulated by an emergency plan for research reactor. Emergency training is conducted annually to train personnel to act in emergency conditions, improve their knowledge and skills in confinement of accident and mitigation of its consequences, exercise emergency response plans.

Emergency Preparedness of CRME and UkrDO Radon Plants

Plans of response to radiation accidents, plans of actions and measures in case of accidents in radwaste transport and plans of response to emergencies have been developed and are in place at the specialized radwaste management enterprises: CRME and UkrDO *Radon* SISPs.

Emergency personnel are provided with an emergency medical kit, sanitary treatment means, overalls, individual protection means and radiation monitoring devices. Technical inspection and metrological certification of equipment used in mitigation in a radiation accident are conducted in accordance with the agreed schedule. Personnel included in emergency crews are systematically trained and take part in scheduled exercises in accordance with the "Plan of Organizational and Technical Measures on Theoretical and Practical Training".

Emergency actions in case of an accident in the exclusion zone are also tested during training at CRME.

According to the Procedure for Interaction between Executive Bodies and Legal Entities Dealing with Nuclear Energy in Case of Illicit Trafficking of Radioactive Materials, approved by the Government, UkrDO *Radon* SISPs are involved in emergency actions of competent authorities for mitigation of emergencies and accidents associated with the detection of orphan sources and radioactive materials in illicit trafficking.

F.5.2. Preparation and Testing of Emergency Plans in Ukraine Considering Probability of a Radiological Emergency at a Spent Fuel or Radioactive Waste Management Facility in the Vicinity of Its Territory

Response and external support (outside facility sites) in case of accidents and emergencies are envisaged by the following plans:

- emergency plans of facilities where practical activities related to radiation or radiation and nuclear technologies are carried out;
- response plans of territorial subsystems of the unified local civil protection system;
- response plans of territorial subsystems of the unified regional protection system…».

Issues of organization and performance of urgent measures in case of radiation accidents are regulated by the "Emergency Response Plan" and "Model Plan of Response to Radiation Accidents of Territorial Subsystems of the Unified Civil Protection System, the Whole or Part of Whose Territory Belongs to NPP Observation Area" approved by order of the Ministry of Emergencies of Ukraine No. 339 dated 06 May 2008.

Territorial plans determine the main measures to arrange and perform activities related to the mitigation of radiation accident consequences, meeting minimum needs for life necessities of the public suffered from the accident, necessary forces and means, material, financial and other resources, establish the allocation of responsibilities and the procedure for activities of the authorities and forces of the territorial subsystem for implementation of these measures.

30 minutes after accident classification, NPP issues recommendations for management of the territorial subsystem of the single state civil protection system for iodine prophylaxis and evacuation of the working public from the territory of the control area, as well as for protective measures of the public living on other territories within the 30-km zone (observation area) of the emergency nuclear power plant. The territorial subsystem management bodies make decisions on iodine prophylaxis and evacuation of the public and ensure notification of the public to take protective measures.

At the same time, the adequacy of decisions and timeliness and effectiveness of activities of the local and central authorities in case of emergencies at NPP is conditioned by general level of training and preparedness of these authorities for emergency actions, as well as pre-worked algorithm for their interaction with all participants in emergency response.

In accordance with the Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and in accordance with the Resolution of the Cabinet of Ministers of Ukraine dated October 2, 2003 No. 1570 (as amended by the Resolution of the Cabinet of Ministers of Ukraine of 13 August 2014 No. 336), SNRIU and the State Emergency Service are the relevant competent national authorities in the event of a radiological emergency also beyond the boundaries of the country.

SNRIU:

- is authorized to ensure notification and send information in case of nuclear accident or radiation emergency in Ukraine, and receive emergency notification and information in case of nuclear accident or radiation emergency in another country;

- is the only competent national communication point responsible for 24 hours duty cycle in order to ensure emergency notification and information submittal at any time as well as request for assistance in case of nuclear accident or radiation emergency.

The State Emergency Service is authorized to send and receive a request for assistance

in case of nuclear accident or radiation emergency and receive proposals for assistance.

In December 2016, the EU Project on the Extension of the RODOS Decision Support System in Ukraine to the Chornobyl Exclusion Zone was launched. The project envisages the adaptation of the RODOS system to specific conditions of the exclusion zone, testing and verification of atmospheric and water transport models in the framework of training exercises including the international ones, spreading of the Project results to other users as the official decision support system in Ukraine in case of radiological emergencies.

F.6. Decommissioning (Article 26)

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that:
i) qualified staff and adequate financial resources are available;
ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;
iii) the provisions of Article 25 with respect to emergency preparedness are applied; and
iv) records of information important to decommissioning are kept.

Decommissioning of Chornobyl NPP Units 1, 2, 3

The only operator in Ukraine having the license for nuclear facility decommissioning is Chornobyl NPP.

During ChNPP decommissioning, the presence of power unit No. 4 (the Shelter) destroyed in the beyond design-basis accident on NPP site shall be considered, which has a status of a nuclear-hazardous facility and temporary storage facility of uncontrolled radioactive waste.

The main spheres of activity aimed at ChNPP decommissioning, the estimated amount of their financing, organizational and technical tasks were defined by the "National Program for Chornobyl Nuclear Power Plant Decommissioning and Shelter Transformation into an Environmentally Safe System".

In 2008, Chornobyl NPP developed a detailed Decommissioning Plan.

In 2016, the Chornobyl NPP Decommissioning Plan was revised. The IAEA expert mission for assessment of the revised Decommissioning Plan visited ChNPP, upon which the measures identified in the Decommissioning Plan were updated.

Deferred dismantling decommissioning option was accepted for ChNPP units.

According to License EO No. 000040, Chornobyl NPP decommissioning proceeds through successful implementation of the following stages:

1. **Decommissioning** (preparatory stage for decommissioning) is a stage during which nuclear fuel is withdrawn and is transported to spent nuclear fuel storage facility.

2. Final closure and safe enclosure of reactors is a stage during which a facility shall be brought to a state enabling its use according to its design, and parts of the facility and radioactively contaminated equipment subjected to long-term enclosure will be preserved.

3. Reactor enclosure is a stage during which a facility is preserved for safe storage of radiation sources in it.

4. Reactor dismounting is a stage during which all systems and components of the facility will be dismounted and withdrawn and management of radioactive waste generated at this stage will be ensured, and measures will be taken aimed at radioactive decontamination of the site.

In the framework of License EO No. 000040, the following is subject to decommissioning:

- power units 1, 2, 3;
- interim storage facilities for liquid and solid radwaste;
- other common plant facilities: auxiliary, electrical and hydraulic structures, cooling pool.

Chornobyl NPP completed the operation termination decommissioning stage. All spent fuel has been removed from the cores of all three units and spent fuel pools and transferred to ISF-1.

In this connection and in compliance with the Law of Ukraine "On Radioactive Waste Management", SNRIU reviewed and agreed ChNPP decision "On Designation of Nuclear Facilities of ChNPP Units 1, 2, 3 as Radioactive Waste Management Facilities in the Decommissioning Process" in December 2016, which complies with definition j) of Article 2 of the Joint Convention.

In accordance with License EO No. 000040, ChNPP shall obtain an individual SNRIU authorization for each decommissioning stage.

Since March 2015, according to a separate license OD No. 000040/8, Chornobyl NPP shall perform the activity aimed at the implementation of the decommissioning stage for final closure and safe enclosure of Chornobyl NPP power units No. 1,2 and 3 (hereinafter FCSE).

FCSE deadline is 2028.

FCSE Project and the Program for the Implementation of the Stage of Final Closure and Safe Enclosure at Chornobyl NPP power units No. 1, 2 and 3 envisage FCSE stage in the framework of six startup packages.

The timely implementation of FCSE stage depends on timely commissioning of lines for cutting the high-level long-length components, the availability of radioactive waste management infrastructure (radioactive waste storage and disposal facilities, commissioning, operation of existing facilities, construction of new facilities for radioactive waste management at Chornobyl Nuclear Power Plant), the speed of dismantling, etc.

Information on the existing radioactive waste management system at Chornobyl NPP is presented in Subsection B.4.2 of this Report.

As of 2017, the projects for dismounting of the equipment that is external to the reactor were implemented at ChNPP site, namely the equipment and structures of ChNPP turbine hall and diesel station of Chornobyl NPP stage 1 and the main heating system.

Chornobyl NPP completed preparatory activities required to start ChNPP cooling pond decommissioning, and after SNRIU approval in August 2016, it started decommissioning of the cooling pond.

The measures taken at the Shelter are intended for its transformation into an environmentally safe system. Information on Shelter-related activities is provided in Annex 9 to this Report.

Decommissioning Plans for Operating NPPs in Ukraine

Based on state review on nuclear and radiation safety for the Periodic Safety Review Report, SNRIU issued licenses for long-term operation of the following power units:

– SUNPP-2, VVER-1000/338, life extended until 31 December 2025;

– ZNPP-1, VVER-1000/320, life extended until 23 December 2025;

– ZNPP-2, VVER-1000/320, life extended until 19 February 2026.

The periodic safety review shall be performed to ensure lifetime extension of power units with VVER-1000/320 – ZNPP-3, ZNPP-4, RNPP-3, KhNPP-1 whose lifetime expires in 2017-2018.

The design lifetimes of other VVER-1000 units expire in 2020-2035.

The Law of Ukraine "On Settlement of Nuclear Safety Issues" requires the following documents to be developed for decommissioning of nuclear facilities:

– decommissioning concepts for nuclear facilities;
– decommissioning projects for nuclear facilities.

On 1 January 2016, the new version of the industrial "Decommissioning Concept for Operating Nuclear Power Plants of Ukraine", approved by MECI Order No. 798 of 10 December 2015. The previous industrial "Decommissioning Concept for Operating Nuclear Power Plants of Ukraine" was revised to justify and increase allocations to the Decommissioning Fund from 283.4 to 784.4 mln. UAH in connection with commissioning of new units and long-term operation of existing ones.

Based on the new version of the industrial "Decommissioning Concept for Operating Nuclear Power Plants of Ukraine", the decommissioning concept for South Ukraine NPP was revised in 2016. The decommissioning concepts for Zaporizhzhya, Khmelnitsky and Rivne NPPs are under revision.

Decommissioning Plans for Research Nuclear Reactors in Ukraine

To comply with the license for operation of the VVR-M research reactor, NRI developed the "Program for Decommissioning of the VVR-M Research Reactor", which was agreed by SNRIU upon state review on nuclear and radiation safety.

The decision has been made on further operation of the VVR-M research reactor until 31 December 2023.

Decommissioning Plans for Radwaste Management Facilities - Radwaste Treatment and Storage Facilities

According to the regulatory requirements on the structure and contents of safety analysis reports for radwaste treatment and storage facilities, the safety analysis reports for these facilities contain a section devoted to decommissioning.

The safety analysis reports on the solid radwaste treatment plant, interim storage facility for high-level and low- and intermediate-level long-lived radwaste, ChNPP liquid radwaste treatment plant and centralized long-term storage facility for radiation sources contain sections on future decommissioning of these facilities.

F.6.1. Qualified Staff and Adequate Financial Resources for Decommissioning

Human resources at Chornobyl NPP, in particular, personnel management, specification of the number, structural layout, staffing, qualification requirements, staff selection, skill improvement, advanced training are envisaged in the Quality program at the stage of FCSE at Chornobyl NPP power units No. 1, 2, 3.

Chornobyl NPP is fully stuffed by highly qualified personnel according to staff schedules for divisions and qualification requirements of job descriptions.

As of the beginning of 2017, ChNPP industrial and production personnel constituted 2366 persons, including:

- 60% with full or basic higher education (1419 persons: 97 with master's degree, 167 with two and more higher educations, 5 with PhD degree);
- 16.1% with incomplete higher education (380 persons);
- 73.1% with more than 10-year record of service at ChNPP (1734 persons);
- 44 years as average age.

Professional training of ChNPP personnel is aimed at improving the occupational quality of the enterprise. Continuous professional development is one the major principles that promote high qualification and skills of ChNPP personnel. There is a training center at the enterprise.

The Training Center performs its activity based on the licenses and permits obtained according to the established procedure in the following areas:

- training of operating personnel taking into account the features of each decommissioning stage of NPP units and related organizational and technical safety measures (in accordance with the license of the State Nuclear Regulatory Committee of Ukraine for the right to train personnel in the Training Center);
- training in the area of safe methodologies to perform the activities related to the increased hazard and the activities performed in launching the Shelter Implementation Plan (on the basis of the certificate of the State Committee of Ukraine on Industrial Safety, Labor Protection and Mining Supervision);
- vocational and technical training for the specialties mostly demanded to perform the activities at ChNPP site, namely: dosimetrist, radwaste processor, slinger, decontaminator (according to the license of the Ministry of Education and Science of Ukraine);
- psychological support of professional activities of ChNPP staff and personnel involved in launching the Shelter Implementation Plan (based on the certificate of the National Academy of Pedagogical Sciences for the right to conduct psychological and psychophysiological diagnostics of personnel).

In order to analyze the requirements for competence and the needs for training to perform activities related to safety at a certain stage of nuclear facility life cycle, the methodologies of advanced planning are used based on the approved National Program for Decommissioning of the Chornobyl Nuclear Power Plant and the Shelter Transformation into an Environmentally Safe System.

The personnel of contractors involved in the activities performed at the Shelter shall be trained according to a specially developed and approved program that covers all issues on safe work performance under conditions of increased radiation and nuclear risks. The permit to work for the contractor's personnel shall be issued only in presence of documented positive results of knowledge examination.

In planning and preparation of a separate power unit for transfer to the decommissioning life-cycle stage, *the Energoatom* plans maximum involvement of qualified and experienced personnel who worked at the power unit during its operation.

The preparation for decommissioning, decommissioning of Chornobyl NPP units and transformation of the Shelter into an environmentally safe system shall be funded by the State Budget of Ukraine, international technical assistance and voluntary contributions from legal entities and individuals as well as by other sources not prohibited by law.

On the basis of the National Program for Chornobyl Nuclear Power Plant Decommissioning and Shelter Transformation into an Environmentally Safe System and the Law on State Budget of Ukraine, the program of activities aimed at maintaining Chernobyl NPP power units and the Shelter in a safe state and their decommissioning is annually formed. It summarizes all the activities (in accordance with the allocated funds) to be performed by the enterprise for ChNPP decommissioning and the Shelter transformation into an environmentally safe system, for maintenance of ChNPP power units, the Shelter and ISF-1 in a safe state, radioactive waste management, etc.

Information on funding of Chornobyl NPP decommissioning and a financial reserve ensured by *Energoatom* for future decommissioning of operating NPPs (decommissioning fund) is provided in Subsection F.2.2 of this Report.

F.6.2. Operational Radiation Protection, Minimization of Discharges and Unplanned and Uncontrolled Releases during Decommissioning

According to regulations, the operating organization shall adapt the radiation protection program to new conditions before the beginning of decommissioning activities.

The basic document defining the goals and tasks, the structure and description of ChNPP activity in terms of radiation protection at FCSE stage is the Radiation Protection Program for the Stage of Final Closure and Safe Enclosure of Chornobyl NPP Units No. 1, 2, 3.

In the FCSE stage, radiation dose monitoring and environmental monitoring shall be ensured in compliance with the Radiation Monitoring Procedure for ChNPP Decommissioning and Shelter Safety Assurance, which establishes requirements for the scope and periodicity of monitoring using stationary automated systems, individual and movable devices and laboratory methods.

The ChNPP established limits for radiation hazardous factors including:

– reference levels of radiation safety for personnel;

– technological levels of radiation factors for separate areas of the territory and rooms.

Reference levels of radiation safety determine:

– effective doses of external and internal exposure;

– exposure dose rates and radioactive contamination of surfaces in the working area;

– radiation contamination of air and drinking water;

– radioactive releases and discharges.

The reference levels are established as low as is practically achievable, taking into account monitored parameters in normal operation, and do not exceed 70% of the respective permissible levels.

The technological levels of radiation factors for separate areas of the territory and rooms are used for their zoning to optimize exposure of personnel at work. These technological levels establish average annual parameters:

– gamma dose rate;

– beta radiation flux density;

– airborne concentrations of alpha and beta long-lived radionuclides.

Permissible levels for releases are established in the document “Permissible Airborne Radioactive Releases at the Chornobyl NPP”. Permissible levels for discharges are established in the document “Permissible Radioactive Water Discharges at the Chornobyl NPP”.

Permissible radioactive releases to the atmosphere and discharges to water bodies are based on the dose limit quota for the ChNPP, specifically: 40 μSv/year for inhalation intake (for all dose pathways) and 10 mSv/year for ingestion intake (due to critical water use). The reference levels for radionuclide discharge with sewage waters and atmospheric releases are no more than 70% of the permissible levels.

Releases of radioactive substances from ChNPP facilities into the atmosphere shall be formed from the following stationary sources:

VT-1 – releases from the ventilation systems at units A, B, V, D of Stage 1 (power units No. 1, 2);

NVT – releases from the ventilation systems in Stage 2 rooms (power unit No. 3, liquid and solid radioactive waste storage facility (LSRSF) and the Shelter bypass system);

Through ventilation pipes in separate buildings: ISF-1, liquid radioactive waste storage facilities (LRSF), LRTP and SRTP.

Before the release of radioactive substances through the stationary sources, the airflow comes first through the filtration station/local filtration facility for cleaning from aerosols. The air from the general ventilation system is released without cleaning.

The ChNPP has no radioactive discharges to open ponds. The ChNPP cooling pond is both a nature conservation and process reservoir; blowdown of the cooling pond is not provided by the design. In 2014-2016, the activity of waters in the industrial storm water drainage discharged to the cooling pond was due to washout of rain and melt water and residual radiation contamination of accident origin.

The dynamics of airborne atmospheric releases and water discharges to the cooling pond is shown in Figures L.8.13 – L.8.14 of Annex 8 to this Report.

Analysis of individual doses of ChNPP personnel involved in the stage of operation termination (see Subsection F.4.1.2 of this Report) demonstrates that most of them receive individual doses lower than 10 mSv/year. The average individual doses of ChNPP personnel (mSv/person per year) are provided in Figure L 8.2 of Annex 8 to this Report.

The Energoatom does not have nuclear facilities at the stage of decommissioning. MECI regulation "Radiation Protection and Environmental Monitoring Program for NPP Decommissioning. The Requirements for the Structure and Content. SOU-N YaEK 1.025: 2009" is currently in force in Ukraine. The Radiation Protection and Environmental Monitoring Program for NPP Decommissioning should be submitted to the SNRIU to obtain a license for activities during nuclear facility decommissioning.

F.6.3. Emergency Preparedness

The ChNPP implements necessary measures to ensure emergency preparedness. For this purpose, the following documents were developed and implemented:

- ChNPP Plan of Response to Accidents and Emergencies, 32P-S;
- Provisions on Plant Commission of Emergencies, 33P-S;
- Provisions on ChNPP Emergency Teams and Groups, 11P-S;
- Provisions on Information Transfer, 22P-S;
- Provisions on ChNPP Evacuation Team, 86P-S;
- Procedure for Use of the Computer-Aided System for Automated Notification of ChNPP Management, 61E-S.

Information on emergency plans in force at ChNPP is provided in Subsection F 5.1 of this Report.

Emergency crews and teams were formed at the ChNPP. Personnel of the ChNPP and emergency crews and teams are provided with respiratory protection means. The ChNPP emergency kit includes skin protection means, special emergency rescue equipment, equipment for emergency recovery measures on process lines, dosimeters and chemical survey devices, equipment and tools needed to mitigate emergencies at ChNPP facilities.

Experts of the emergency preparedness and response department annually check the preparedness of Chornobyl NPP personnel to act in emergencies. Exercises and training are also conducted for ChNPP personnel to correctly use skin and respiratory protection means and test evacuation routes to protective structures.

Interaction and coordination with forces of the regional subsystem of the Unified State System for Prevention of and Response to Emergencies are tested during training and exercises.

Emergency training is conducted under schedules approved by the ChNPP. Plant-level training on personnel's response to civil defense signals is organized twice a year.

The preparedness of departments, emergency crews and teams in case of emergencies is checked during plant-level "safety days".

At the Chornobyl NPP, there are three protective structures with self-contained power supply and ventilation systems that are kept ready to shelter personnel. An emergency center operates in protective building 1 (under Administrative and Office Building-1.

F.6.4. Records of Information Important to Decommissioning

Records of Information Important to Decommissioning for ChNPP Units 1, 2, 3

Chornobyl NPP continued implementation of the project "Information Support System for Decommissioning of the Chornobyl NPP" under IAEA international technical assistance.

The project scope includes design, supply, installation, testing and commissioning of the information support system, ChNPP personnel training, supply of spare parts and consumables and warranty service. The system is currently in trial commercial operation.

Within the framework of the international technical assistance project provided by the Government of the Kingdom of Norway, ChNPP launched the Center for Visualization of the Chornobyl NPP Decommissioning. The goal of its activity is to implement virtual reality technologies, 3D modeling and visualization technologies to improve the efficiency and safety of activities at the decommissioning stages.

Since 2016, the system is in trial commercial operation.

Records of Information Important to Decommissioning for Ukrainian NPPs Operated by Energoatom

According to the *Energoatom* Enterprise Standard "NPP Decommissioning. Information Support System. Structure and Procedure for Collection, Processing and Storage of Information", South Ukraine, Rivne and Khmelnitsky NPPs implemented automated systems to support comprehensive engineering radiation inspection (ASS CERI) of power units. The system is intended to:

– collect and organize information on radiation contamination of equipment, piping, rooms, structures of buildings and power units and NPP territory adjacent to the power units obtained in their comprehensive engineering and radiation inspection;

– store design and operational documentation.

ASS CERI is under implementation at Zaporizhzhya NPP.

Section G. SAFETY OF SPENT FUEL MANAGEMENT

G.1. General Safety Requirements (Article 4)

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;
iii) take into account interdependencies among the different steps in spent fuel management;
iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;
v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;
vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;
vii) aim to avoid imposing undue burdens on future generations.

The Ukrainian legislation provides for compulsory licensing of operating organizations during construction and commissioning, operation and decommissioning of facilities for spent fuel management.

General safety requirements at all stages of spent fuel management are established in the Laws of Ukraine "On Nuclear Energy Use and Radiation Safety" and "On Authorizing Activity in Nuclear Energy".

Requirements and rules for spent fuel management are established by regulations that cover spent fuel management on NPP sites, research reactors and interim spent fuel storage facilities, specifically:

– General Safety Provisions for Nuclear Power Plants;

– Nuclear Safety Rules for Nuclear Power Plants with Pressurized Water Reactors;

– General Safety Provisions for Design, Construction and Operation of Research Reactors;

– Nuclear Safety Rules for Research Reactors;

– Safety Rules for Nuclear Fuel Storage and Transport at Nuclear Facilities;

– Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities;

– Requirements for Modifications of Nuclear Facilities and Procedure for Their Safety Assessment;

– Requirements for Systems for Emergency Cooling of Nuclear Fuel and Heat Removal to Ultimate Heat Sink.

The regulatory and legal framework after the Fukushima-1 accident is improved within implementing the "Action Plan for Special Targeted Safety Assessment and Further Safety Improvement of NPP Units Considering Events at Fukushima-1" approved by the SNRIU Board dated 19 May 2011.

G.1.1. Criticality and Residual Heat Removal

According to the requirements of the above regulations, the effective neutron multiplication factor in spent fuel management shall not exceed 0.95 in normal operation and design-basis accidents to be ensured by appropriate characteristics of the facilities. Subcriticality in spent fuel storage is ensured by limitation of the fuel assembly pitch; fuel burnup credit (if burnup is used as a parameter in nuclear safety justification); use of heterogeneous or homogenous absorbers and absorber credit; monitoring of the presence, state and composition of the cooling media in dry storage facilities; monitoring of process parameters of the spent fuel management systems. According to the document "Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities", subcriticality in dry interim spent fuel storage facilities shall be mainly ensured by the geometry of spent fuel location.

The design of spent fuel management systems provides for residual heat removal and for appropriate chemical composition of the heat-removing media to prevent increase in fuel cladding temperature and uncontrolled corrosion rate in excess of the design values for normal operation and design-basis accidents. Thus, for facilities where spent fuel is stored in water (spent fuel pools of operating NPPs and ChNPP ISF-1), devices and systems are provided for water supply, treatment and cooling, ventilation, and for monitoring of radioactivity, temperature, level, chemical composition of water and, if necessary, hydrogen concentration.

G.1.2. Minimization of Radioactive Waste Generation

In the reporting period, the requirements for minimization of radwaste generation associated with spent fuel management have not changed (see Subsection G.1.2 of NRU-2003). Pursuant to the "Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities", the operating organization develops and implements the radwaste management program to identify measures for minimization of radwaste generation and safety assurance during collection, sorting, treatment, storage and transfer of radwaste for disposal or long-term storage.

G.1.3. Interdependencies among Different Steps in Spent Fuel Management

The interdependencies among different steps in spent fuel management are taken into account beginning from the design of fresh nuclear fuel. The technical specifications for supply of fresh nuclear fuel contain requirements for spent fuel storage in cooling pools, permissible temperature of fuel claddings in spent fuel storage, etc. Two options are currently underway:

– transfer of ZNPP spent fuel from the reactor ponds to the dry spent fuel storage facility operated at the ZNPP;

– transport of spent fuel from the RNPP, KhNPP and SUNPP to Russian enterprises for technological storage and reprocessing and subsequent return of the resulting high-level waste to Ukraine.

In the reporting period, the requirements for interdependencies among different steps in spent fuel management have not changed.

G.1.4. Radiation Protection of Personnel, the Public and the Environment

The radiation protection system of Ukraine is described in Subsection F.4 of this Report.

G.1.5. Biological, Chemical and Other Risks

Biological, chemical and other risks that can be associated with spent fuel management shall be taken into account in safety assessment of spent fuel management facilities. Information on such risks is provided according to the "Recommendations on the Structure and Contents of the Safety Analysis Report for Spent Fuel Storage Facilities".

Biological, chemical and other risks are evaluated within state comprehensive review.

G.1.6. Avoiding Reasonably Predictable Impacts on Future Generations Greater Than Those for the Current Generation

Protection of future generations is considered in the safety analysis reports for spent fuel management facilities, which should demonstrate that future protection of the public and personnel will not be lower than that at the beginning of operation. If necessary, processes inside the containment and degradation of fuel elements and spent fuel storage components

are inspected during operation with the purpose of taking timely corrective measures (if needed).

G.1.7. Avoiding Undue Burdens on Future Generations

The policy of avoiding undue burdens on future generations in Ukraine is implemented through:

– application of effective quality management systems for operators at all life stages of nuclear facilities and authorities for state control and nuclear and radiation safety regulation;

– improvement and development of regulations in the field of nuclear and radiation safety;

– implementation of high safety culture with strict compliance with standards and rules on nuclear and radiation safety for present generation dealing with siting, design, commissioning and operation of nuclear facilities and radwaste disposal storages;

– introduction of methodologies for long-term safety of radwaste disposal facilities for the entire period of potential danger.

Timely preparation of operators for decommissioning of nuclear facilities such as spent fuel storage facilities has become relevant in the context of reducing the financial burden on future generations.

This issue is currently resolved by implementation of the Law of Ukraine "On Settlement of Nuclear Safety Issues" (see Subsection F 2.2 of this Report), in particular, by:

– planning of future decommissioning, beginning from the design of a nuclear facility;

– development of decommissioning concepts, beginning from licenses for construction and commissioning of nuclear facilities, including their periodic revisions to take into account improvement of the regulatory and legal framework, development of science and technologies and incidents (accidents) that occurred during operation;

– timely development of decommissioning projects on the basis of decommissioning concepts for nuclear facilities;

– timely establishment of a decommissioning fund with the purpose of accumulating funds during operation to finance measures foreseen by the decommissioning project for a nuclear facility;

– implementation of measures during the entire life cycle of a nuclear facility for collection, processing, recording and storage of information on the facility that may substantially contribute to the decommissioning process (databases (archives)) and other measures.

G.2. Existing Facilities and Past Practices

Spent fuel in Ukraine is managed at the facilities listed in Annex 1 to this Report. Information on operation of the existing spent fuel management facilities is provided in Subsections B.2.1. - B.2.3 of this Report.

G.2.1. Safety of Existing Facilities

The safety of existing spent fuel management facilities is ensured by current technical regulations, design decisions, technical specifications, operating and maintenance procedures, technical decisions and quality assurance procedures.

All spent fuel management facilities are designed to be equipped with surveillance and monitoring systems.

The automated radiation monitoring system *Koltso* and a network of observation wells to monitor underground and ground waters are in operation on the territories around the Zaporizhzhya DSFSF. Radiation parameters on the site and adjacent territory around the storage facility are monitored with the periodicity established in radiation monitoring procedures. The results are analyzed and compared with reference levels. Quarterly and summary annual safety reports on Zaporizhzhya DSFSF safety performance indicators are submitted to the SNRIU.

As was noted in previous NRUs, the safety reassessment of Ukrainian NPPs and DSFSF did not reveal any fundamental drawbacks that would require modernization of the spent fuel management systems at operating NPPs.

The reactor cores of Ukrainian NPPs are reloaded in a timely manner and regulations that require free capacities in the cooling pools for complete accident core unloading are met owing to the efficient operation of the Zaporizhzhya DSFSF and compliance with the schedule for spent fuel transport to specialized enterprises of the Russian Federation for reprocessing.

In 2016, nuclear fuel was completely removed from ChNPP units 1, 2, 3.

Spent fuel from ChNPP RBMK-1000 reactors, amounting to 21,284 SFAs, has been placed into the wet spent fuel storage facility (ISF-1) on the ChNPP site.

ChNPP developed the "Plan of Measures for Improvement of ISF-1 Safety" and agreed it with SNRIU. The plan is currently under implementation.

The safety assessment of ISF-1 for storage of ChNPP spent fuel is provided in the "Safety Analysis Report on Interim Spent Fuel Storage Facility (ISF-1)", Inv. No. 06 of 24 June 2015.

G.3. Siting of Proposed Facilities (Article 6)

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:

i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;

ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

iii) to make information on the safety of such a facility available to members of the public;

iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

G.3.1. Evaluation of Site-Related Factors Likely to Affect the Safety of the Facility during Its Operating Lifetime

In the reporting period, the requirements for Zaporizhzhya DSFSF site-related factors that can affect safety of the facility during its service life have not changed. The information provided in Subsection G.3.1 of NRU-2003, NRU-2005, NRU-2008, and NRU-2011 is relevant at present.

The development of EIA, which is a part of the Feasibility Study for construction of the centralized spent fuel storage facility for Ukrainian NPPs with VVER reactors (CSFSF), takes into account evaluation of site-related factors that can affect the safety of the CSFSF. After the accident at the Fukushima-1 NPP in Japan, natural hazards peculiar to the site

recommended for the CSFSF and their potential impact on its safety were additionally analyzed. The analysis showed that these impacts would not challenge the limits of CSFSF safe operation preliminary identified in the CSFSF Feasibility Study.

In developing the design documentation for the stage of "design" (following the feasibility study), the EIA during CSFSF construction and operation was revised, the conclusions made at the design stage of the feasibility study were specified and confirmed.

The state review (No. 00-0602-16/PB) for revision of the design documentation within the project "Construction of CSFSF for fuel from Ukrainian NPPs with VVER" established compliance of the developed documentation with the requirements for strength, reliability and durability of the constructed facility, its operational safety and engineering support, sanitary and epidemiological support of the public, labor protection, ecology, fire and industrial safety, nuclear and radiation safety and the possibility to approve relevant documentation.

To evaluate factors of the Chornobyl ISF-2 under construction in the 10-km exclusion zone, feasibility study for siting of ISF-2 was developed. In addition, the "Preliminary Safety Analysis Report for ISF-2 (PSAR)" and "Environmental Impact Assessment of the Chornobyl NPP ISF-2" were prepared. These documents analyze natural and man-induced conditions on the ISF-2 construction site.

The feasibility study, additional material to the feasibility study and conclusions of their state reviews were used to select the most suitable site for ISF-2 (of the four candidate sites), which was approved by Cabinet Resolution No. 1963 of 25 October 1999.

Additional seismic studies were conducted in 2005 on the Chornobyl NPP site. Their results were taken into account in revision of ISF-2 PSAR upon SNRIU recommendations.

G.3.2. Evaluation of Likely Safety Impact of the Facility on Individuals, Society and the Environment

According to Article 51 of the Law of Ukraine "On Environmental Protection", economic and other projects shall include environmental and human health impact assessment (EIA). Requirements for the EIA structure and contents are established in the State Construction Standards of Ukraine "Composition and Contents of the Environmental Impact Assessment (EIA) for Design and Construction of Enterprises, Buildings and Structures. Basic Design Rules".

According to the Law of Ukraine "On Ecological Review", design documentation on spent fuel management facilities is subject to state ecological review, including EIA as part of this design documentation.

As required by the State Construction Standards of Ukraine, EIA includes Statement of Ecological Consequences, which contains the final EIA results. The Statement is a legal document that sets forth ecological consequences and guarantees that measures are taken to ensure environmental safety over the entire period of planned activity. The Statement shall be made public through mass media and submitted to local authorities for subsequent oversight.

NRU-2011, item G.3.2 included the information on "Statement of Ecological Consequences resulting from Construction and Operation of the Centralized Spent Fuel Storage Facility for the Rivne, Khmelnitsky and South Ukraine NPPs Operated by *Energoatom* and Feasibility Study for CSFSF Construction".

Based on the feasibility study of CSFSF construction, the task for design and town-planning conditions and constraints, the project "Construction of CSFSF for fuel from Ukrainian NPPs with VVER" was developed. The section "Nuclear and Radiation Safety" includes the assessment of radiation safety during the construction, operation and

decommissioning of CSFSF. The implementation of the measures envisaged by the project will ensure an acceptable radiation safety level.

According to the conclusion of the state review on nuclear and radiation safety of the preliminary SAR on CSFSF, "The design decisions for CSFSF and planned activities at CSFSF life cycle stages presented in the CSFSF project documentation and justified in the previous CSFSF SAR meet the regulatory requirements for nuclear and radiation safety. It ensures the implementation of fundamental safety principles and compliance with nuclear and radiation safety criteria for spent fuel management at CSFSF site. The implementation of the fundamental safety principles and compliance with nuclear and radiation safety criteria for spent nuclear fuel management at CSFSF site is provided".

Based on the application, the state review on nuclear and radiation safety and other documentation attached to the application, the SNRIU issued a license for lifecycle stages CSFSF "construction and commissioning".

Assessment of ISF-2 impact on the public, personnel, and environment is provided in the EIA under ISF-2 project.

G.3.3. Informing Members of the Public of the Facility Safety

Public hearings on nuclear energy use and radiation safety are envisaged in the valid Legislation. Their procedure is established by Cabinet Resolution "On Approval of the Procedure of the Public Hearings on Nuclear Energy Use and Radiation Safety" No. 1122 of 18 June 1998.

The Law of Ukraine "On Management of Spent Nuclear Fuel for Siting, Design and Construction of the Centralized Storage Facility for Spent Nuclear Fuel from Ukrainian VVER Nuclear Power Plants", No. 4384 of 09 February 2012, establishes a rate of 10% from the cost of the project to be allocated for the construction of social facilities in administrative and territorial units adjacent to the CSFSF site and defined in the Law.

The Energoatom performs regular activities for notification of the public on CSFSF construction and safety and for placing relevant documentation in both central and local print media. The information on CSFSF construction and safety is also available on the website of *the Energoatom.*

To inform the public of the ChNPP ISF-2 safety:

– information on ISF-2 is regularly published in mass media in Slavutych and broadcast on the local TV channel;

– lectures and visits to the Chornobyl NPP and ISF-2 are arranged for inhabitants of Slavutych and populated centers adjacent to the 30-km exclusion zone;

– 6 March 2014, the SNRIU carried out open public discussions on implementation of ISF-2 construction project with participation of representatives from ChNPP, Holtec International, SSTC NRS, the public and mass media.

G.3.4. Consulting Contracting Parties in the Vicinity of the Facility

In the reporting period, requirements for procedures of consultation with neighboring states have not changed. The information on the CSFSF provided in Subsection G.3.4 of NRU-2003, NRU-2005, NRU-2008, NRU-2011 and NRU-2014 is still relevant.

In 2012-2016, there were no requests or needs for additional consultation.

G.4. Design and Construction of Facilities (Article 7)

Each Contracting Party shall take the appropriate steps to ensure that:
i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;
ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;
iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

G.4.1. Limitation of Possible Radiological Impacts of Spent Fuel Management Facilities

The project "Construction of CSFSF for Ukrainian NPPs with VVER Reactors" provides measures to ensure appropriate radiation safety and limit radiological impact of CSFSF.

According to the conclusion of the state review on nuclear and radiation safety of the preliminary SAR on CSFSF design, the envisaged design decisions on CSFSF and the planned activity at CSFSF lifecycle stages presented in CSFSF design documentation and justified in the preliminary SAR on CSFSF meet the national regulations on nuclear and radiation safety.

G.4.2. Conceptual Plans and Technical Provisions for Decommissioning of Spent Fuel Management Facilities

Requirements for the development of conceptual decommissioning plans for nuclear facilities including spent fuel storages are established in the Law of Ukraine "On Settlement of Nuclear Safety Issues". According to this Law, the operating organization shall develop a conceptual plan of decommissioning (concept) and then use it as a basis for a decommissioning project for a nuclear facility.

In compliance with the procedure for review and approval of the decommissioning project for a nuclear facility, the decommissioning project is developed by the operating organization no later than 18 months prior to the operation termination of a nuclear facility – expiry of the license for operation – and is submitted for state review. The decommissioning project, provided that findings of its state reviews foreseen by Ukrainian legislation for investment programs and construction projects are favorable and all necessary agreements of state regulatory and control authorities are obtained, is submitted to the Cabinet of Ministers of Ukraine for review and approval six months before the operation termination of a nuclear facility.

Requirements concerning future decommissioning of nuclear facilities, including spent fuel storage facilities, beginning from the design stage, are stated in Article 42 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and in the regulation "Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities".

In accordance with the above regulation, the operating organization shall prepare for future decommissioning during different lifecycle stages of the DSFSF. In addition, the operating organization shall collect, process, record and save data on the DSFSF needed to develop documentation for its decommissioning over the entire life of the DSFSF.

Hence, decommissioning issues for nuclear facilities, including spent fuel storage facilities, are a part of documentation submitted to justify safety at each licensing stage in compliance with the "Recommendations for the Structure and Contents of the Safety Analysis Report for Spent Fuel Storage Facilities".

Regarding the development of conceptual decommissioning plans for spent fuel storage facilities in Ukraine:

1. For the Zaporizhzhya DSFSF, the operator has developed and agreed:

– Program for DSFSF Unloading and Decommissioning;

– Program for Management of Spent Fuel after Reaching the Maximum Storage Period in Zaporizhzhya DSFSF.

2. The Feasibility Study for CSFSF construction particularly includes a General Decommissioning Plan (Vol. 1, Part 3) with the main objectives to:

– determine decommissioning principles;
– determine decommissioning approaches;
– determine main approaches to the decommissioning strategy;
– evaluate foreseeable types and amounts of radwaste;
– identify potential areas for radwaste management.

The preliminary SAR on CSFSF includes Section "Decommissioning". This Section describes the basic conceptual provisions for CSFSF decommissioning.

The basic conceptual provisions for CSFSF decommissioning include the information on:

- regulatory requirements for CSFSF decommissioning;
- the objectives of CSFSF decommissioning;
- preconditions and assumptions in planning CSFSF decommissioning;
- features of CSFSF design that simplify its decommissioning;
- selection of the option of CSFSF decommissioning strategy;
- the main measures aimed at decommissioning;
- documentation on decommissioning;
- radioactive waste management;
- safety assurance;
- the infrastructure ensuring the activity related to decommissioning.

A detailed study of possible decommissioning options will be performed at the later stages of CSFSF operation. During CSFSF operation, the necessary analysis and specification of these provisions will be carried out taking into account operational experience, changes in the situation in the exclusion zone, development of the technologies for dismantling, decontamination, management of radioactive waste and spent fuel, and amendments in the requirements of the regulatory bodies.

Based on the conclusion of the state review on nuclear and radiation safety of CSFSF design including CSFSF decommissioning concept, SNRIU issued to CSFSF operator a license for CSFSF life cycle stages "construction and commissioning".

3. For the ChNPP ISF-1, according to the license conditions for ISF-1 operation, the ISF-1 decommissioning concept was developed.

Moreover, Section 13 "Decommissioning" of the ISF-1 Safety Analysis Report describes the ISF-1 general decommissioning concept and considers several decommissioning options. The ultimate decommissioning option will be selected at the final stage of ISF-1 operation.

4. For the dry spent fuel storage facility (ISF-2), the Preliminary Safety Analysis Report describes the ISF-2 general decommissioning concept and considers several decommissioning options. The ultimate decommissioning option will be selected at the final stage of ISF-2 operation.

G.4.3. Support of Technologies Incorporated in the Design by Experience, Testing or Analysis

In this reporting period, the requirements for support of technology incorporated in the design by experience, testing or analysis have not changed (see Subsection G.4.3 of NRU-2011).

The technology of dry storage of spent fuel developed by Holtec International (USA) will be used to ensure spent fuel storage in CSFSF.

Holtec International develops and produces containers for spent nuclear fuel storage and transport taking into account the diversity of nuclear fuel modifications and conditions for its management at NPPs in different countries.

Holtec International is a leader in the implementation of innovative technologies for dry storage and transport of spent nuclear fuel to be used in spent fuel storage in CSFSF, in particular:

- technology of multipurpose container,
- vertical ventilated protective storage container,
- storage and transport of fuel with high burnup level,
- forced drying by helium,
- composite neutron-absorbing material on the basis of metal matrix resistant to high temperature,
- shielded transfer container,
- transfer of spent nuclear fuel with low dose loads,
- universal transfer container with high thermal load.

The following types of containers will be used in CSFSF:

- multipurpose containers MPC-31 (for placement of 31 SFA of VVER-1000);
- multipurpose containers MPC -85 (for placement of 85 SFA of VVER-440);
- HI-STORM 190 storage containers (for storage of spent nuclear fuel placed in MPC-31 or MPC-85)
- HI-STAR 190 ML (for transport of spent fuel placed in MPC-31 or MPC-85);
- HI-TRAC 190 (for spent fuel loading to MPC and its placement in HI-STAR 190 ML).

These containers are designed for spent fuel storage during 100 years, and MPC will be double-walled.

Holtec technology for SNR storage and transport is used at more than 70 power units with light water reactors in the USA, UK, Mexico, Spain, Switzerland, Belgium, Sweden, South Korea, China and will be used in Ukraine and Slovenia..

G.5. Assessment of Safety of Facilities (Article 8)

Each Contracting Party shall take the appropriate steps to ensure that:
i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;
ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

G.5.1. Safety Assessment and Environmental Assessment

In this reporting period, the requirements for safety assessment and environmental review have not been changed (see Subsection G.5.1 of NRU-2014).

Safe storage of spent nuclear fuel in dry storage facility for spent fuel from ZNPP VVER-1000 was justified by the operator and presented in the ZNPP DSFSF Safety Analysis Report and agreed by the SNRIU as such; this confirms the compliance of the safety level of the dry spent nuclear fuel storage facility with the requirements of the radiation safety standards, rules and regulations.

Due to the implementation of FA-A at ZNPP for justification of the possibility of sending spent FA-A for storage to ZNPP DSFSF, the document "Amendment to ZNPP DSFSF safety analysis. Storage of FA-A in ZNPP DSFSF" that is an integral part of the SAR was developed and agreed with SNRIU.

In addition, during 2015-2016 *the Energoatom* performed regular safety review of DSFSF whose results were described in the Periodic Safety Review Report (PSRR). In August 2016, SNRIU approved DSFSF PSRR. The next review will be performed in 2025.

In the framework of the ISF-2 design, the operating organization developed ISF-2 preliminary safety analysis report (PSAR) that obtained a positive conclusion of state review on nuclear and radiation safety.

The conclusion of the state review on nuclear and radiation safety on the construction design and safety justification documents for ChNPP ISF-2 demonstrated that the selected technology for spent fuel storage is appropriate in view of nuclear and radiation safety and complies with the policy for interim spent fuel storage accepted in Ukraine. The nuclear and radiation safety principles applied in development of this project meet the national regulatory and legal acts and approaches to ensure safety.

G.5.2. Safety Reassessment in Construction and Commissioning

In the reporting period, the requirements for safety reassessment during construction and commissioning have not changed (see Subsection G.5.2 of NRU-2011).

The ChNPP obtained license for nuclear facility construction and commissioning (spent fuel storage facility ISF-2) No. 001002 of 20 February 2013.

The interim SAR to be submitted to the SNRIU for obtaining a license for commissioning under this license should include the evidence of safety level compliance of the constructed ISF with design safety level, safety justification of changes, amendments and corrections made in the design during construction and ISF preoperational inspections and tests. The operating organization will further add the final SAR revised to incorporate results of commissioning to the application for obtaining a license for ISF operation. It will be submitted to the next expert review at this stage.

G.6. Operation of Facilities (Article 9)

Each Contracting Party shall take the appropriate steps to ensure that:

i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;

iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;

iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility;

v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

G.6.1. License to Operate Facilities

In the reporting period, the licensing procedure for operation of facilities has not changed (see Subsection G.6.1 of NRU-2014).

G.6.2. Definition and Revision of Operational Limits and Conditions

Information on the definition and revision of operational limits and conditions for nuclear facilities is provided in Subsection G.6.2 of NRU-2003. According to the requirements of the "Basic Safety Provisions for Interim Dry Spent Fuel Storage Facilities", the design shall define operational limits and conditions to be revised by the operating organization with the periodicity established by the SNRIU.

Ukraine currently operates DSFSF for VVER-1000 fuel at the Zaporizhzhya NPP and ISF-1 at the Chornobyl NPP.

Safety review of ZNPP DSFSF was completed in 2016 and finalized in the "Periodic Safety Review Report for ZNPP Dry Spent Fuel Storage Facility". The report received a positive conclusion of state nuclear and radiation safety review and was agreed by SNRIU.

The safety review showed the following:

Abnormal operation or emergencies were not revealed at DSFSF site during the reporting period.

The difference between the temperature of the air coming out of the ventilation channels and the environmental temperature for all vented storage containers did not reach 610 ^{o}C that is the normal operation limit specified in the SAR.

The exposure dose rate of gamma-radiation beyond the external fence of DSFSF site (at the distance of 50 meters) is at the level of the natural background typical for the region of Zaporizhzhya NPP layout of 0.12 ÷ 0.13 μSv/h.

The correctness of the approach selected for storage of spent fuel was confirmed.

DSFSF has no negative impact on the environment and shows a high level of environmental safety.

G.6.3. Operating Procedures

Information on operating procedures for spent fuel storage facilities is provided in Subsection G.6.3 of NRU-2011.

G.6.4. Engineering and Technical Support in Operation

Information on engineering and technical support in operation of spent fuel storage facilities is provided in Subsection G.6.4 of NRU-2011.

The scientific engineering and technical support to operation of spent fuel management facilities is provided by the Scientific and Technical Center of the *Energoatom* in cooperation with the research institutions such as:

- Nuclear Research Institute of the National Academy of Sciences of Ukraine;
- Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine;

Institute for Safety Problems of Nuclear Power Plants of National Academy of Sciences of Ukraine.

In particular, the first-priority areas of scientific, engineering, and technical support in spent fuel management are as follows:

- research of the behavior of fuel rod cladding during long-term storage in dry spent fuel storage facilities to justify the boundary permissible terms for safe dry storage of fuel rods;
- development of the Concept for management of spent fuel from Ukrainian NPPs considering the identification of possible directions of NFC progress for a long-term perspective and with the definition of the final stage of nuclear fuel cycle, selection of technology for safe management of spent fuel after the expiration of the period for its long-term storage;
- reactor tests and implementation of concretes with improved neutronic properties based on titanium hydride, produced according to the technology developed by the Institute for Problems of Materials Science (National Academy of Sciences of Ukraine) and tested at the Nuclear Research Institute, into nuclear energy (in particular, DSFSF containers).

The examples of cooperation between *Energoatom* and institutes of the National Academy of Sciences of Ukraine include the development of:

- prototype of facility for immediate burnup control of spent fuel from VVER-1000 that allows designing of the national facility for spent fuel burnup control with the characteristics exceeding foreign analogues;
- new neutron shielding material based on titanium hydrides and obtaining of two Ukrainian Patents No. 56381 "Neutron Shielding Titanium Hydride" and No. 56382 "High-Hydrogen Zirconium Hydride Neutron Moderator".

To examine dry storage conditions of VVER-1000 spent fuel, *Energoatom* continues implementation of the long-term work program for studying spent fuel storage conditions. The program is aimed at obtaining results to confirm either adequacy or excessive conservatism of restrictions imposed on the operation of DSFSF, safety requirements being properly met.

G.6.5. Reporting of Safety-Significant Incidents to the Regulatory Body

In this reporting period, the procedure of informing the regulatory body on incidents important to safety have not changed (see Subsection G.6.5 of NRU-2011).

In particular, current regulatory document NP 306.2.100-2004 (Provisions) "Procedure for Investigation and Reporting of Operational Events at Nuclear Power Plants" established the following procedure for informing the regulatory body on incidents (operational events) related to drop and/or damage of fuel assemblies, fuel elements, absorber rods during handling operations with dry or spent nuclear fuel (P01, P02, P06 categories):

1. NPP shift supervisor or his official upon his order shall immediately inform the SNRIU duty officer and Head of on-site State Nuclear Safety Inspectorate on an incident (operational event) via telephone immediately (P01, P02) or in one hour (P06) after detection of an incident (operational event).
2. Preliminary notification on an incident signed by NPP Chief Engineer and the Head of NPP On-site State Nuclear Safety Inspectorate is transferred via telephone or internet to the regulatory body and its department on safety analysis of nuclear facilities.
3. If needed, a supplementary (clarifying) notification sighed by these persons is sent to the same address as the preliminary notification within five days.

Energoatom unconditionally fulfills these requirements.

A nuclear facility monitoring group that involves five people working according to general schedule (day and night duty) was formed within the Emergency Technical Center by *Energoatom* to improve the emergency preparedness system considering SNRIU proposals on improvement of emergency preparedness service and crisis response in

emergency situations and modes and to provide additional monitoring of nuclear facilities according to *Energoatom* Order No. 989 of 22 November 2011.

The main functions of this group are:

- interaction (information exchange) with the state authorities and other organizations responsible for making decisions and implementation of emergency response plans in crisis and emergency situations and accidents at nuclear facilities;
- monitoring of NPP parameters on a regular basis to define critical safety functions, check compliance with limits and conditions of reactor safe operation and preparedness of safety system trains;
- informational support to departmental oversight services and appropriate services of the state governmental authorities related to functioning of equipment important to NPP safety and its specified parameters and states;
- participation in emergency exercises and training combined with application of all communication systems, equipment, involving personnel and using procedures for which this group is responsible;
- maintaining constant preparedness of the equipment and communication systems for operation in crisis and emergency modes, their testing and inspection including checking of communications with foreign partners established in compliance with the requirements of international conventions and treaties;
- keeping of computerized database in crisis centers of Ukraine and other countries.

The emergency planning system allows checking emergency preparedness at the level of state and facility through emergency exercises and training.

Measures are taken to inform the public, state establishments and international organizations.

G.6.6. Analysis of Relevant Operating Experience

Information on analysis of relevant operating experience is provided in Subsection G.6.6 of NRU-2011.

G.6.7. Decommissioning Plans

Information on legislative requirements of Ukraine on decommissioning of nuclear facilities, such as spent fuel storage facilities, and on the development of decommissioning plans is provided in Subsection G.4.2 of this Report.

G.7. Disposal of Spent Fuel (Article 10)

As stated in Subsection B.1 of this Report, the Energy Strategy of Ukraine until 2035 established the so-called deferred decision for spent fuel management, which includes long-term storage (50 years and more) and subsequent definition and approval of the final decision on spent fuel reprocessing or disposal.

According to Task 3 of the National Target Ecological Program for Radioactive Waste Management, a facility for long-term storage of high-level waste generated from reprocessing of spent fuel from Ukrainian NPPs in the Russian Federation is being designed on the *Vektor* site.

There are plans to create a geological repository for final disposal of high-level and long-lived waste, including waste resulting from spent fuel reprocessing, in accordance with the Strategy for Radioactive Waste Management in Ukraine.

According to para. 5 of the Decree of the President of Ukraine No. 141 dated 13 April 2016 “On Additional Measures for Transformation of the Shelter into an

Environmentally Safe System and the Remediation of the Territories Exposed to Radioactive Contamination Resulting From Chernobyl Disaster", the Cabinet of Ministers of Ukraine was instructed to ensure the development taking into account Council Directive 2011/70/EURATOM dated July 19, 2011 and approval of the State Environmental Program for Spent Nuclear Fuel Management at the national nuclear power plants. In order to fulfill this, an appropriate interdepartmental working group was established.

The working group included representatives of the Committee of the Verkhovna Rada of Ukraine on Environmental Policy, Nature Resources Utilization and Elimination of the Consequences of Chornobyl Catastrophe, the Committee of the Verkhovna Rada of Ukraine on the Fuel and Energy Sector, Nuclear Policy and Nuclear Safety, MECI, MENR, SNRIU, SAEZ, Institute of Geological Sciences, Institute of Environmental Geochemistry, Institute of Mathematical Machines and Systems Problems, Nuclear Research Institute, SIC for Radio hydrogeological Environmental Field Investigation, NSC Kharkiv Institute of Physics and Technology, the National Institute for Strategic Studies, SSTC NRS, the *Energoatom*, ChNPP, UkrDO *Radon*. The Head of the State Agency of Ukraine on Exclusion Zone Management was elected for the position of the Head of the interdepartmental working group.

A number of meetings of this interdepartmental working group took place to consider this issue, during which in broad discussion the proposal was supported to develop a joint long-term (for 100 years) Concept of the State Program for Spent Nuclear Fuel and Radioactive Waste Management.

Section H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

H.1. General Safety Requirements (Article 11)

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;

ii) ensure that the generation of radioactive waste is kept to the minimum practicable;

iii) take into account interdependencies among the different steps in radioactive waste management;

iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;

vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

vii) aim to avoid imposing undue burdens on future generations.

General safety requirements for all stages of radwaste management are established in legislative and regulatory documents identified in Subsection H.1 of NRU-2008. Annex 6 to this Report indicates regulations implemented in the period from 2014 to 1 July 2017.

The licensees' compliance with safety requirements is confirmed by safety assessments of radwaste management facilities and radwaste management activities and

analysis of annual reports on compliance with radiation safety requirements during operation and state oversight.

According to the regulatory requirements, the licensee conducts periodic safety reassessment taking into account experience in activities.

H.1.1. Criticality and Removal of Residual Heat

According to the radwaste classification established in the "Basic Health and Radiation Safety Rules of Ukraine", the category of high-level waste is divided into two subcategories:

- low-temperature HLW whose specific heat release in temporary storage or disposal does not exceed 2 kW/m^3;
- heat-releasing HLW whose specific heat release is 2 and more kW/m^3.

In compliance with the regulatory document "Requirements for Packages for Long-Term Storage and Disposal of High-Level Waste Resulting from Spent Fuel Reprocessing":

- requirements for HLW packages limit the heat release of a radwaste package so that its physical, chemical and mechanical characteristics remain stable over the design lifetime of the facility;
- requirements for the waste limit the content of fissile materials in the HLW form so that criticality in a radwaste package is prevented. To justify that a package is subcritical, the presence and amount of the following radionuclides shall be taken into account:

Radionuclide	Chemical symbol
Uranium	U-232, U-234, U-235, U-236
Neptunium	Np-237
Plutonium	Pu-238, Pu-239, Pu-240, Pu-241, Pu-242
Americium	Am-241, Am-242m, Am-243
Curium	Cm-243, Cm-244, Cm-245

According to Order of the Ministry of Energy and Coal Industry of Ukraine No. 485 of 4 July 2012, the regulatory document "Requirements for Containers and Packages for Long-Term Storage of HLW Returned to Ukraine after Reprocessing of VVER-440 Spent Fuel in the Russian Federation" was put into force. It establishes that:

- specific heat release of the HLW form returned to Ukraine must not exceed 2 kW/m^3;
- concentrations of fissile radionuclides must be determined by laboratory measurements and criticality calculations must take into account possible inhomogeneous distribution of these radionuclides in a package.

Based on the technology for obtaining vitrified HLW and the information submitted to the Ukrainian side from the Industrial Association *Mayak*, the heat release of the HLW form does not exceed 2 kW/m^3, the life of the canister with vitrified HLW is designed for 250 years.

The design of the storage facility for vitrified HLW at the Vektor envisages natural ventilation of the storage modules providing heat release from the canisters with HLW. This is in line with the recommendations of the IAEA on the priority of passive safety means. If the set temperature limit is exceeded, forced ventilation shall be connected.

In order to check this information, the design for construction of vitrified HLW storage facility envisages at the stage of working design to perform the research effort "Development of Thermal and Physical Models and Computer Analysis of Heat Release, Selection of Optimum Ventilation Modes of Storage Facility Modules". Resulting from this effort, it is necessary to determine the optimal areas for air inflow from intake ventilation and air bleeding of the exhaust ventilation. The specification of the air temperature criterion is also envisaged, which requires connection of forced ventilation.

In order to prevent critical event, the storage facility design envisages a number of measures for the neutron absorption, namely, the designer of the storage facility proposed two possible options of the use of neutron absorber:

- manufacturing of components in the structure of the storage cell for packages with HLW in storage facility sections of boron-containing materials;
- filling of guide tubes in the storage cell for packages with HLW with boron-containing material (e.g., B4C).

The selection of the option for neutron absorber application and filling density of the storage facility by them is possible based on the results of the relevant research effort "Nuclear Safety (Subcriticality) in the Storage Module for Long-Term Storage of Vitrified High-Level Radioactive Waste Returned from the Russian Federation after Reprocessing of Spent Nuclear Fuel from Ukrainian Nuclear Power Plants with VVER-440", the implementation of which is envisaged in the approved storage facility design.

H.1.2. Minimization of Radioactive Waste Generation

Basic provisions of legislation to minimize radioactive waste generation are presented in Subsection H.1.2 of NRU-2011.

The *Energoatom* Comprehensive Program for Radioactive Waste Management is a fundamental document of the operating organization on radioactive waste management specifying the main activities, technical and organizational measures on radioactive waste management, particularly: minimization of radioactive waste generation, improvement of NPP radioactive waste management systems, improvement of handling operations for radwaste packages etc.

To minimize liquid radwaste, NPPs annually analyze the sources and amounts of floor drains and liquid radwaste. Based on analysis, NPPs developed and implement measures to minimize liquid radwaste, including: elimination of leakages in spent fuel pools, change in regeneration of filters for active water treatment facilities, separation of liquid flows, application of modern decontamination technologies for equipment, rooms and individual protection means, monitoring and account of floor drains from NPP compartments etc.

An important aspect in management of solid radwaste is to implement waste minimization measures. These measures (definition of limits for radwaste generation, introduction of thermal insulation reuse, limited introduction of packaging materials to the controlled area, separate collection and disposal of clean and contaminated chips etc.) allowed quite high tendencies to decrease in radwaste flows transferred to storage facilities on NPP sites. However, it should be noted that indicators for generation of solid radwaste are irregular during scheduled outages and upgrade and modernization measures for long-term operation.

The administrative and technical measures taken under the Comprehensive Program have resulted in a clear tendency toward decrease in the annual generation and accumulation of radwaste.

Reference levels for generation and transfer of solid and liquid radwaste to plant storages have been developed and approved at each NPP, including the Chornobyl NPP. These levels are periodically revised to consider their decrease depending on the actual amounts of radwaste generation due to measures aimed at minimizing radioactive waste generation at *Energoatom* plants and ChNPP. In 2016, NPPs introduced new "Reference Levels for Radioactive Waste Generation and Transfer to Storage Facilities".

The ChNPP administrative and technical measures to minimize radwaste generation to the extent possible include:

- decontamination of dismounted contaminated equipment;
- release of radioactive materials as equipment fragments and metal structures from regulatory control;
- operation of the site for temporary storage of process materials that are generated in Shelter transformation into an environmentally safe system and may be reused in construction.

Decontamination of equipment fragments and metal structures from carbon steel, stainless steel and nonferrous metal as parts of generator turbines, piping and transformer winding, circuits of heating systems, and metal structures of post-emergency armor cars is performed by chemical and hydraulic methods (using high-pressure apparatus).

Under project INSC U3.01/11E, a facility is under development at ChNPP for release of materials from regulatory control, including also development of standards, methodologies and procedures for release of materials from regulatory control, taking into account the best international practices.

H.1.3. Interdependencies among Different Steps of Radioactive Waste Management

Requirements on interdependencies among different steps in radwaste management are determined in a number of regulations. The main regulations are indicated in Subsection H.1.3 of NRU-2008.

Strategic areas and practical measures for interdependencies among different steps of radwaste management are described in Subsections B.3, B.4.1 - B.4.4 of this Report. The main measures include creation and implementation of an integral infrastructure of radioactive waste management in Ukraine.

The regulatory and legal support is being continued including development and implementation of radioactive waste classification system depending on the disposal option. See Subsection B 5 of this Report.

The main area of the technical policy for radioactive waste management of *Energoatom* is to develop the modern radioactive waste management infrastructure to ensure interdependency of all radwaste management stages from collection to transfer for disposal, namely:

- safe collection and primary processing of radioactive waste to a state acceptable for temporary storage in storage facilities and at NPP sites;
- processing of radioactive waste in order to obtain the final product that can be transported for long-term storage and disposal.

The ChNPP developed and operates the Radioactive Waste Management Program at Chornobyl NPP site. The objective of this program is to develop and maintain an integrated optimized system for radioactive waste management at ChNPP taking into account the existing radwaste management facilities and the ones to be constructed at ChNPP and in the exclusion zone. The integrated system for radioactive waste management at ChNPP will ensure management of all radioactive waste flows at ChNPP, both accumulated during

operation and generated during the mitigation of the consequences of ChNPP disaster, and flows that will be generated during decommissioning and activities at the Shelter.

The design of the process building for processing of low- and intermediate level solid radwaste was started at the *Vektor* site according to INSC U4.01/11A Project "Support to the Construction of Radioactive Waste Processing Facilities at the Vektor". This facility should provide for the centralized processing of radwaste from small producers, for which it is economically advisable to build their own radwaste processing facilities, as well as processing of small radwaste flows.

H.1.4. Effective Protection of Individuals, Society and the Environment

The radiation protection system for personnel, the public and the environment and radiation protection measures taken in Ukraine for radwaste management are described in Subsection F.4 of this Report.

H.1.5. Biological, Chemical and Other Risks

The content of biological, chemical, toxic, inflammable or explosive substances in radwaste shall be taken into account to determine the methods and technologies for waste sorting, preliminary treatment and processing. The adverse impact of these substances at further stages of radwaste management, storage and disposal, must be prevented.

According to regulations:

- radwaste containing chemical substances must be treated to neutralize them completely and avoid their presence in radwaste packages;
- explosive or inflammable radwaste must be transferred to safe state in situ;
- combustible radwaste must be transferred into noncombustible state;
- amount of organic and biological substances and complexing agents in radwaste is limited to minimize degradation in engineering barriers of the storage/disposal facility and failure of the structural stability of a radwaste package;
- toxic radwaste is not accepted for disposal.

The permissible content of hazardous substances in a radwaste package is evaluated during safety assessment of a radwaste storage/disposal facility based on calculations of the cumulative effects of radiation and other hazardous factors on human health.

H.1.6. Avoiding Reasonably Predictable Impacts on Future Generations Greater Than Those for Current Generation

According to the main principles of state policy for nuclear energy use identified in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", no activity in the area of nuclear energy may bring greater detriment to future generations than that accepted for the present generation.

The implementation of this principle becomes especially important for disposal and long-term (more than 50 years) radwaste storage since the life of such facilities is greater than the life of one generation. Hence, reliable waste isolation from the environment during its disposal and long-term storage is one of the principles of state policy for radwaste management in compliance with Article 3 of the Law of Ukraine "On Radioactive Waste Management".

Reliable isolation of radwaste is provided by a system of multiple natural and engineering barriers that shall ensure safety over the period while waste remains potentially dangerous, taking into account possible external natural and man-induced hazards, and is demonstrated in safety justification of radioactive waste storage facilities.

Safety assessment of radwaste storage/disposal facilities should provide evidence that radiation impacts on the public are not exceeded in the long-term post-closure period according to radiation safety standards. In compliance with regulatory requirements, safety assessment of facilities for radwaste disposal and long-term storage is carried out for the operational and post-closure periods.

According to the regulatory documents, radiation protection of future generations is considered adequate during disposal (taking into account uncertainties of estimates for times far into the future) if estimated risks for human health range from 5E-7 to 5E-5 per year. The risk of 5E-7 per year is regarded as the target value used in optimization of radiation protection. If the estimated risk exceeds 1E-6 but is lower than 5E-5 per year, radiation protection is considered sufficient.

In addition, the probability of inadvertent human intrusion into a storage/disposal facility must be decreased through proper selection of the storage/disposal site and measures of active and passive institutional control and storage of records on the storage/disposal facility.

H.1.7. Avoiding Undue Burdens on Future Generations

Radioactive waste shall be managed to avoid imposing responsibility for safety on future generations.

Regarding radwaste disposal, it is ensured by passive safety control of the disposal system after completion of the active institutional control period. This means that characteristics of the barriers shall be such that safety of the disposal facility does not rely on monitoring, oversight, preventive or corrective actions after completion of the active institutional control and the need for active control is minimum.

Centralized disposal and long-term storage of radwaste in Ukraine will be arranged on the *Vektor* site in the exclusion zone. Hence, necessary measures and length of active and passive institutional control of facilities for radwaste disposal and long-term storage will be determined taking into account safety assessment of total radiation impact of radioactive waste management facilities at the *Vektor* site and all existing and planned facilities at this site, as well as long-term status of the exclusion zone.

Reliable storage of data on all radioactive waste disposal facilities at the territory of current exclusion zone related to assessment of their total impact is important.

Taking into account the results of a comprehensive assessment of the radiological situation in the exclusion zone associated with the consequences of the Chornobyl disaster and the use of its territory for spent fuel and radioactive waste management, it is important to legislate the special status of the exclusion zone and the zone of special industrial use.

Regarding radwaste treatment storage facilities, regulations require that projects of future decommissioning be developed in the design stage to be periodically revised to incorporate advanced technologies and means.

In order to decrease financial burdens on future generations, a financial mechanism should function for the State Fund for Radioactive Waste Management, according to which radwaste generators pay appropriate taxes during their activities to contribute to the development of an appropriate infrastructure for radwaste management. Financial provisions for radwaste management are considered in detail in Subsections F 2.2 and F 2.3 of this Report.

H.2. Existing Facilities and Past Practices (Article 12)

Each Contracting Party shall in due course take the appropriate steps to review:
i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;
ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

A list of the existing radwaste management facilities as of 1 July 2017 is presented in Annex 3 to this Report. Information on operation of the existing radwaste management facilities is provided in Subsections B.4.1 – B.4.5.

A list of radwaste resulting from past practices is provided in Subsection D.4.3 of this Report.

H.2.1. Safety of Existing Facilities

The safety of existing radwaste management facilities is ensured and monitored in compliance with technical specifications and procedures for operation and maintenance, procedures for radiation monitoring and environmental monitoring, emergency response plans and quality assurance procedures.

All facilities are designed to be equipped with radiation monitoring systems, and observation boreholes to monitor underground and ground waters are arranged around the radwaste facilities. Radiation performance indicators of facilities and the environment are monitored with the periodicity and are compared with the established reference levels.

Personnel are provided with adequate individual protection means and are subject to individual dose monitoring.

All radwaste management facilities are also equipped with engineered safety features such as systems for fire alarm and fire-fighting, ventilation and air purification, active drainage, moisture detection and removal, leakage and water level monitoring (for liquid radwaste storage facilities), redundant tanks, etc. The radwaste treatment facilities include systems for control and monitoring of radwaste treatment processes.

In compliance with the "Requirements for Periodicity and Contents of Reports Submitted by the Licensees in Nuclear Energy Use", the licensees provide the regulatory body with quarterly and annual reports on radiation safety of radwaste management facilities, which contain data on results of individual dose and radiation monitoring, compliance with reference levels, analysis of incompliance with reference levels and safety improvement measures.

The annual reports of the licensees and state inventory of radwaste indicate that the existing radwaste management system is satisfactory. There were no deviations in the performance of protection systems of radwaste management facilities in the reporting period. The radwaste management conditions comply with regulatory requirements on safety. There are no leakages of radwaste into soil or radwaste loss in transport and storage.

All amendments in design and operating documentation, upgrading, modernization and major repairs that may affect safety are subject to state review on nuclear and radiation safety.

H.2.2. Past Practices

Legacy radwaste in Ukraine includes the following:

- radwaste disposed in Soviet times at radwaste management facilities of state

interregional specialized of UkrDO *Radon*;

- radwaste resulting from the Chornobyl accident and placed at RWDS, RICS and VTS/SSR;

- radwaste resulting from military programs of the former USSR.

Information on this radwaste is provided in Subsections 4.5 and 4.6 of Annex 4 to this Report.

Information on current activities related to radwaste storage/disposal facilities is provided in Subsections B.4.3 and B. 4.4 of this Report.

According to the Strategy for Radioactive Management in Ukraine, measures are implemented to ensure safety of these facilities, including their safety assurance, safety reassessment, planning of further remediation and closure.

Safety Reassessment of SISP Radwaste Storage Facilities

For implementation of the National Target Ecological Program for Radioactive Waste Management, particularly, for making well-grounded decisions on timeframes and sequence of radwaste retrieval from closed radwaste disposal facilities of SISPs, safety of RWDS on each SISP site shall be reassessed.

Under project INSC U3.01/08, SNRIU developed the "Guidance on Safety Reassessment of Existing Radwaste Disposal Facilities and Criteria for Decision Making on Further Activities at These Facilities" recommended to the licensees in safety reassessment. Safety reassessment shall take into account data on the designs of facilities taking into account modernizations or upgrades; data on radionuclide composition, activity and other characteristics of radwaste placed in the storage/disposal facilities; data on site characteristics (hydrogeological, metrological, seismic, demographic, etc.); data on events and external and natural hazards observed during the lifetime of facilities that could affect their safety; results from radiation monitoring and environmental monitoring during operation of the storage/disposal facilities.

UkrDO *Radon* performed safety review of radwaste storage facilities of Kharkiv, Kyiv, Dnipropetrovsk and L'viv SISPs. SNRIU with the involvement of Ukrainian and European experts analyzed these reviews in the framework of the regulatory projects INSC: UK/TS/39 and UK/TS/46.

Making acceptable decisions for safe management of stored radwaste (in particular, assessment of the state of engineering barriers in the storage facility) is envisaged in the future. Depending of the selected radwaste management strategy (waste retrieval or placing for a long period), the following is envisaged:

- assessment of long-term consequences of these facilities if some radwaste can be placed at SISP sites for a long period of time;

- description of facilities and presentation of radiation protection measures for safety demonstration of operations related to radwaste retrieval.

Safety Reassessment of RWDS and RICS in Exclusion Zone

Under international project INSC-U4.01/10D, RWDS and radwaste pits and trenches were surveyed in RICS territories, safety reassessment of these facilities was performed.

RWDS Pidlisny and RWDS ChNPP Stage III:

In the course of industrial project INSC U4.01/10D and regulatory project INSC U3.01/10 (UK/TS/46) involving European experts and applying current safety assessment methodologies, a safety assessment of RWDS *Pidlisny* and RWDS *ChNPP Stage III* was performed, which confirmed that currently taking into account the implemented safety

improvement and stabilization projects, these facilities provide safe radwaste storage. At the same time it is necessary to continue enhanced institutional control with obligatory measures for aging management of facilities and their monitoring to confirm the reliability of the measures taken.

In the long term, the issue of removing radwaste from these RWDS and their redisposal in appropriate disposal facilities should be solved. Preparing for radwaste removal from these RWDS is part of the long-term measures to be implemented in stages after developing removal, management and disposal technologies for this waste.

It is recommended to coordinate solving issues and developing technologies of radwaste removal and management for RWDS *Pidlisny* with the activities at the *Shelter*.

RICS

Upon agreement by the SNRIU of approach to safety assessment developed within the project, RICS safety assessment was performed and its results were used to rank RICS by their potential hazard, as well as it was defined where to perform remediation and develop practical remediation measures.

The main conclusions of RICS safety assessment defined that:

• RICS are risk facilities that require measures to reduce them for protection of personnel, the public and the environment.

• For the majority of RICS, institutional control for about 500 years within a certain territory in the exclusion zone (approximately 10 kilometers) is sufficient to ensure protection of the public, personnel and the environment.

• Assessment of certain alternative scenarios (for example, fires, tornadoes) has shown that personnel and the public may receive allowable exposure doses. However, emergency preparedness measures may significantly reduce the impact of this dose.

• Removal of radioactive waste from certain RICS pits/trenches (and hot spots from the contaminated upper soil layer) may be justified in terms of safety improvement of personnel and visitors, as well as reducing the overall dose.

• After a period of 500 years of institutional control, most restrictions can be removed.

Safety Assessment and Remediation of VTS/SSR Outside the Exclusion Zone

In the period of ChNPP accident mitigation, in the areas adjacent to the exclusion zone, storage sites for radwaste resulting from decontamination and sanitary treatment of vehicles (SSR), where the upper soil layer, roofing materials, debris, etc. were placed, and vehicle sanitary treatment sites (VTS) were established. The total number is 53 SSR/VTS, six of which are VTS. Twenty six of 53 SSR/VTS are located in the exclusion zone.

In the framework of INSC U4.01/12D “Remediation of Radioactive Waste Storage Sites formed after the Chernobyl Accident outside the Exclusion Zone”, additional SSR/VTS surveys and safety assessments were conducted. These assessments are the basis for ranking facilities by hazard level to make decisions on planning further remediation measures, including priority radwaste removal from those SSR/VTS for which there is a risk of intervention or the estimated exposure dose of the public under implementing a set of probable scenarios is approximate to or exceeds a criterion of 0.3 mSv/year.

The technical condition of the individual SSR/VTS is unsatisfactory (no fence, warning signs, draining trenches for water drainage are not operable, no/damaged top cover). It is planned to develop recommendations on implementing immediate measures to bring the SSR VTS to an acceptable condition for the period prior to waste removal from them (depending on hazard degree).

Within the project, the assessment and ranking were performed for SSR/VTS, which were surveyed in 2013-2015: 13 SSR and 6 VTS. According to the assessment results, 4 most hazardous facilities were defined: 1 SSR, 3 VTS. These four facilities will be considered as a priority for implementing the remediation measures. The "Methodology for Safe Radwaste Removal from SSR/VTS and Remediation of Disposal Sites" was developed, selection of a pilot facility was planned, as well as criteria for territory remediation after waste removal are under consideration.

Remediation of Pilot Radioactive Waste Disposal Facility Resulting from Military Programs of Former USSR

On the territory of Ukraine, there are several legacy facilities (storage facilities) of the 1970s-1980s. They contain radioactive waste resulting from military programs of the former USSR. The transfer of these legacy storage facilities to the ecologically safe state (remediation) by removal and further management of radioactive waste is envisaged by Task 12 of the National Targeted Environmental Program for Radioactive Waste Management.

In order to support implementing this task, the Cabinet of Ministers of Ukraine has concluded an Implementing Agreement with the NATO Support Agency for Management of Radioactive Waste resulting from implementing military programs of the former USSR in Ukraine ratified by the Law of Ukraine No. 526-VIII of 17 June 2015. Within the Implementation Agreement, a pilot project for radwaste removal from the *Vakulenchuk* storage facility in the Zhytomyr region was implemented. Its beneficiaries were SAEZ and the State Border Service. This storage facility was built in the late 1970s. All information on radwaste stored in the storage facility was lost, radiation survey showed that in the building there are, among other, neutron radiation sources.

Licensee LLC NT-ENGINEERING, in accordance with the agreed project, carried out activities on radwaste removal from the *Vakulenchuk* storage facility in the form of disused radiation sources and their transport to the Kyiv SISP for storage. At the same time, activities were conducted on solid radwaste removal and fragmentation in the form of reinforced concrete structures of the facility and this radwaste transfer to RWDS *Buryakivka* for disposal. In addition, the criteria for remediation of the area released from radwaste of the Vakulenchuk storage facility, radiation monitoring program and technical decision on implementing the final remediation of the storage site were developed and agreed with the SNRIU.

The value of the annual effective exposure dose of a person, which may in the future live at or near the site of the liquidated storage facility is defined as the base criterion for storage site remediation and it is not more than 10 μSv/year, which meets the requirements of the radiation safety standards of Ukraine.

The experience gained from implementing the pilot project will be taken into account in future during planning, design and safety assessment on the implementation of subsequent projects on radwaste removal from the legacy storage facilities, including those left from the military programs of the former USSR.

H.3. Siting of Proposed Facilities (Article 13)

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:
i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;
ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;
iii) to make information on the safety of such a facility available to members of the public;
iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.
2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

According to the Strategy for Radioactive Waste Management in Ukraine, new facilities for treatment and temporary storage of radwaste are planned to be constructed on sites of operating NPPs, ChNPP, UkrDO *Radon* SISPs and *Vektor*.

According to the requirements of the General Safety Provisions on Predisposal Radioactive Waste Management, a site at which a nuclear installation or radioactive waste disposal facility is located is suitable for location of a predisposal radioactive waste management facility. For such facilities, the results of previous studies of the site during establishing a nuclear installation or radioactive waste disposal storage facility may be taken into account.

In the reporting period, activities are conducted on siting in the territory of the ChNPP site to establish additional radioactive waste management facilities:

– facilities for cleaning liquid radwaste of the Shelter from organic compounds and transuranium elements,

facilities for release of materials from regulatory control.

The safety assessment of these facilities, in accordance with the structure and contents of the safety analysis report for radwaste treatment and storage facilities, shall include analysis of factors associated with site location (meteorological, geological, hydrological, seismic, technology-related and social and economic factors) that affect the safety of the facility during construction, operation and decommissioning.

The sites for radioactive waste management facilities at UkrDO *Radon* SISP are defined by the boundaries of conditionally contaminated areas of SISP radioactive waste storage sites. Additional siting is not envisaged.

According to the regulation "Requirements for Siting for a Radioactive Waste Disposal Facility", a site is considered acceptable for a disposal facility if its safety assessment has proved that the disposal system is capable of confining and/or isolating radwaste from the accessible environment over the period while waste remains potentially hazardous, in compliance with radiation safety requirements and criteria.

Consideration shall be given to site characteristics that:

- ensure radionuclide isolation from accessible environment;
- may influence the rate of transport and accumulation of radioactive substances in the environment;
- ensure protection of engineering barriers against external events and processes.

External natural and technology-related events and processes that may affect the safety of the disposal system during operation, closure and in the post-closure period are also considered.

The requirements are used to select new sites and reassess the safety of facilities located on previously selected sites, including the sites of *Vektor*, *Buryakivka* RWDS and UkrDO *Radon* SISPs.

According to the Law of Ukraine "On Decision Making Procedure for Siting, Design and Construction of Nuclear Facilities and Radioactive Waste Management Facilities of National Importance", a decision on siting and design of a radwaste disposal facility is made by the Verkhovna Rada of Ukraine through adoption of a relevant law. The Verkhovna Rada makes this decision only if the site for a disposal facility is agreed by the local executive authorities and local governments following a consultative referendum involving the public and public hearings.

To meet the requirements of the Strategy for Radioactive Waste Management in Ukraine it is envisaged to establish a geological repository for radioactive waste disposal. Task 11 of the National Targeted Environmental Program on Radioactive Waste Management defines the measures to conduct a number of search, evaluation, scientific and methodical, research and design activities on siting of a geological repository for disposal of long-lived and high-level of radioactive waste.

During the last years, scientists of the institutes of the National Academy of Sciences of Ukraine and experts of the enterprises carried out thematic activities on assessing the promising features of the granite formations of the Ukrainian crystalline shield to locate a geological repository. According to the results of these activities:

- in-depth analysis and interpretation of available documents and data of geological and geophysical studies on the territory of the Chernobyl exclusion zone and adjacent territories was performed. Specialized field studies were not performed;
- data on the section of stratified sedimentary formations are systematized;
- criteria to define priority areas for priority field studies are developed, namely: calm nature of the geophysical fields, location on water areas and beyond the fault zones, minimum density of lineaments;
- granitoids of the Korosten and Zhytomyr complexes are identified as the most promising for further studies;
- three alternative priority areas are identified: Novosilka, Zhovtneve, Veresnianka;
- draft program of further field studies of areas is developed
- stages and sequence of further studies are determined.

The level of geological and geophysical exploration degree of the identified areas is different and requires further studies to compare and select the most promising area for geological repository. In the first place, it is proposed to perform geophysical studies on promising features of the Novosilka area.

Analysis results and generalization of available geological and geophysical information were used in INSC U4.01/09-B project "Concept of Radioactive Waste Disposal in Ukraine" to perform general preliminary safety analysis of two concepts of geological disposal. The following concepts are considered:

- deep geological repository for disposal of vitrified HLW and possibly spent fuel (KBS-3V concept, Sweden);
- intermediate depth disposal facilities for disposal of long-lived radwaste (SFL concept, Sweden).

Evaluations of exposure doses and time of achieving the peak dose values are made taking into account properties of Ukrainian radwaste and geological conditions of the Chernobyl exclusion zone.

It is shown that for various scenarios, which differ by the intensity of groundwater flows, exposure doses for a million years is two-three orders lower than a boundary dose of 10 $\mu Sv \cdot year^{-1}$ established by regulatory documents. In this case, only a few nuclides have a significant impact, namely: I-129, Cl-36, C-14, Ni-59 and Cs-135. In addition, it is shown that sedimentary strata present at the Ukrainian sites significantly slow down nuclide migration and thus provide a possibility to optimize the design of engineering barriers in geological storage repositories. In general, it is shown that geological repositories located in crystalline rocks in the geological conditions of the Chornobyl exclusion zone may meet the safety requirements, if a site and depth for location of radwaste packages are selected appropriately.

H.4. Design and Construction of Facilities (Article 14)

Each Contracting Party shall take the appropriate steps to ensure that:
i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;
ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;
iii) at the design stage, technical provisions for the closure of a disposal facility are prepared;
iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

According to Article 24 of the Law of Ukraine "On Radioactive Waste Management", radwaste management facilities are designed in compliance with current standards and regulations using technologies proven by experience, testing or analysis.

The design of a radwaste disposal facility must rely on safety assessment for the operational period and long-term post-closure period.

Compliance of the design decisions on a radwaste management facility with standards and rules on radiation safety is assessed during the state review of such designs. The state review of the designs for radwaste management facilities necessarily includes state review on nuclear and radiation safety and state ecological review. The state review on nuclear and radiation safety is conducted by the SNRIU involving technical support organizations. The state review on nuclear and radiation safety of the designs involves national and international technical support organizations in the framework of international cooperation with the SNRIU and EC, EBRD and countries with developed nuclear energy. The state ecological review is conducted by MENR.

In making a decision to issue a license for construction of a radwaste storage or disposal facility, one of the main documents is a favorable conclusion of the state review of the design, taking into account state review on nuclear and radiation safety and state ecological review.

In order to further develop the radwaste management system, in accordance with the requirements of the Strategy for Radioactive Waste Management in Ukraine and the National Targeted Environmental Program on Radioactive Waste Management, new radioactive waste management facilities are designed. Some design solutions for these facilities include the following.

Long-Term Storage Facility for Vitrified HLW Resulting from VVER-440 Spent Fuel Reprocessing

The storage is intended for acceptance, preparation for storage and long-term storage of vitrified HLW. The design capacity of the storage facility is 550 m^3 of HLW. It includes 1024 cells for packages with HLW (each package containing three 200-liter drums), which is sufficient to place 550 m^3 HLW with a margin. The design time for HLW acceptance to the storage facility is 15 years and storage period of HLW packages is 100 years.

The storage facility has two process areas: production area and storage area for HLW packages.

For HLW acceptance and preparation for storage, the production area has required process sections. HLW is prepared for storage in a shielded (hot) cell.

The storage modules are designed as shielded cells. There is a rail above the storage modules and hot cell for movement of the reloading equipment. At the same time, this equipment is required for loading of HLW packages into cells of the storage modules and unloading of HLW packages from the cells and their placement into the hot cell (if needed).

The design provides for the following functions to ensure safety in HLW preparation for storage and long-term storage:

– automated control and management of technological processes and equipment;
– HLW control and accounting;
– radiation control at all stages of the technological process of HLW management and storage;
– environment monitoring;
– decontamination;
– own radwaste management;
– functions of ensuring personnel safety.

See also Subsection H 1.1 of this Report.

Process Building for Treatment of Radioactive Waste on Vektor Site

The Process Building is intended for acceptance, processing and preparation for disposal of solid low- and intermediate-level radwaste from small producers and small radwaste flows is designed according to project INSC U04.01/11A “Support in Radioactive Waste Management at the *Vektor* in Ukraine”.

It is planned to supply radwaste from Ukrainian NPPs, UkrDO *Radon* SISP, radwaste from military sites, research reactors, radwaste of the exclusion zone (except ChNPP radwaste), operational radwaste of the *Vektor*, etc. to the Process Building for processing.

The following main functions of the Process Building are envisaged:

- radwaste acceptance, characterization, sorting (including separation of disused radiation sources from radwaste in a hot cell), fragmentation and preparation for transfer to radwaste processing facilities;
- radwaste incineration;
- radwaste compaction;
- radwaste cementing;
- radwaste preparation for transfer for disposal and certification;
- control and accounting of radwaste, containers, packages;
- transfer of radwaste packages for disposal and containers with disused radiation sources for long-term storage.

Industrial Facility for Removal of Transuranium Elements and Organics from ChNPP Liquid Radioactive Waste

At present there is flowing of radioactively contaminated water from the Shelter to ChNPP-3, which is pumped into the tanks of special drains of Unit 3 and then transferred to a special water treatment facility for processing. Shelter water has an increased content of organic compounds and transuranium elements. The evaporation bottoms accumulated in the liquid radwaste storage facilities also contains organic compounds and transuranium elements.

According to project INSC U4.01/11C, the Industrial Facility for treatment of ChNPP liquid radwaste from transuranium elements and organic compounds is designed. It is intended for treatment of Shelter water and accumulated evaporation bottoms.

The treatment criteria shall meet the criteria of acceptance to the special water treatment facility and LRTP.

For Shelter water treatment it is envisaged to use the technology of substance deposition in the initial solution using polymeric inorganic coagulants, as well as reagent compositions of synthetic powder water-soluble flocculants with subsequent separation of sludge and cleaned product. The hydrothermal method is used to clean the evaporation bottoms: the oxidation process of the evaporation bottoms and polymerization of the organic compounds occur in a hydrothermal reactor at high temperature and pressure.

Facility for Release of Radioactive Materials from Regulatory Control

The design of a facility for release of radioactive materials from regulatory control at ChNPP, along with the relevant standard, methodologies and procedures is designed within industrial project INSC U4.01/11E.

The facility for release of radioactive materials from regulatory control is intended for measuring radiation characteristics of radioactive materials to confirm compliance/incompliance with the release levels.

The facility for release of radioactive materials from regulatory control includes equipment to measure radiation characteristics of materials subject to release:

- stationary system of gamma-spectrometric control on the basis of detectors of especially pure germanium;
- operator module with a control panel and auxiliary equipment;
- portable device for gamma-spectrometric control;
- portable device of radiometric control;
- portable device to control alpha- and beta-contamination of surface and dose rate;
- surface alpha- and beta- contamination monitor;
- stationary monitor of dose rate;
- portable radiation monitor.

H.5. Assessment of Safety of Facilities (Article 15)

Each Contracting Party shall take the appropriate steps to ensure that:
i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;
ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;

iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

Safety assessment of a radwaste management facility is finalized into a safety analysis report (SAR). Requirements for the SAR structure and contents are established in relevant regulations. SARs are developed and gradually updated at all life stages of facilities: from siting and design to decommissioning and closure.

The SAR for a radwaste disposal facility for the post-operational period is revised to incorporate operating experience and data of environmental monitoring and to include additional safety justification for the post-closure period.

Assessment of long-term safety of a radwaste disposal facility includes estimates of radiological impact of the disposal facility on human and the environment for different scenarios and comparison of these estimates with established safety criteria. The following is considered:

- normal evolution scenarios (on-site natural processes and degradation of engineering barriers of the disposal facility);
- alternative scenarios (unlikely natural destructive events that affect confining and isolating functions of the disposal system in the post-closure period);
- scenarios of inadvertent intrusion into the disposal facility upon completion of institutional control.

In the framework of project INSC U4.01/08-B "Improvement of infrastructure for radioactive waste management in the Chornobyl exclusion zone", long-term safety assessment of *Buryakivka* RWDS was carried out to check its current state and justify its upgrading.

The most critical aspects of safety assessment were the total content and specific activity of long-lived alpha- and beta-radionuclides. The calculation showed that in 300 years after repository closure, release levels would be achieved only for gamma and beta-emitting nuclides, while for alpha-emitting nuclides there will be only an insignificant activity decrease.

The safety assessment for normal evolution of the disposal facility was focused on exposure groups living outside the disposal facility territory since access to RWDS *Buryakivka* and adjacent areas of the exclusion zone will remain restricted for many years. Under these conditions, the calculated values are considerably lower than the established regulatory level of current exposure for the public of 10 μSv/year.

In the framework of project INSC U4.01/11B "Support to Operator in Licensing ENSDF and SRW-1, SRW-2 Disposal Facilities at the *Vektor"*, measures on safety reassessment of ENSDF, safety analysis of SRW-1, SRW-2 disposal facilities are implemented. Based on the results, selection of radwaste acceptance criteria for disposal in ENSDF, SRW-1, SRW-2 is justified. It is also envisaged to update the reports containing the analysis of seismic characteristics of SRW-1, SRW-2 disposal facilities.

In the framework of INSC U4.01/10 F a comprehensive safety assessment of the *Vektor* facilities (taking into account current plans for its development and impact of other radwaste management facilities in the exclusion zone) was performed. The main objective of the comprehensive assessment is to show that the *Vektor* taking into account all radwaste management facilities planned to be a part of it, will have the necessary safety level since according to the plans approved by the Government of Ukraine, the *Vektor* "Is a key element of the national radioactive waste management infrastructure, including disposal".

According to project results:

- methodology that allowed combining separate safety assessments of the *Vector* facilities into a single safety assessment was developed;
- comprehensive safety assessment of the *Vektor* facilities was carried out, where both the operation period and the period after closure of the facilities were considered, at the same time normal and alternative scenarios were considered.

It is concluded that further operation of operating licensed facilities at the *Vektor* will not lead to additional impact on the public or personnel. It is also determined that the *Vektor* has sufficient potential for additional optimization and expansion in order to accept radwaste from NPPs and other waste producers in Ukraine for processing, storage and/or disposal.

For radwaste treatment facilities at sites of operating NPPs, ChNPP site and CLTSF on the *Vektor* site, the final SARs will be developed taking into account commissioning activities.

In the framework of developing design documentation "Construction of Interim Storage Facility for High-Level Waste Returned from the Russian Federation after Reprocessing of Spent Fuel of VVER-440 Ukrainian NPPs", SAR was developed for the construction of this facility.

Information on safety assessment of facilities for management of radwaste resulting from past practices is provided in Subsection H 2.2 of this Report.

H.6. Operation of Facilities (Article 16)

Each Contracting Party shall take the appropriate steps to ensure that:

i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;

iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;

iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;

v) procedures for characterization and segregation of radioactive waste are applied;

vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

vii) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;
ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

H.6.1 License to Operate Radioactive Waste Management Facilities

Information on the licensing system for spent fuel and radioactive waste management is provided in Subsection E 2.2 of this Report.

Regulatory requirements for radioactive waste management activities to be met by the entities (licensees) dealing with radioactive waste management are provided in the previous Report (see NRU-2014).

H.6.2 Definition and Revision of Operational Limits and Conditions

The SAR on the radwaste management facility and technical specifications for operation include a detailed list of activities related to operation of a facility depending on its purpose, waste acceptance, internal transport, treatment processes, procedure for radwaste placement for storage or disposal, radwaste accounting, decontamination of equipment and tools for radwaste management, acceptance inspection of radwaste packages (for treatment facilities). The SAR also justifies operational limits and conditions for process systems and equipment, radiation monitoring systems and systems of storage or disposal barriers. Taking into account commissioning activities, operational experience or experience in facility safety reassessment, decisions may be taken to improve safety of the facilities by correction of operational limits and conditions, modifications and reconstructions. The documents on changes in operational limits and conditions, modification, reconstruction, and major repair are subject to the state review on nuclear and radiation safety.

H.6.3 Operating and Maintenance Procedures

In the framework of its quality system, the licensee develops technical specifications and provisions needed to support processes, maintenance operations, radiation monitoring and emergency measures.

H.6.4 Engineering and Technical Support

Information on engineering and technical support during operation of radwaste management facilities is provided in Subsection H.6.4 of NRU-2003. Engineering support during survey, assessment, scientific, research and design activities on sitting for a geological repository for disposal of long-lived and high-level waste is provided by the Institute of Environmental Geochemistry and Science and Engineering Center for Radiological Field Surveys of the National Academy of Sciences of Ukraine.

Technical assistance for the activities of the Ukrainian NPPs in radwaste management is provided by:

- *Energoatom* Scientific and Technical Center;
- NPP Operation Support Institute of the National Academy of Sciences of Ukraine;
- State Research Center of Control Systems and Emergency Response.

Within the international technical assistance in the framework of INSC projects, support is provided in designing, developing systems and equipment for radwaste management facilities taking into account the best international practice.

H.6.5 Radioactive Waste Characterization and Sorting Procedures

Radwaste management facilities constructed on the sites of operating NPPs and ChNPP (see Subsections B 4.1, 4.2) are designed to be equipped with radwaste sorting and characterization systems using modern dosimetric and spectrometric instrumentation. Therefore, radwaste characteristics important for disposal will be determined: radionuclide composition and specific activity of each radionuclide. Sorting will take into account radwaste acceptance for the appropriate option of further treatment – incineration, compaction and cementation.

Considering characteristics of liquid radwaste to be treated at the LRTP, the ChNPP developed the compositions for cementing liquid radwaste so that the LRTP final product complies with acceptance criteria for disposal in ENSDF.

During commissioning of the retrieval facility and solid radwaste treatment plant within ChNPP ICSRM, additional tests of the radwaste sorting system are performed. The specific features of the sorting system are associated with the characteristics of radwaste accumulated at the ChNPP, one part of waste generated from operation and the other from the Chornobyl accident. This radwaste has different radionuclide composition, which was not determined during waste loading into the ChNPP SRSF because appropriate equipment was missing at that time (to 2003).

CLTSF on the *Vektor* site provides for identification and sorting of radwaste as disused radiation sources and their placement in containers according to the type of radiation and half-life and further storage of containers with radiation sources of different types in separate storage compartments, marking of containers according to radionuclide half-life in order to optimize management of this radwaste after retrieval of packages from the storage facility after completion of the storage period.

To improve the infrastructure for management of radioactive waste in the Chornobyl exclusion zone, a central analytical laboratory (CAL) for radwaste characterization at State Enterprise Ecocenter and a mobile laboratory at CRME were created in 2015 under project INSC U4.01/08B (phase II)/U4.01/10A.

CAL acts as an independent expert on radwaste characterization and supports radwaste suppliers and operator of radwaste management facilities in determining radwaste characteristics depending on the defined goal for a particular stage of radwaste management. The CAL, using the “Methodology of Measurement for Full Characterization of Radwaste in CAL and Survey of Radioactively Contaminated Territories by a Mobile Laboratory”, ensures independent identification of radwaste properties required to characterize and classify waste of all types before its storage and disposal in the facility. The laboratory's activities take into account the best international practices and IAEA recommendations. CAL annually passes qualification tests (intercalibration) and is a participant of the LABONET community.

CAL analytical capacity is at least 5000 samples per year.

From the beginning of its work, the following activities are carried out in CAL:

- develop programs (logics) for characterization of certain radwaste types;
- model bituminous compound and study its behavior during long-term leaching;

- study properties of new polymer materials for the immobilization of spent ion-exchange resins and ash from radwaste incineration;
- assess migration of tritium in groundwater in radiation accident;
- characterize legacy radwaste of the *Vakulenchuk* storage facility within its liquidation;
- measure chemical composition of liquid radwaste in SISP facilities;
- perform expert assessment of radioactive contamination of metal-containing materials.

The use of vehicles with high maneuverability of CRME Mobile Laboratory Unit (MLU) equipped with the necessary equipment and instruments allowed efficient survey of radioactive waste in hard-to-reach RICS areas, which were sometimes swampy and overgrown with forests and bushes. Using the MLU, RWDS in the exclusion zone, *Vakulenchuk* storage facility in the Zhytomyr region, facilities of the former Prydniprovsk Chemical Plant, etc. were surveyed.

H. 6.6 Reporting of Incidents Significant to Safety to the Regulatory Body

According to the regulation "Safety Conditions and Requirements (Licensing Terms) for Radwaste Management", in case of any situation or circumstance that caused incompliance with radiation safety standards and rules or in case of a radiation accident, the licensee:

- notifies the regulatory body and territorial body of the Ministry of Health of Ukraine within an hour;
- starts actions to eliminate incompliance or, in case of an accident, measures under emergency plans;
- conducts official investigation of causes and circumstances that caused incompliance or accidents and submits the investigation report to the SNRIU.

In the reporting period, there were no incidents or accidents in radwaste management activities.

H.7. Institutional Measures after Closure (Article 17)

In designing any disposal facility, the operating organization shall determine measures for storage of archives and for placement of relevant data and limitations on maps stored by relevant state authorities. According to Article 21 of the Law of Ukraine "On Radioactive Waste Management", the responsibility for storage of documentation that characterizes the facility lies with the state control body for radwaste management and local state executive authority.

Institutional control after closure of a radwaste disposal facility includes active and passive institutional control. Active institutional control covers monitoring, maintenance, inspection of integrity of barriers and, if necessary, recovery activities and prevention of access to the territory of the disposal facility. A program for post-operational monitoring of the disposal facility shall be developed to ensure monitoring of protective properties of disposal barriers and timely detection of radionuclide transport beyond the facility in order to take, if needed, corrective actions and repairs. To prevent unauthorized access to the territory of the disposal facility, warning signs and fences may be used during active institutional control.

Passive control provides for restrictions on economic activities within the disposal site and storage of information on the disposal facility.

To arrange active institutional control during closure of a radwaste disposal site, the operating organization shall obtain a separate SNRIU authorization.

The decision on the length of institutional control (passive and active) of the *Vektor* site after closure of its radwaste disposal facilities will be made according to comprehensive assessment of the common radiation impact of *Vektor* facilities for a long-term period and considering the long-term status of the *Vektor* territory. See Subsection K 2.2 of this Report.

There are no radwaste disposal facilities in Ukraine that would pass the closure stage.

Section I. TRANSBOUNDARY MOVEMENT (Article 27)

1. Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In so doing:

i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;

ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized;

iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

iv) a Contracting Party which is a State of origin shall authorize a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

2. A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal.

3. Nothing in this Convention prejudices or affects:

i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;

iii) the right of a Contracting Party to export its spent fuel for reprocessing;

iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

Ukraine does not undertake nor is involved in transboundary movement of radwaste.

Transboundary movement of spent fuel takes place from Ukrainian NPPs to the Russian Federation in compliance with the Agreement between the Governments of Ukraine and Russian Federation on Cooperation in Radioactive Material Transport of 1996.

Ukraine does not send spent fuel for storage or disposal to the south of latitude 60 (para. 2 of Article 27 of the Joint Convention).

To comply with para. 1i) of Article 27 of the Joint Convention, the SNRIU uses an authorization procedure for each spent fuel transport according to the Procedure for Authorization of International Transport of Radioactive Material approved by Cabinet Resolution No. 1196 “Some Issues of Radioactive Material Transport” of 3 October 2007.

As one of the conditions to obtain an authorization, the Russian consignee (operator) shall have a permit for spent fuel import issued by the authorized state body of the Russian Federation to confirm the consent of the state of destination. Preliminary notification on

transboundary movement takes place according to a contract under which the Ukrainian operator shall notify the Russian operator no later than seven days before spent fuel departure.

Section J. DISUSED SEALED SOURCES (Article 28)

1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.
2. A Contracting Party shall allow for reentry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

The main amount of disused radioactive sources is placed in the facilities of the UkrDO *Radon* SISPs for safe and secure storage. Information on the UkrDO *Radon* SISPs and plans and measures to ensure and improve the operational safety of facilities for storage of radwaste and spent sources is provided in Subsections B.4.4, H2.2 and K.1 of this Report. Data on radiation sources transferred into the category of radwaste and stored at UkrDO *Radon* SISPs are provided in Subsection 4.6.2 of Annex 4 to this Report.

Energoatom transferred disused radiation sources to UkrDO *Radon* SISPs from 2014 to 2016 as follows :

- 73 disused radiation sources from Zaporizhzhya NPP to Dnipropetrovsk SISP;
- 42 disused radiation sources from South Ukraine NPP to Dnipropetrovsk SISP;
- 147 disused radiation sources from Rivne NPP to Lviv SISP;
- 282 disused radiation sources from Khmelnitsky NPP to Kyiv;
- 49 disused reference radiation sources from the Emergency Technical Center to Kyiv SISP.

The safety in management of radiation sources prior to their transfer to specialized radwaste management enterprises is ensured by:

- licensing of use and manufacture of radiation sources;
- supervision over compliance with safety standards and rules and licensing terms for use and manufacture of radiation sources;
- functioning of the State Register of Radiation Sources;
- implementation of tax liabilities within the Tax Code of Ukraine for radiation source users to pay taxes for temporary storage of sources after expiry of their lifetime to encourage the enterprises to transfer disused radiation sources to specialized radwaste management enterprises in a timely manner.

At the same time, there are enterprises, organizations and establishments that used radiation sources in industrial and research activities but now cannot ensure proper monitoring of their radiation sources because of change in activity or bankruptcy and cannot transfer radiation sources to specialized enterprises because of lack of funding.

These issues are resolved under the State Program for the Safety of Disused High-Level Radiation Sources in Storage, approved by the Government of Ukraine in August 2006. The Program addresses, among other things, management of disused radiation sources that were fabricated to 1990 for use in X-ray, measurement and diagnosis units and devices and were not transferred to specialized enterprises because of bankruptcy or financial failure of the owners or other reasons. The first stage of the Program covered registration of disused high-level radiation sources and survey of radiation source storage places and

conditions, which served as a basis for identifying priorities of actions on conditioning, containerization or unloading of facilities with disused radiation sources.

The Program is further implemented by involvement of resources under international technical assistance provided on a bilateral basis between the Great Britain, Germany, France, the USA, and other donor countries within the nonproliferation initiatives.

Under the Treaty between the Federal Ministry for Environment, Nature Conservation and Reactor Safety (BMU) and Company for Installations and Reactor Safety (GRS) of Germany for contribution to G8/GP to ensure removal and safe storage of unprotected radiation sources in Ukraine, the project "Decommissioning of Irradiation Facilities and Safe Storage of Radiation Sources" is continued. Within this project, radiation sources of bankrupt enterprises are retrieved and transported for further safe storage.

In the framework of the project, 19,405 radiation sources with a total activity of 1.19E+15 Bq were retrieved from enterprises in different regions of Ukraine, and their containerization and safe storage in SISP radwaste facilities were provided. Current efforts under the project include making the next list of bankrupt enterprises.

US international technical assistance to Ukraine is continued under the project intended to improve the security of disused radiation sources in Ukraine. In 2014, 250 disused radiation sources of GIK-7-4 type from the Sterilizatoin–III gamma unit of the Geoplast Company (Belgorod-Dnerstrovsky) with a total activity of 4.34E+14 Bq, one GK-60 source from the Mykolaiv Regional Oncology Center with activity 84.7E+13 Bq, and 58 disused radiation sources of GIS-7-4 type from the Institute of Physics of the National Academy of Sciences of Ukraine with activity 1.04E+14 Bq were transferred to SISPs.

The key element in improving the management system for disused radiation sources declared as radwaste is CLTSF on *Vektor* site (see also Subsection B.4.3 of this Report).

Under support of the French Atomic Energy Commission, a Mobile Unit of Equipment for removal of disused gamma radiation sources from shielding operated at UkrDO *Radon* SISP and a special packaging for placement and transport of these disused radiation sources were developed and manufactured (see also Subsection B.4.4 of this Report).

Section K. GENERAL EFFORTS TO IMPROVE SAFETY

K.1. Measures Taken to Solve Issues Defined as Challenges and Suggestions According to the Fifth Review Meeting

Upon the Fifth Review Meeting of the Contracting Parties, the following challenges were identified for Ukraine:

1. Completion of the New Safe Confinement for the ChNPP Shelter.

Information on the progress in NSC construction is provided in Annex 9 to this Report.

2. Construction of first-priority radwaste and spent fuel management facilities in the exclusion zone, including design and construction of CSFSF and design and construction of a storage facility for long-term storage of vitrified HLW from VVER-440 spent fuel reprocessing.

Information on the design and construction of radwaste management facilities in the exclusion zone is provided in Subsection B 4.3 of this Report. Information on the construction and upgrading of spent fuel management facilities in the exclusion zone is provided in Subsections B 2.1 and B 2.2 of this Report.

Upon the Fifth Review Meeting of the Contracting Parties, the following suggestions were identified for Ukraine:

1. Development of plans regarding the future of the Chernobyl exclusion zone:

1.1 Development of conceptual plans on future use and status of this zone.

Today, draft documents are under development to define at the legislative level a special status for a part of the exclusion zone territory, which has high levels of contamination with alpha-emitting plutonium isotopes with large half-life (thousands of years), and in which radiation nuclear facilities are located including radioactive waste disposal facilities, as a zone of special industrial use excluded from the use for habitation of the public for a long-term.

In order to provide radiological protection and safety of present and future generations the following was developed:

- Draft Law of Ukraine "On Amending Certain Laws of Ukraine on Establishing a Special Zone for Industrial Use", which proposes to legislatively define that a certain part of the exclusion zone will not be returned to the public for thousands of years and will be used for the construction and operation of spent fuel and radwaste management facilities, including radwaste disposal facilities;

- Draft Strategy for Overcoming Chernobyl Accident Consequences and Remediation of the Radioactively Contaminated Territories, which envisages both long-term exclusion of parts of the exclusion zone (special industrial use zones) for habitation of the public, development of the infrastructure for spent fuel and radioactive waste management, and development on the exclusion zone territory of certain economic activities (for example, formation of alternative energy facilities) under unconditional meeting the radiation safety standards.

It is planned to develop a procedure for determining the boundaries and size of the special industrial use zone. In general, the boundaries and size of the special industrial use zone should be established on the basis of assessments of total radiation exposure to all existing and planned nuclear radiation facilities, as well as radioactively contaminated areas in this zone on critical groups of the public beyond its borders.

1.2. During further development of the conceptual plans for the exclusion zone, the views of other countries should be taken into account (countries affected by the Chernobyl accident are meant), in particular the Republic of Belarus.

In 2013, in order to ensure possible consultations on the potential transboundary impact of the planned activity and measures to reduce or mitigate its impact, the MENR of Ukraine, in accordance with the procedure established by Article 3 of the Convention on Environmental Impact Assessment in a Transboundary Context (the ESPOO Convention), sent to the countries having a common border with Ukraine (Belarus, Poland, Hungary, Moldova, and Romania), notification of planned activities on design and construction of a storage facility for intermediate storage of high-level waste that would be returned from the Russian Federation after the reprocessing of spent nuclear fuel of Ukrainian NPPs. As of 1 June 2017, consultations are in progress with the Belarusian party.

2. Continuation of safety reassessment of UkrDO *Radon* radwaste management enterprises and improvement measures if needed.

Information on radwaste management, safety reassessment of storages and safety improvement measures for conversion and re-equipment of UkrDO *Radon* SISPs is provided in Subsections B 4.4 and H 2.2 of this Report.

According to the licenses granted, SISPs carried out safety reassessment of radioactive waste storage facilities at SISP sites. Reassessment was carried out both for those storage facilities operated under the technology of temporary container radwaste

storage and for the preserved legacy radwaste facilities, which were operated in the previous period according to the disposal technology. In compliance with the state nuclear and radiation safety review of Safety Review Reports for radwaste storage facilities, each SISP developed long-term action plans for further improvement of the Safety Review Reports and defined deadlines for selected tool activities involving specialized organizations and implementing arrangements.

K.2. Major Challenges Related to Spent Fuel and Radioactive Waste Management in Ukraine and Ways of Their Solution

The key element in the spent fuel and radwaste management system in Ukraine is construction of spent fuel and radwaste management facilities in the exclusion zone to support the final stage in use of nuclear energy – centralized long-term storage and disposal. It also remains relevant to introduce modern technologies for radwaste treatment at the ChNPP site and *Vektor* site (for centralized treatment of minor radwaste generators and radwaste flows).

In view of this and assessment results of radiological situation in the exclusion zone associated with Chernobyl accident consequences, it is important to establish at the legislative level a special status of the special industrial use zone in the exclusion zone for its efficient use in economic and nuclear areas and protection of future generations.

An important element for the development of radwaste management system in compliance with Council Directive 2011/70 Euratom is to ensure development of a geological repository of radwaste disposal.

In this connection, the major challenges for Ukraine related to spent fuel and radwaste management are as follows:

1. Construction of spent fuel and radwaste management facilities in the exclusion zone and on ChNPP site including:

- construction and commissioning of CSFSF;
- construction and commissioning of a storage facility for vitrified HLW resulting from reprocessing of VVER-440 spent fuel to be returned from the Russian Federation;
- design and construction of a radwaste treatment facility at the *Vektor* site;
- design and construction of additional facilities for management of ChNPP radwaste.

2. Legislative recognition of the special status of the industrial zone in the exclusion zone for its efficient use in economic and nuclear areas and protection of future generations.

3. Activation of efforts on establishing a geological repository for radwaste disposal, including:

- determine an operating organization (operator) for a geological repository;
- develop an action plan on establishing a geological repository for radwaste disposal;
- start siting for a geological repository.

K.3. Improvement of Safety in Spent Fuel and Radioactive Waste Management Considering Lessons Learnt from Fukushima-1 Accident

In June 2011, Ukraine joined the European stress-test initiative for NPPs in European Union member states and neighboring countries (Declaration on Stress Tests). The stress tests for Ukrainian NPPs were conducted in accordance with the methodology agreed by the European Commission and ENSREG (13 May 2011, Declaration of ENSREG, Annex 1 “EU Stress-Test Specifications”. The following facilities were subject to stress tests:

– ZNPP units 1-6 (VVER-1000/320) and dry spent fuel storage facility (DSFSF) on the Zaporizhzhya site;

– RNPP units 1, 2 (VVER-440/213) and units 3, 4 (VVER-1000/320);

– SUNPP unit 1 (VVER-1000/302), unit 2 (VVER-1000/338) and unit 3 (VVER-1000/320);

– KhNPP units 1, 2 (VVER-1000/320);

– ChNPP units 1-3 (spent fuel pools) and ChNPP ISF-1.

The National Action Plan upon Stress-Test Results was developed for the operating organizations to implement safety upgrades determined in stress tests, ensure effective SNRIU supervision and implement recommendations of the stress-test peer review for Ukrainian NPP.

To monitor implementation of safety improvement measures identified upon stress tests and peer review results for Ukrainian NPPs, the SNRIU Board held an open meeting on 20 November 2012. Following the Board meeting, additional safety improvement measures related to severe accident management were determined to take into account peer review recommendations.

In order to improve effectiveness of personnel actions in case of accidents at SFPs, emergency procedures and severe accident management guidelines are under development. A spent fuel pool consists of a metallic shell placed in reinforced-concrete enclosing structures to ensure its protection against external events. Personnel actions in case of accidents at SFPs are considered in the development and justification of SFP emergency operating procedures and severe accident management guidelines. Mobile diesel generators for SFP makeup are envisaged under the detailed emergency strategy for long-term station blackout.

Upon stress-test results, additional measures are planned for SFP makeup at VVER-440 and VVER-1000 units from mobile pumps in case of station blackout.

The measure for spent fuel pool makeup and cooling in station blackout was implemented at SUNPP-1 in 2013.

In connection with implementation of second-generation fuel, the SNRIU allowed RNPP-1,2 to use uncompact upper racks in the spent fuel pool for temporary storage of spent fuel based on partial filling of the upper racks and placement of fuel followers.

The criticality analysis of Rivne-1, 2 spent fuel pools with upper removable racks and lower Skoda compacted fuel storage racks confirmed that subcriticality was not ensured without absorbers in case of complete filling of the upper racks.

In order to consider the ENSREG stress-test recommendations and manage large amounts of post-accident radwaste within the National Action Plan upon Stress-Test Results, it is planned to analyze potential volumes of radioactive water, the productivity of the existing evaporation system, the number of drums for evaporation bottoms and storage places (creation of additional reserve if necessary) and assess the adequacy of water activity monitoring means and measures to prevent contamination of groundwater etc. After the analysis and assessment, recommendations and, if necessary, conceptual technical decisions on management of large volumes of radioactive water will be developed.

In the reporting period, calculations were performed to determine specific activity and amount of water resulting from a severe accident, radiation impact on the environment was assessed during a design-basis accident for power units: occurrence of a project accident for power units:

- with VVER-1000/320;
- with VVER-1000/338;
- with VVER-440/213.

Appropriate technical reports were developed and submitted to the SNRIU.

Another part of the activities on analyzing capacity of containers available at NPPs for receiving radioactive water and evaporation bottoms, adequacy of measures to prevent

environment contamination and developing conceptual technical decisions for each NPP will be completed in 2018.

K.4. Measures to Ensure Openness and Transparency of Activities on Compliance with Obligations under the Joint Convention

All NRUs and reports upon IRRS-2008 and IRRS-2010 (follow-up) missions are open for the public at the official SNRIU website www.snrc.gov.ua.

CONCLUSIONS

Since the Joint Convention entered into force on 18 June 2001, Ukraine has become an active participant of all processes and events under the Joint Convention in order to fulfill its tasks. The First, Second, Third, Fourth and Fifth National Reports of Ukraine were presented to the Contracting Parties of the Joint Convention at review meetings. The comments and recommendations of the review meetings serve as a basis for preparing and implementing national plans for the development of nuclear energy and the improvement of spent fuel and radwaste management system. The Report provides factual information to the Contracting Parties of the Joint Convention and to the public of Ukraine on the safety of spent fuel management and on the safety of radioactive waste management and actions taken to protect personnel, the public and the environment against hazardous effects of radiation. The Report highlights the progress and changes since the Fifth Review Meeting and identifies prospects for further development and issues to be resolved.

The Report demonstrates that Ukraine takes all measures to fulfill its obligations under the Joint Convention. This is confirmed by a detailed description of measures identified in the Strategy for Radioactive Waste Management in Ukraine and Energy Strategy and implemented in the framework of national and industrial programs to ensure the safety of spent fuel and radioactive waste management. The strategies, programs and regulatory requirements based on fundamental safety principles are continuously updated and harmonized with EC directives and IAEA standards and incorporate the best international practices.

Ukraine has an effective legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management and a state system for management and regulation of nuclear energy use and radwaste management. The role and independence of the SNRIU as a state competent regulatory body for nuclear and radiation safety are enhanced through legislative status, competence and required resources, compliance with quality procedures for regulatory activity and international technical cooperation.

In the sphere of spent fuel and radwaste management, Ukraine is an active participant of international cooperation under the EC, IAEA, EBRD, G-7 and bilateral cooperation projects.

Section L. ANNEXES

Annex 1. List of Spent Fuel Management Facilities as of 1 July 2017

Facility	Location	Purpose	Status
Spent fuel pool of unit 1 at Zaporizhzhya NPP	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of unit 2 at Zaporizhzhya NPP	,,	,,	In operation
Spent fuel pool of unit 3 at Zaporizhzhya NPP	,,	,,	In operation
Spent fuel pool of unit 4 at Zaporizhzhya NPP	,,	,,	In operation
Spent fuel pool of unit 5 at Zaporizhzhya NPP	,,	,,	In operation
Spent fuel pool of unit 6 at Zaporizhzhya NPP	,,	,,	In operation
Zaporizhzhya DSFSF, Stage 1	,,	Interim storage of spent fuel	In operation since 2001
Zaporizhzhya DSFSF, Stage 2	,,	Interim storage of spent fuel	In operation since 2012
Spent fuel pool of unit 1 at Khmelnitsky NPP	KhNPP 30100, Neteshin Khmelnitsky Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of unit 2 at Khmelnitsky NPP	,,	,,	In operation
Spent fuel pool of unit 1 at Rivne NPP	RNPP 34400, Varash, Rivne Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of unit 2 at Rivne NPP	,,	,,	In operation
Spent fuel pool of unit 3 at Rivne NPP	,,	,,	In operation
Spent fuel pool of unit 4 at Rivne NPP	,,	,,	In operation
Spent fuel pool of unit 1 at South Ukraine NPP	SUNPP 55000, Yuzhnoukrainsk Mykolaiv Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of unit 2 at South Ukraine NPP	,,	,,	In operation

Facility	Location	Purpose	Status
Spent fuel pool of unit 3 at South Ukraine NPP	„	„	In operation
ISF-1 1 at Chornobyl NPP	ChNPP 07100, Slavutych, Kyiv Region	Interim storage of spent fuel	In operation
ISF-2 of Chornobyl NPP	„	Long-term spent fuel storage (to 100 years)	Construction
Spent fuel storage of the research reactor VVR-M, SFP-1	NRI 03680, Kyiv 47 Nauki Avenue	Temporary storage to reduce decay heat	In operation
Spent fuel storage of the research reactor VVR-M, SFP-2	„	„	In operation
Centralized spent fuel storage facility		Interim spent fuel storage	Design completed, pre-design activities in progress

Annex 2. Inventory of Spent Fuel as of 1 July 2017

Material	Location	Number of SFAs	Weight of heavy metal, t
VVER-1000 SFAs	KhNPP Unit 1	433	184.75
VVER-1000 SFAs	KhNPP Unit 2	491	212.56
VVER-440 SFAs	RNPP Unit 1, 2	1217	146.47
VVER-1000 SFAs	RNPP Unit 3	508	212.45
VVER-1000 SFAs	RNPP Unit 4	421	177.79
VVER-1000 SFAs	SUNPP Unit 1	270	117.29
VVER-1000 SFAs	SUNPP Unit 2	252	111.09
VVER-1000 SFAs	SUNPP Unit 3	424	180.82
VVER-1000 SFAs	ZNPP Unit 1	326	141.32
VVER-1000 SFAs	ZNPP Unit 2	305	131.65
VVER-1000 SFAs	ZNPP Unit 3	356	153.82
VVER-1000 SFAs	ZNPP Unit 4	334	144.77
VVER-1000 SFAs	ZNPP Unit 5	363	157.25
VVER-1000 SFAs	ZNPP Unit 6	299	129.25
VVER-1000 SFAs	ZNPP DSFSF	3354	1349.87
RBMK-1000 SFAs	ChNPP ISF-1	21284	2396.111
Research reactor VVR-M SFAs	NRI	0	0
Research reactor IR-100 SFAs	SUNEI	0 *	0

* The amount of nuclear fuel loaded into IR-100 during commissioning is sufficient for its operation until lifetime expiration.

Annex 3. List of Radioactive Waste Management Facilities as of 1 July 2017

3.1. List of Radioactive Waste Management Facilities at Operating NPPs

Facility	Location	Purpose	Design capacity	Year of commissioning
UGU-1-500	ZNPP	Deep evaporation of bottoms	500 dm^3/h	1987
UGU-1-500	ZNPP	Deep evaporation of bottoms	500 dm^3/h	2000
UGU-1-500	KhNPP	Deep evaporation of bottoms	500 dm^3/h	1990
UGU-1-500	RNPP	Deep evaporation of bottoms	500 dm^3/h	2004
UGU-1-500	RNPP	Deep evaporation of bottoms	500 dm^3/h	2007
Incineration facility	KhNPP	Incineration of radioactive oil	5 dm^3/h	1994
Centrifuge	KhNPP	Treatment of floor drains	1-10 m^3/h	2011
Bitumization facility*	RNPP	Bitumization of liquid radwaste	150 dm^3/h	1995
Centrifuge	RNPP	Treatment of floor drains	1.5-7 m^3/h	2004
Incineration facility	ZNPP	Incineration of low-level waste	40 kg/h – solid radwaste 12 kg/h – liquid radwaste	1992
Compaction facility VRN-500	ZNPP	Minimization of low-level solid radwaste	P = 500 kN Volume reduction factor = 4	1991
Compaction facility C-26	SUNPP	Minimization of low-level radwaste	P = 2000 kN Volume reduction factor = 4	1997
Interim unit for liquid radwaste storage in special building 1	ZNPP	Acceptance and storage of liquid radwaste	3800 m^3	1984
Interim unit for liquid radwaste storage in special building 2	ZNPP	Acceptance and storage of liquid radwaste	1000 m^3	1987
Storage of solid radwaste in special building 1	ZNPP	Acceptance and storage of solid radwaste	5910 m^3	1984
Storage of solid radwaste in special building 2	ZNPP	Acceptance and storage of solid radwaste	1906.7 m^3	1989
Storage of solid radwaste in processing building (storage	ZNPP	Acceptance and storage of solid radwaste	11174 m^3	1986

Facility	Location	Purpose	Design capacity	Year of commissioning
unit)				
Storage of liquid radwaste in special building 1	RNPP	Acceptance and storage of liquid radwaste	4590 m^3	1981
Storage of liquid radwaste in special building 2	RNPP	Acceptance and storage of liquid radwaste	3800 m^3	1986
Burial as a part of reactor shop of power units 1 and 2	RNPP	Storage of high-level solid waste	84.2 m^3	1981
Storage of solid radwaste in special building 1	RNPP	Acceptance and storage of solid radwaste	4180 m^3	1981
Storage of solid radwaste in special building 2	RNPP	Acceptance and storage of solid radwaste	6042 m^3	1986
Storage of solid radwaste in storage unit in the building on radwaste processing	RNPP	Acceptance and storage of solid radwaste	7756 m^3	2001
Storage of liquid radwaste (LRSF-1)	KhNPP	Acceptance and storage of liquid radwaste	800 m^3	1987
Storage of liquid radwaste (LRSF-2)	KhNPP	Acceptance and storage of liquid radwaste	2250 m^3	2004
Site “BB-Cube”	KhNPP	Storage of liquid radwaste (containers with salt fusion cake)**	240 m^3	1997
Storage unit of solid radwaste storage facility	KhNPP	Storage of liquid radwaste (containers with salt fusion cake), acceptance and storage of solid radwaste	7183 m^3	2002
Storage of solid radwaste in special building	KhNPP	Acceptance and storage of solid radwaste	6368.1 m^3	1987
Storage of liquid radwaste No. 1	SUNPP	Acceptance and storage of liquid radwaste	2121 m^3	1982
Storage of liquid radwaste No. 2	SUNPP	Acceptance and storage of liquid radwaste	1969 m^3	1987
Storage of liquid radwaste No. 3	SUNPP	Acceptance and storage of liquid radwaste	760 m^3	1989
Storage of low-level waste	SUNPP	Acceptance and storage of solid radwaste	12000 m^3	1982
Storage of solid	SUNPP	Acceptance and storage	1250 m^3	1982

Facility	Location	Purpose	Design capacity	Year of commissioning
radwaste No. 1		of solid radwaste		
Storage of solid radwaste No. 2	SUNPP	Acceptance and storage of solid radwaste	3053 m^3	1989
Storage of solid radwaste No. 3	SUNPP	Acceptance and storage of solid radwaste	10811 m^3	2002

* preserved in 2002

** operated until 2016, now containers with salt fusion cake moved to LSRSF

3.2. List of Radioactive Waste Management Facilities at Chornobyl NPP

Facility	Location	Purpose	Year of commissioning
Solid radwaste storage facility	ChNPP site	Temporary storage of solid radwaste in operation and decommissioning of power units	1978 Acceptance of high-level solid radwaste terminated on 9 May 2003
Liquid radwaste storage facility	ChNPP site	Temporary storage of liquid radwaste in operation and decommissioning of power units	1977
Liquid and solid radwaste storage facility	ChNPP site	Temporary storage of liquid radwaste in operation and decommissioning of power units	1981 Storage compartments for solid radwaste were not operated. Within ICSRM project, compartments for solid radwaste were upgraded and temporary storage for high-level waste and low- and intermediate-level long-lived waste was created
Temporary storage facility for high-level and low- and intermediate-level long-lived waste	ChNPP site	Temporary storage of packages with high-level waste and low- and intermediate-level long-lived waste to be transferred from SRTP	2010 LSRSF at upper elevations within ICSRM project
Temporary storage facility for solid high-level waste	ChNPP site	Temporary storage of solid high-level waste	2004
Temporary storage for spent radioactive oil	ChNPP site	Temporary storage of spent radioactive oil	1999

Facility	Location	Purpose	Year of commissioning
Temporary storage for oil-fuel mixture in diesel station of first stage	ChNPP site	Temporary storage of oil-fuel mixture	2012 Arranged in the diesel station of ChNPP stage I (1AMB-1, 1ATB-1 tanks)
Liquid radwaste treatment plant	ChNPP site	Management of liquid radwaste accumulated during ChNPP operation and radwaste to be generated during ChNPP decommissioning and SIP	Commissioning in 2018
Solid radwaste retrieval facility Solid radwaste treatment plant within ICSRM	ChNPP site	Management of solid radwaste accumulated during ChNPP operation and radwaste to be generated during ChNPP decommissioning and implementation of SIP	Commissioning in 2018

3.3. List of Radioactive Waste Management Facilities in the Exclusion Zone

Facility	Enterprise/ location	Purpose	Design capacity (for radwaste storages)	Year of commissioning	Status
ENSDF	CRME/ *Vektor*	Disposal of SRW packages	50,210 m^3	2009	Operation
RWDS *Buryakivka*	CRME/ Exclusion Zone	SRW disposal	690,000 m^3	1987	Operation
RWDS *Pidlisny*	CRME/ Exclusion Zone	Storage of accident radwaste	*	1986	Stabilized, monitoring, maintenance
RWDS *ChNPP Stage III*	CRME/ Exclusion Zone	Storage of accident radwaste	*	1986	Stabilization, monitoring, maintenance

RICS	CRME/ Exclusion Zone	Storage of accident radwaste	*	1986-1987	Survey, monitoring, maintenance
Decontamination facility	CRME/ Exclusion Zone Leliv	Decontamination of radwaste, vehicles		1987	Operation
Station for decontamination of individual protection means and overalls	CRME/ Exclusion Zone Prypiat	Decontamination of individual protection means and overalls		1986	Operation
Decontamination facility No. 1	Chornobyl Specialized Plant/ Exclusion Zone	Radwaste decontamination		1987	Preserved in 2012
Decontamination facility No. 2 (Dibrova)	Chornobyl Specialized Plant/ Exclusion Zone	Radwaste decontamination		1987	Preserved in 2007
Vektor Stage I, SRW-1, SRW-2	CCMEZ/ *Vektor*	SRW disposal	19,200 m^3	2015	Construction
CLTSF	*Vektor*	Processing and storage of disused radiation sources	500,000 pcs.	2015	Hot tests
Experimental facility for incineration of radioactive contaminated wood (incinerator)	CRME/Exclusion Zone	Radwaste processing		2015	Trial operation

* design documentation is missing.

3.4 List of Radioactive Waste Management Facilities at UkrDO *Radon* SISP

Enterprise/ Location	Basic activity	Design capacity	Year of commissioning	Name	State
Dnipropetrovsk SISP 23-km Dnipropetrovsk–Zaporizhzhya highway	Transport, processing, storage of radwaste	SRW (near-surface underground tanks) – 450.0 m^3	1962	SRW 1	Preserved
			1982	SRW 2	In operation, radwaste is not accepted
			1963	BRW 5	
		SRW – 1300.0 m^3	2014	SRW 6	In operation (container

		SRW – 700 m^3	2005	Hangar covering above SRW 2	storage)
		DRS storage facility – 50 kg-eqv. Ra	1979	DRS 3	In operation, radwaste is not accepted
		LRW – 200.0 m^3	1965	LRW 4	In operation, radwaste is not accepted
Kyiv SISP Kyiv 1 Komunalna St.	Transport, processing, storage of radwaste	SRW (near-surface underground tanks) – 1800.0 m^3	1985	SRW 5-6	In operation, radwaste is not accepted
			1975	SRW 7	
			1971	SRW 8	Preserved
			1967	SRW 9-10	
		Hangars with containers – 334.0 m^3	1995	Hangar storage 2, section 11	In operation (container storage)
		Container – 10.5 m^3	2000	Container storage 18	Radwaste is not accepted
		DRS – 120 kg-eqv. Ra	1985	DRS 1-5	In operation, radwaste is not accepted
			1978	DRS 6	
		LRW – 800.0 m^3	1968	LRW 12-13	In operation, radwaste is not accepted
			1968	LRW 14	In operation
			2014	LRW 3	In operation
	Monitoring of SSR in the Kyiv, Zhytomyr and Chernihiv regions	SRW – 36090.0 m^3*	1987-1995 (mitigation of ChNPP accident)		Monitoring and maintenance
Lviv SISP Yavoriv District Lviv Region	Transport, processing, storage of radwaste	SRW (near-surface underground tanks) – 1140.0 m^3	1963	SRW 1	Preserved
			1989	SRW 2-8 (under hangar covering)	In operation (container storage)
			1989	BRW	In operation
		LRW – 200.0 m^3	1962	LRW	Not operated, empty
		DRS – 80 kg-eqv. Ra	1978 1989	DRS DRS 1	In operation, radwaste is not accepted
			2005	DRS 2	
Odessa SISP 75-km Odessa–Kyiv highway	Transport, processing, storage of radwaste	SRW (near-surface underground tanks) – 583.0 m^3	1962	SRW 1-6	Preserved
				SRW 7-11 (under hangar covering)	In operation

		LRW – 400.0 m^3	1963	LRW 1	In operation, radwaste is not accepted
				LRW 2	Not operated, empty
		DRS – 50 kg-eqv. Ra	1968	DRS 13	In operation, radwaste is not accepted
		SRW (containers) - 687 m^3	2001	Containers 14, 14a, 14b, sections 17, 22 (under hangar covering)	In operation
		DRS "RITEG"	2002	DRS "Riteg" 15	In operation, radwaste is not accepted
Kharkiv SISP Derhachiv District Kharkiv Region	Transport, processing, storage of radwaste	SRW (near-surface underground tanks) – 2275.7 m^3	1962	SRW 1-13 (under hangar covering)	In operation (container storage)
			1991	SRW 18-20	Preserved
		LRW – 1000.0 m^3;	1962	LRW 21	In operation
				LRW 22-25	Redundant
		DRS – 60 kg-eqv. Ra	1990	DRS 15, 16, 17	In operation, radwaste is not accepted
		Tubing storage – 812 m^3	1998	NKT 30	In operation, radwaste is not accepted
		Facility 'Packet'	2011	SRW 14	In operation
		Experimental decontamination of tubing	2013	Experimental section for decontamination of tubing	Experimental work

Notes: * design capacity is indicated for facilities in the Chernihiv Region and is absent for other facilities;

** design documentation is missing.

Annex 4. Inventory of Radioactive Waste as of 1 July 2017

4.1. Information on Radioactive Waste in Storage at Sites of Operating NPPs

Material	Location	Volume, m^3	Activity, Bq	Main radionuclides
Filtering materials	KhNPP	180.8	1.10E+05[1]	^{134}Cs, ^{137}Cs, ^{60}Co[1]
Evaporation bottoms	KhNPP	352.4	4.73E+06[2]	^{134}Cs, ^{137}Cs, ^{60}Co[2]
Dehydrated sludge	KhNPP	50.0	8.28E+04	^{134}Cs, ^{137}Cs, ^{60}Co, ^{54}Mn
Salt fusion cake	KhNPP	1090.4	3.54E+07	^{134}Cs, ^{137}Cs, ^{60}Co
Low-level solid radwaste	KhNPP	5371.5	-[3]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{110m}Ag
Intermediate-level solid radwaste	KhNPP	129.83	-[3]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{110m}Ag
High-level solid radwaste	KhNPP	10.37	-[3]	-[3]
Filtering materials	ZNPP	350(342.9)[5]	1.29E+07[1]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag[1]
Evaporation bottoms	ZNPP	2819	4.84E+06[2]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag [2]
Salt fusion cake	ZNPP	4840.4	6.76E+07	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag
Low-level solid radwaste	ZNPP	8275.1	2.48E+06[4]	^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
Intermediate-level solid radwaste	ZNPP	872.7	9.27E+05[4]	^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
High-level solid radwaste	ZNPP	99.44	-[3]	-[3]
Filtering materials	SUNPP	427	7.60E+04[1]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn[1]
Evaporation bottoms	SUNPP	2763	1.04E+08[2]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn[2]
Low-level solid radwaste	SUNPP	17070.6	-[3]	^{58}Co,^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn, ^{110m}Ag
Intermediate-level solid radwaste	SUNPP	617	-[3]	^{34}Cs, ^{137}Cs, ^{60}Co
High-level solid radwaste	SUNPP	16.35	-[3]	-[3]
Filtering materials	RNPP	576.1	8.08E+05[1]	^{134}Cs, ^{136}Cs, ^{137}Cs, ^{60}Co, ^{110m}Ag, ^{54}Mn [1]
Evaporation bottoms	RNPP	3120	1.78E+07[2]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{54}Mn [2]
Salt fusion cake	RNPP	2467	1.97E+08	^{134}Cs, ^{137}Cs, ^{60}Co
Dehydrated sludge	RNPP	18.4	4.23E+05	^{134}Cs, ^{137}Cs, ^{58}Co, ^{60}Co, ^{54}Mn, ^{110m}Ag
Bituminous compound	RNPP	147.8	1.46E+07	^{134}Cs, ^{137}Cs, ^{60} Co
Low-level solid radwaste	RNPP	7607.1	-[3]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co,^{54}Mn, ^{110m}Ag
Intermediate-level solid radwaste	RNPP	379.7	-[3]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{110m}Ag
High-level solid radwaste	RNPP	91.4	-[3]	-[3]

[1] - average total activity and radionuclide composition of surface samples taken from tanks with spent filtering materials

[2] - average total activity and radionuclide composition of evaporation bottoms

[3] - specific activity and radionuclide composition of solid radwaste accumulated in storage facilities since the beginning of power unit operation will be determined in solid radwaste retrieval and solid radwaste total activity will be evaluated
[4] - tentative data obtained by calculation
[5] – amount of the solid phase shown in brackets (for filtering materials)

4.2. Information on Radioactive Waste in Storage at Chornobyl NPP Site

Radwaste material	Location	Volume, m^3	Mass, t	Activity, Bq	Main radionuclides
Low-level solid radwaste	SRSF	1069.00	-	1.1E+11	Mixture of nuclides*: Cs, Sr, Co, Pu, Am
Intermediate-level solid radwaste	SRSF	926.50	-	4.11E+12	-//-
High-level solid radwaste	SRSF	506.93	-	1.2816E+14	-//-
High-level solid radwaste	Temporary storage for HLW and low- and intermediate -level long-lived waste-	1.815	0.68	2.98E+10	^{137}Cs; ^{241}Am; ^{154}Eu; ^{94}Nb
High-level solid radwaste	Temporary storage for solid high-level waste	10.716	-	7.18E+12	^{137}Cs, ^{134}Cs, ^{60}Co, ^{152}Eu, ^{154}Eu, ^{94}Nb, ^{241}Am, ^{90}Sr, ^{241}Pu, ^{63}Ni, $^{238\text{-}240}$Pu
Low- and intermediate-level long-lived waste		0.33	0.211	2.78E+10	^{137}Cs, ^{60}Co, ^{154}Eu
Evaporation bottoms	LRSF	9685.20	-	2.73E+14	^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr
Ion-exchange resins	LRSF	2845.67	-	1.71E+12	^{137}Cs, ^{60}Co, ^{90}Sr , ^{238}Pu, ^{239,240}Pu, ^{241}Am
Pulp	LRSF	1628.83	-	2.92E+12	^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am
Evaporation bottoms	LSRSF	3892.00	-	1.08E+14	^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr
Ion-exchange resins	LSRSF	1263.80	-	5.62E+11	^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am
Pulp	LSRSF	667.05	-	9.52E+11	^{137}Cs, ^{134}Cs, ^{60}Co, ^{90}Sr, ^{241}Am
Spent radioactive oil	Temporary storage	104.80	-	1.44E+07	^{137}Cs
Oil-fuel mixture	Temporary storage for oil-fuel mixture	40.514	-	1.19E+07	^{137}Cs

* - nuclide composition of radwaste during facility loading was not determined because respective tools and guidelines were missing

4.3. Information on Radioactive Waste in Storage at Sites of Research Reactors

NRI					
Material	**Location**	**Volume, m^3**	**Mass, t**	**Specific activity,** Bq/L (Bq/kg)	**Main radionuclides**
Intermediate-level solid radwaste	Storages 8, 9, 10, 11, 12	- *	7.168	$1.71x10^6$	^{137}Cs, ^{60}Co
Low-level liquid radwaste	Sewer tanks 1	163.7	- *	$3.18x10^4$	^{137}Cs, ^{60}Co
	Sewer tanks 2	253.58	- *	$9.18x10^4$	^{137}Cs, ^{60}Co
	Sewer tanks 3	20.4	- *	$1.44x10^2$	^{137}Cs, ^{60}Co

* - activity and radionuclide composition are not determined because appropriate guidelines and/or equipment are missing

4.4 Information on Radioactive Waste Disposed of at CRME

Waste state	**Waste category**	**Facility**	**Mass , t**	**Volume m^3 (pcs.)**	**Activity, Bq**	**Main nuclides**
Solid radwaste	Low- and intermediate-level	RWDS *Buryakivka*	1404671	689 700 **1)**	2.54E+15	Mixture of nuclides Cs, Sr, Eu, Pu, Am
Solid radwaste	High-level, long-lived	RWDS *Pidlisny*	7920 **2)**	3960 **2)**	2.59E+15	137Cs,90Sr, 134Cs, 154Eu, 155Eu, 238Pu, 239,240Pu, 241Pu, 241Am
Solid radwaste	Low- and intermediate-level, long-lived	RWDS *ChNPP Stage III*	41900	26200	3.40E+14	137Cs, 90Sr, 238Pu, 239,240Pu, 241Pu, 241Am
Radwaste packages	Low-level solid waste	ENSDF	164	100.7	1.73E+11	90Sr, 137Cs, 135Cs, 134Cs, 235U, 236U, 238U, 237Np, 241Pu , 241Am, 242Am
Solid radwaste	DRS	CLTSF *Vektor*	40	1634 pcs.	1.56E+13	Cs, Co, Am, Ra

Notes: 1) Volume is indicated as of 1 January 2017. The final data will be determined after closure and preservation of last trench 21 based on geodesic measurements.

2) Amount of high-level waste is indicted. However, according to inventory of 1989 and taking into account materials used to stabilize radwaste in RWDS *Pidlisny* modules (liquid concrete, sand-gravel mixture), which have induced activity and are also radwaste, the total amount of waste in modules is 22.0 thousand ton and 11.0 thousand m^3, respectively.

4.5 Information on Chornobyl-Origin Radioactive Waste Stored at CRME

Waste state	Waste category	Location	Mass, t	Volume, m^3	Activity, Bq
Solid radwaste	Low- and intermediate-level	RICS *Nova Budbaza*	29960	21950	6.61E+12
		RICS *Stara Budbaza*	62550	40150	3.52E+13
		RICS *Naftobaza*	180600	95430	2.96E+13
		RICS *Pischane Plato*	91534	57288	5.19E+12
		RICS *Yaniv Station*	15000	30000	3.70E+13
		RICS *Rudyy Lis*	250000	500000	3.74E+14
		RICS *Prypiat*	11000	16000	2.59E+13
		RICS *Kopachi*	90000	110000	3.33E+13
		RICS *Chystohalivka*	150000	874	6.95E+10
Total:			956154	871692	1.99E+15

4.6. Information on Radioactive Waste and Disused Radiation Sources in Storage at UkrDO *Radon* SISPs

4.6.1. Information on Radioactive Waste Stored at UkrDO Radon SISPs

Waste material	Location	Volume*, m^3	Mass*, t	Activity**, Bq	Main radionuclides
Low- and intermediate-level solid radwaste	Kyiv SISP	2105.0	2493.3	2.92E+15	Cs-137, Ra-226, C-14, H-3,Th-232
	Dnipropetrovsk SISP	591.5	935.5	5.95E+11	Cs-137, Pu-239, Ra-226, U-238+U-235
	Odessa SISP	525.6	343.8	1.66E+13	Cs-137, Kr-85, Ra-226, U-238+U-235
	Lviv SISP	698.2	730.6***	5.69E+12	C-14, H-3, U-238+U-235
	Kharkiv SISP	2122.6	091.7	5.93E+12	H-3, Cs-137, Tc-99, Ra-226
Low- and intermediate-level liquid radwaste	Kyiv SISP	480	-	1.09E+13	H-3, C-14
	Dnipropetrovsk SISP	124	-	1.38E+10	H-3, Cs-137
	Odessa SISP	183	-	1.10E+11	C-14, H-3, Cs-137
	Kharkiv SISP	2	-	7.96E+06	Cs-137

Tubing contaminated by technology-enhanced naturally-occurring sources	Kharkiv SISP	812	780.2	2.72E+08	Ra-226

Notes:

* - mass and volume of solid radwaste take into account shielding of spent sources

** - activity takes into account decay of radionuclides

*** - mass of solid radwaste takes into account material used for layer-by-layer cementation of facilities

4.6.2. Information on Disused Radiation Sources Stored at UkrDO *Radon* SISPs

Waste material	Location	Number, pcs.	Activity**, Bq	Main radionuclides
Disused sealed radiation sources placed in well-type storages	Kyiv SISP	6611	1.39E+14	Cs-137, Co-60, Pu-239
	Dnipropetrovsk SISP	8391	1.02E+14	Cs-137, Am-241, Co-60,
	Odessa SISP	19312	5.49E+13	Cs-137, Pu-239, Co-60
	Lviv SISP	8151	3.84E+13	Cs-137, Co-60, Sr90+Y90
	Kharkiv SISP	15348	8.09E+13	Cs-137, Co-60, Am-241
Disused sealed radiation sources in shielding	Kyiv SISP	114053	1.44E+15	H-3, Cs-137, Co-60, Pu-239
	Dnipropetrovsk SISP	212376	7.07E+14	Am-241, Cs-137, Co-60, Sr90+Y90
	Odessa SISP	38485	5.72E+14	Cs-137, Sr90+Y90
	Lviv SISP	96765	2.36E+14	Cs-137, H-3, Am-241
	Kharkiv SISP	93719	2.41E+14	H-3, Cs-137, Co-60
Disused sealed high-power radiation sources (RITEG)	Odessa SISP	15	1.97E+16	Sr90+Y90

Annex 5. List of ChNPP Nuclear Facilities in Decommissioning

Facility	Power unit	Location	Reactor type	Date of shutdown
Nuclear facility	No. 1	ChNPP	RBMK-1000 (modified RBM-K2)	30.11.1996
Nuclear facility	No. 2	ChNPP	RBMK-1000 (modified RBM-K2)	11.10.1991
Nuclear facility	No. 3	ChNPP	RBMK-1000 (modified RBM-K7)	15.12.2000

Annex 6. Ukrainian Regulations on Nuclear and Radiation Safety Adopted in the Reporting Period

LAWS OF UKRAINE

1. Law of Ukraine No. 2059-VIII dated 23 May 2017 "On Environmental Impact Assessment".

2. Law of Ukraine No. 2125-VIII "On Amendments to the Budget Code of Ukraine on Improving Mechanism for Financing of Radioactive Waste Management Activities" (will come into force on 01 January 2018).

3. Law of Ukraine No. 2124-19 dated 11 July 2017 "On Amendments to Article of the Law of Ukraine "On Radioactive Waste Management" on Improving Mechanism for Financing of Radioactive Waste Management" (will come into force on 01 January 2018).

RESOLUTIONS AND ORDINANCES OF THE CABINET OF MINISTERS OF UKRAINE

1. On Approval of the Procedure for Transfer of Spent Nuclear Fuel of Ukrainian Nuclear Power Plants and Radioactive Waste Resulted from its Processing across the Border No. 772 dated 27 September 2016;

2. On Functioning of the Territorial Bodies of the State Nuclear Regulatory Inspectorate of Ukraine No. 358 dated 08 June 2016;

3. On Approval of the Provision on the State Nuclear Regulatory Inspectorate of Ukraine No. 363 dated 20 August 2014;

4. Resolution No. 380-r of the Cabinet of Ministers of Ukraine dated 07 June 2017 "On Approval of the Project on Construction of the Centralized Storage Facility for Spent Nuclear Fuel of VVER of National Nuclear Power Plants".

REGULATIONS

1. On Approval of General Safety Provisions in Predisposal Radioactive Waste Management, SNRIU Order No. 279 dated 01 August 2017 registered in the Ministry of Justice of Ukraine under No. 1045/30913 on 22 August 2017;

2. On Approval of General Radiation Safety Rules on Using Radiation Sources in Medicine, SNRIU Order No. 51/151 dated 16 February 2017 registered in the Ministry of Justice of Ukraine under No. 636/30504 on 18 May 2017;

3. On Improving Regulations on NPP Ageing Management, SNRIU Order No. 136 dated 13 April 2017 registered in the Ministry of Justice of Ukraine under No. 578/30446 on 05 May 2017;

4. On Approval of Requirements for Institutional Control of Uranium Mining Sites within Limited Clearance from Regulatory Control, SNRIU Order No. 60 dated 21 February 2017 registered in the Ministry of Justice of Ukraine under No. 353/30221 on 15 March 2017;

5. On Amendments to Requirements for Internal and External NPP Emergency Centers, SNRIU Order No. 201 dated 09 December 2016 registered in the Ministry of Justice of Ukraine under No. 1725/29855 on 28 December 2016;

6. On Approval of Requirements for Seismic Design and Seismic Safety Assessment of Nuclear Power Plants, SNRIU Order No. 175 dated 17 October 2016 registered in the Ministry of Justice of Ukraine under No. 1449/29579 on 07 November 2016;

7. On Approval of the Procedure on Arrangement of Information Interaction of the State Emergency Service of Ukraine and the State Nuclear Regulatory Inspectorate of Ukraine on Prevention and Response to Emergencies, Order No. 724/110 of the Ministry of Internal Affairs of Ukraine and SNRIU dated 27 July 2016 registered in the Ministry of Justice of Ukraine under No. 1175/29305 on 23 August 2016;

8. On Amendments to Requirements for NPP Safety Assessment, SNRIU Order No. 15 dated 11 February 2016 registered in the Ministry of Justice of Ukraine under No. 303/28433 on 29 February 2016;

9. On Approval of Requirements for the Systems of Nuclear Fuel Emergency Cooling and Heat Removal to the Ultimate Heat Sink, SNRIU Order No. 233 dated 24 December 2015 registered in the Ministry of Justice of Ukraine under No. 77/28207 on 16 January 2016;

10. On Approval of Requirements for Power Supply Systems Important to Safety of Nuclear Power Plants, SNRIU Order No. 234 dated 24 December 2015 registered in the Ministry of Justice of Ukraine under No. 78/28208 on 16 January 2016;

11. On Amendments to Requirements for Determining the Size and Borders of NPP Observation Zone, Order No. 206/765 of the SNRIU and the Ministry of Health of Ukraine dated 23 November 2015 registered in the Ministry of Justice of Ukraine under No. 1567/28012 on 15 December 2015;

12. On Approval of Nuclear and Radiation Safety Requirements for Instrumentation and Control Systems Important to NPP Safety, SNRIU Order No. 140 dated 22 July 2015 registered in the Ministry of Justice of Ukraine under No. 954/27399 on 06 August 2015;

13. On Approval of Safety Conditions and Requirements (Licensing Conditions) for Conducting Activities on Uranium Ore Processing, SNRIU Order No. 101 dated 27 May 2015 registered in the Ministry of Justice of Ukraine under No. 700/27145 on 12 June 2015;

14. On Approval of Access Control Rules of the State Nuclear Regulatory Inspectorate of Ukraine No. 93 dated 20 May 2015 registered in the Ministry of Justice of Ukraine under No. 668/27113 on 05 June 2015;

15. On Approval of Amendments to Requirements for the Operating Organization Activity Management System, SNRIU Order No. 90 dated 14 May 2015 registered in the Ministry of Justice of Ukraine under No. 781/27226 on 03 July 2015;

16. On Approval of Registration Card Forms for Radiation Sources, Order No. 69 dated 16 April 2015, registered in the Ministry of Justice of Ukraine under No. 716/27161 on 18 June 2015;

17. On Approval of the Procedure on the List of Documents to be Submitted by the Operating Organization for Obtaining a License to Conduct Activities on a Certain Lifecycle Stage of a Nuclear Facility, SNRIU Order No. 12 dated 28 January 2015 registered in the Ministry of Justice of Ukraine under No. 152/265972 on 12 February 2015;

18. On Approval of the Procedure for Training and Checking Knowledge of Personnel and Nuclear Entity Officials of Radiation Safety Issues, SNRIU Order No. 143 dated 02 October 2014 registered in the Ministry of Justice of Ukraine under No. 1549/26326 on 02 December 2014;

19. On Approval of the Procedure for Using the State Register of Radiation Sources, Order No. 70 dated 16 April 2015 registered in the Ministry of Justice of Ukraine under No. 717/27162 on 18 June 2015;

20. On Approval of Safety Conditions and Requirements (Licensing Conditions) for Conducting Activities on Radiation Source Production, SNRIU Order No. 148 dated 13 August 2015 registered in the Ministry of Justice of Ukraine under No. 1054/27499 on 03 September 2015;

21. On Amendments to Safety Conditions and Requirements (Licensing Conditions) for Conducting Activities on Radioactive Waste Management, SNRIU Order No. 118 dated 20 August 2014 registered in the Ministry of Justice of Ukraine under No. 1102/25879 on 09 September 2014.

Annex 7. National and International Safety Reports for the Reporting Period

1. National Report of Ukraine on Compliance with the Obligations of the Convention on Nuclear Safety (2016).

3. National Report "THIRTY YEARS AFTER THE CHORNOBYL CATASTROPHE: RADIOLOGICAL AND MEDICAL CONSEQUENCES" (2016).

4. National Report on Technology-Related and Natural Safety in Ukraine in 2014.

5. National Report on Technology-Related and Natural Safety in Ukraine in 2015.

6. National Report on Technology-Related and Natural Safety in Ukraine in 2016.

7. Annual Report on Nuclear and Radiation Safety in Ukraine for 2014.

8. Annual Report on Nuclear and Radiation Safety in Ukraine for 2015.

9. Annual Report on Nuclear and Radiation Safety in Ukraine for 2016.

Annex 8. Radiation Protection of Personnel and the Public

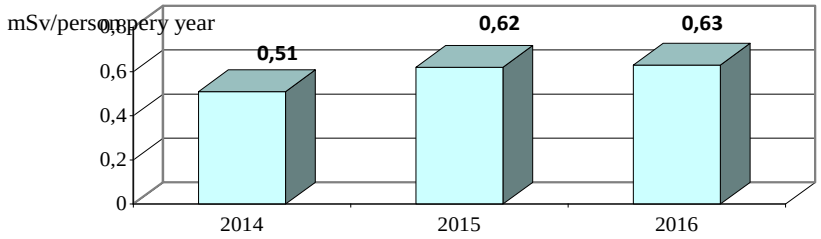


Figure L.8.1 – Average Annual Individual Doses for Personnel of *Energoatom* NPPs (mSv/person per year)

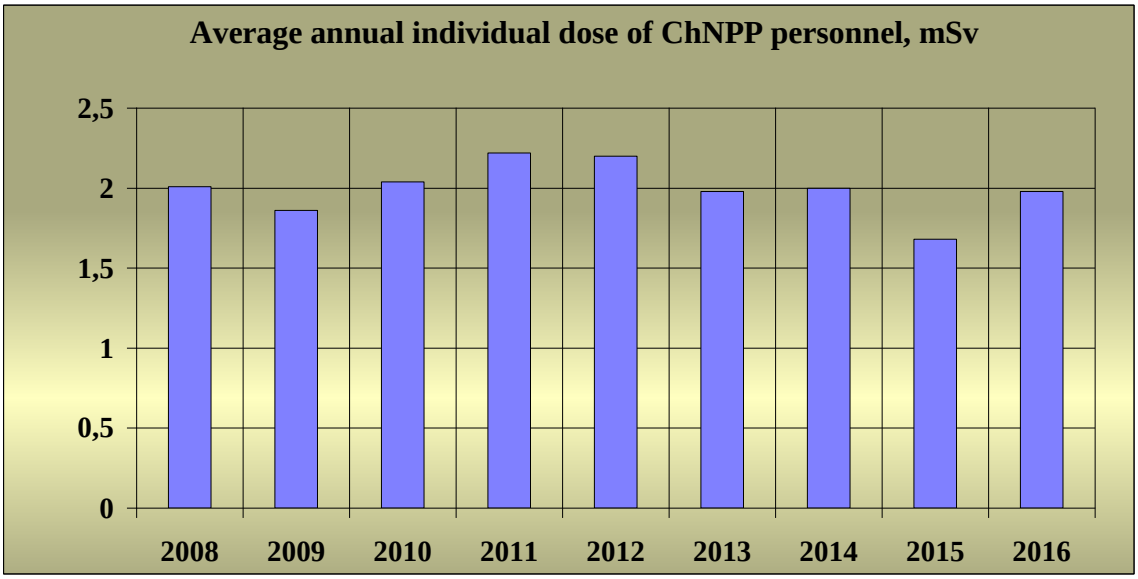


Figure L.8.2 – Average Annual Individual Doses for ChNPP Personnel (mSv/person per year)

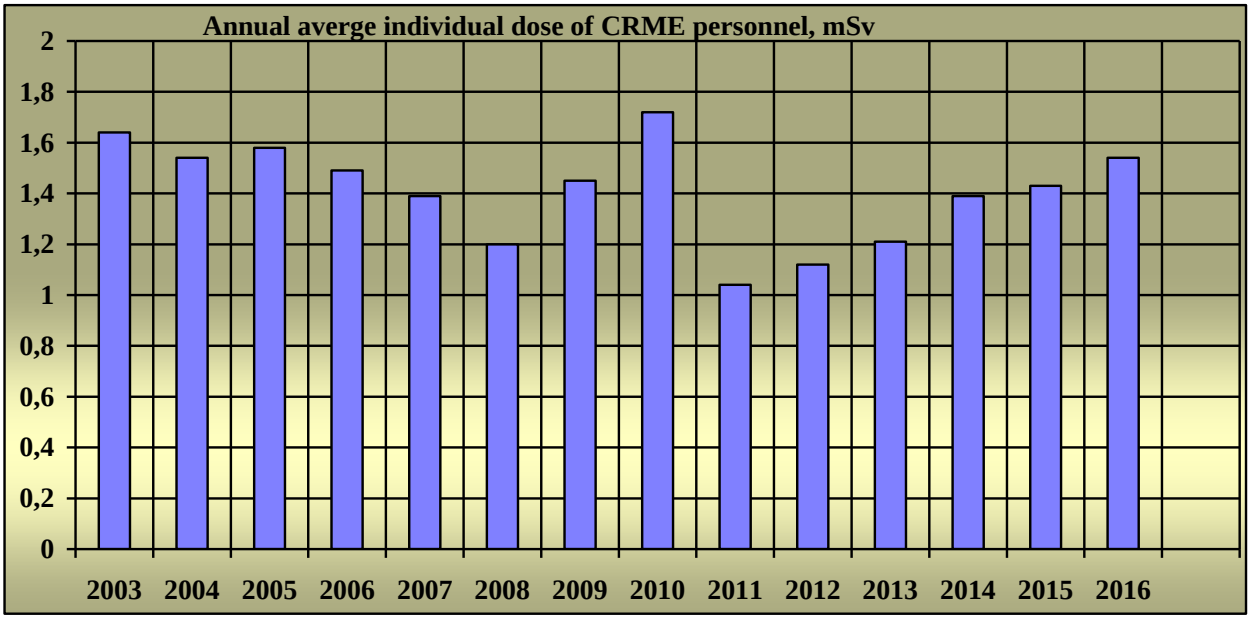


Figure L.8.3 – Average Annual Individual Doses for CRME Personnel

(mSv/person per year)

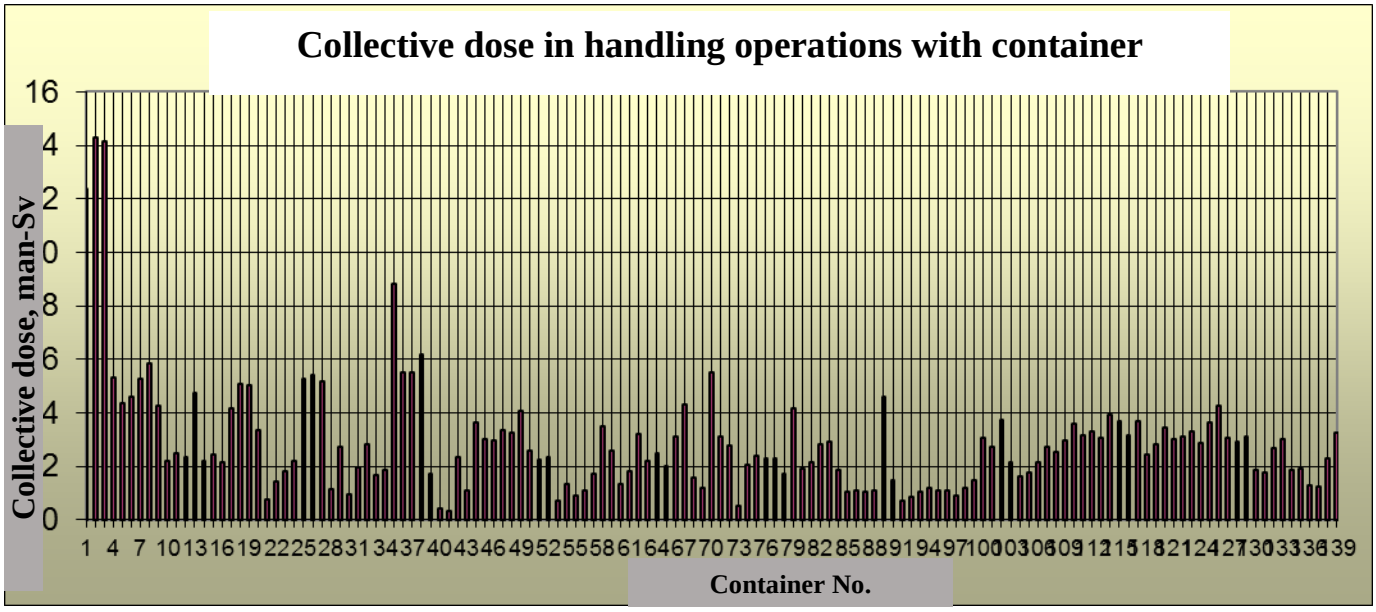


Figure L.8.4 – Collective Dose for Zaporizhzhya NPP Personnel in All Handling Operations with Containers for Spent Fuel Storage

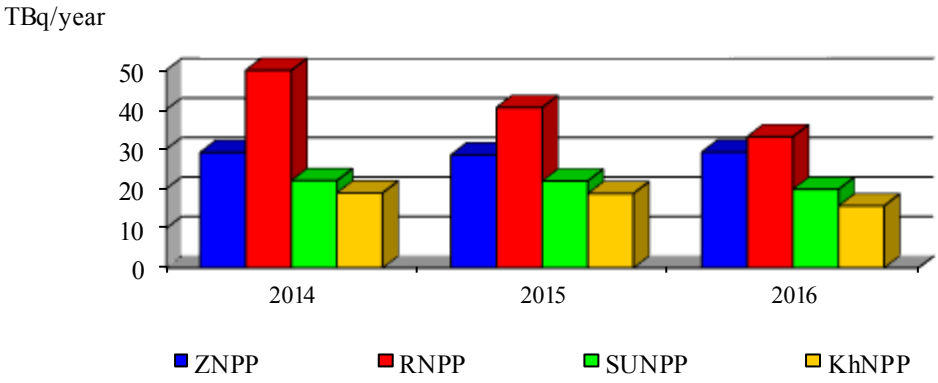


Figure L.8.5 – Releases of Inert Radioactive Gases from Ukrainian NPPs

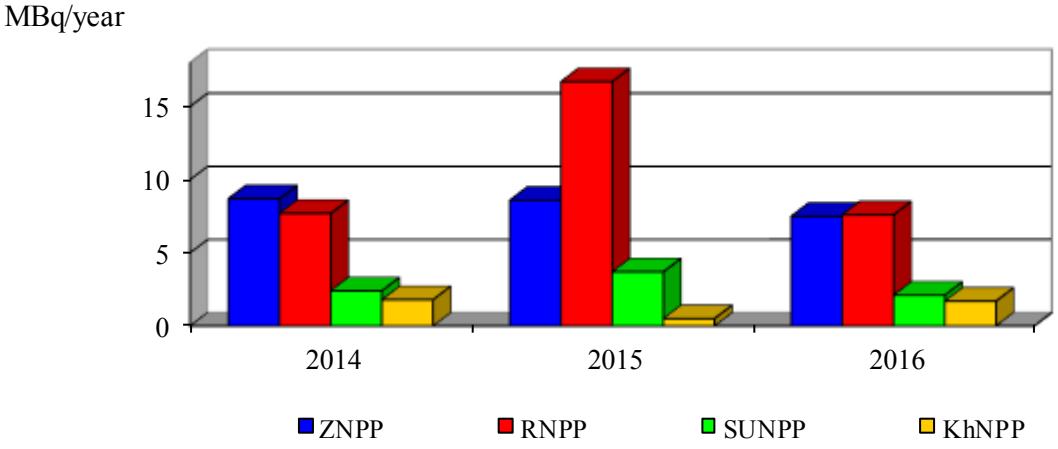


Figure L.8.6 – Releases of Long-Lived Radionuclides from Ukrainian NPPs

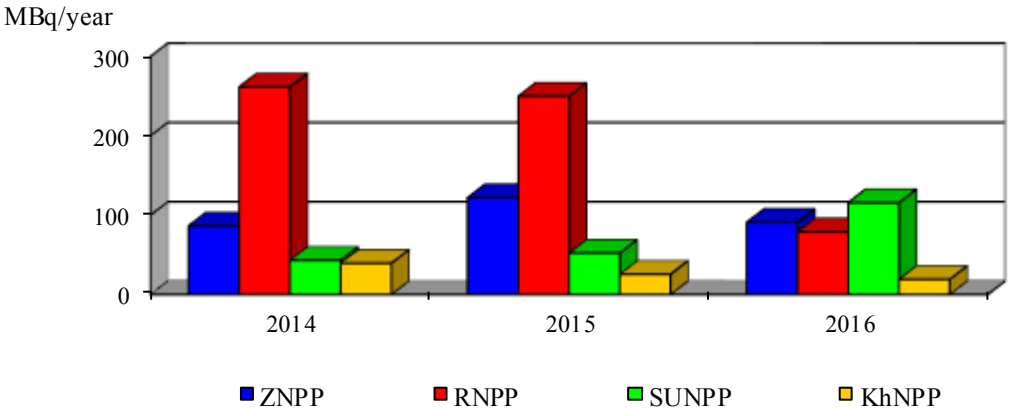


Figure L.8.7 – Releases of Radioactive Iodine from Ukrainian NPPs

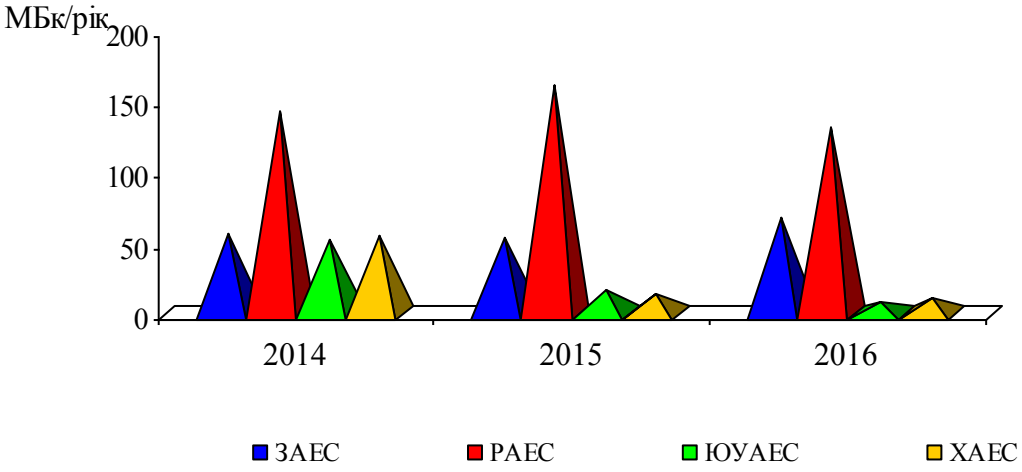


Figure L.8.8 – Releases of Cs-137 from Ukrainian NPPs

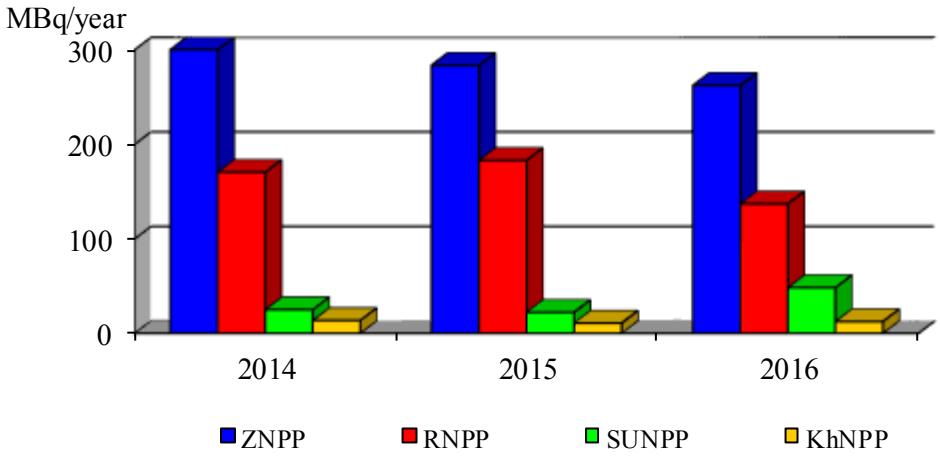


Figure L.8.9 – Releases of Cs-137 from Ukrainian NPPs

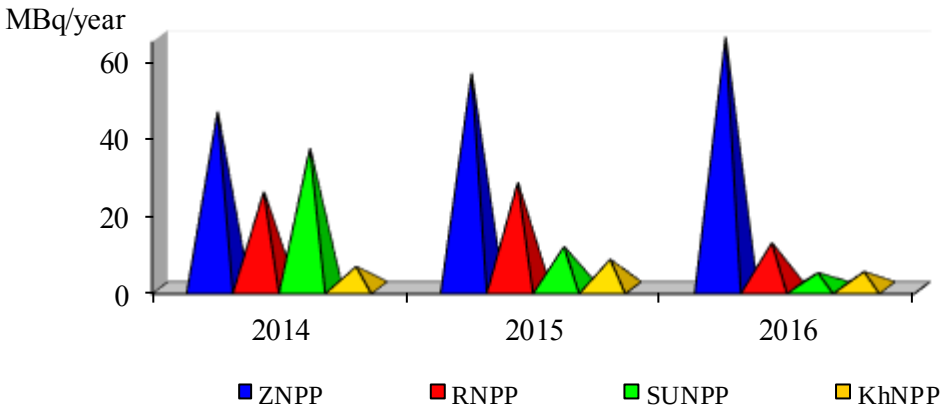


Figure L.8.10 – Releases of Cs-134 from Ukrainian NPPs

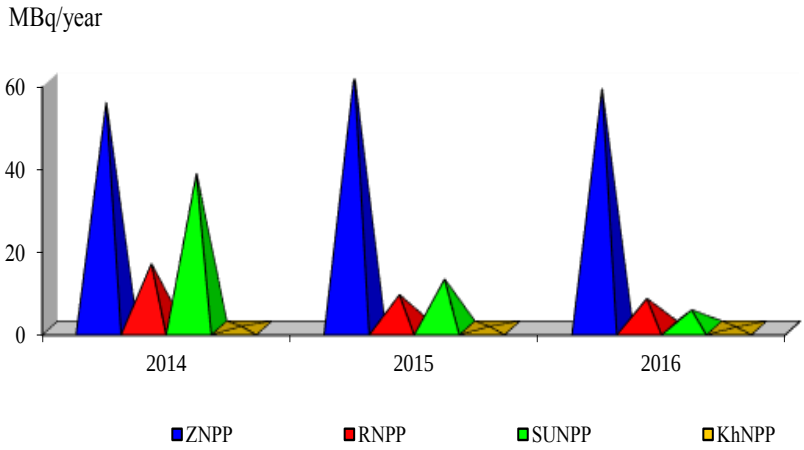


Figure L.8.11 – Releases of Co-60 from Ukrainian NPPs

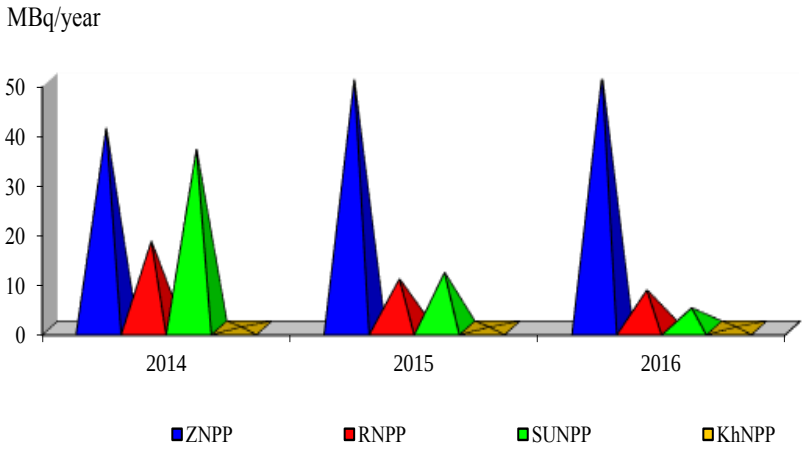


Figure L.8.12 – Releases of Mn-54 from Ukrainian NPPs

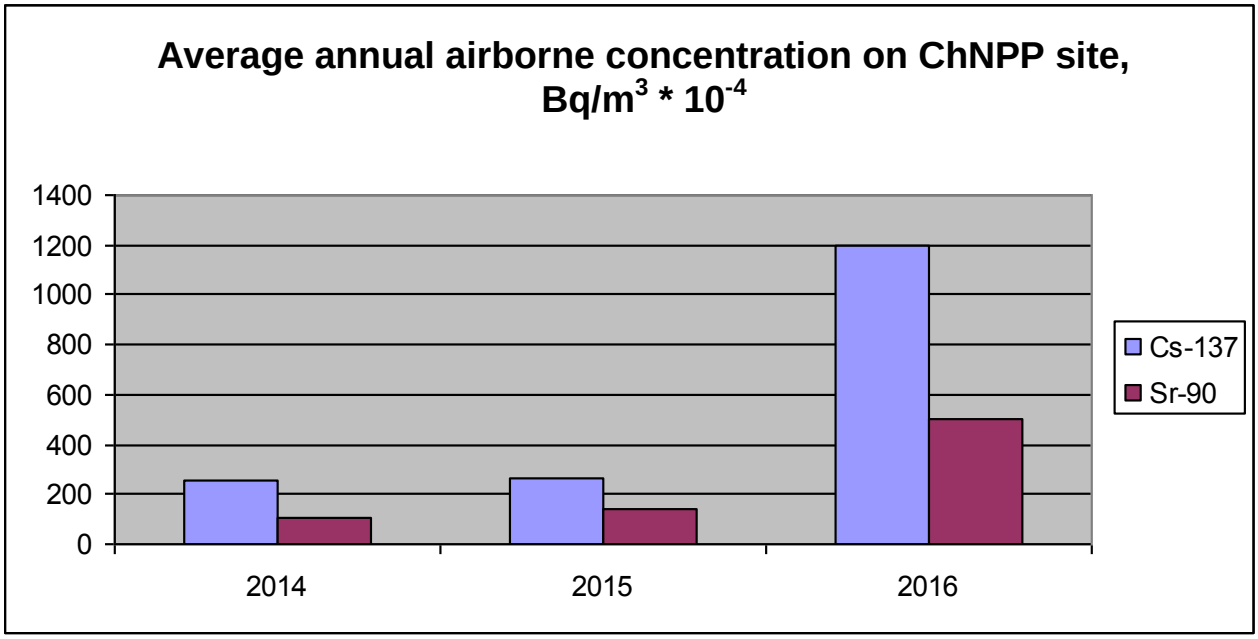


Figure L.8.13 – Average Annual Airborne Concentration on ChNPP Site

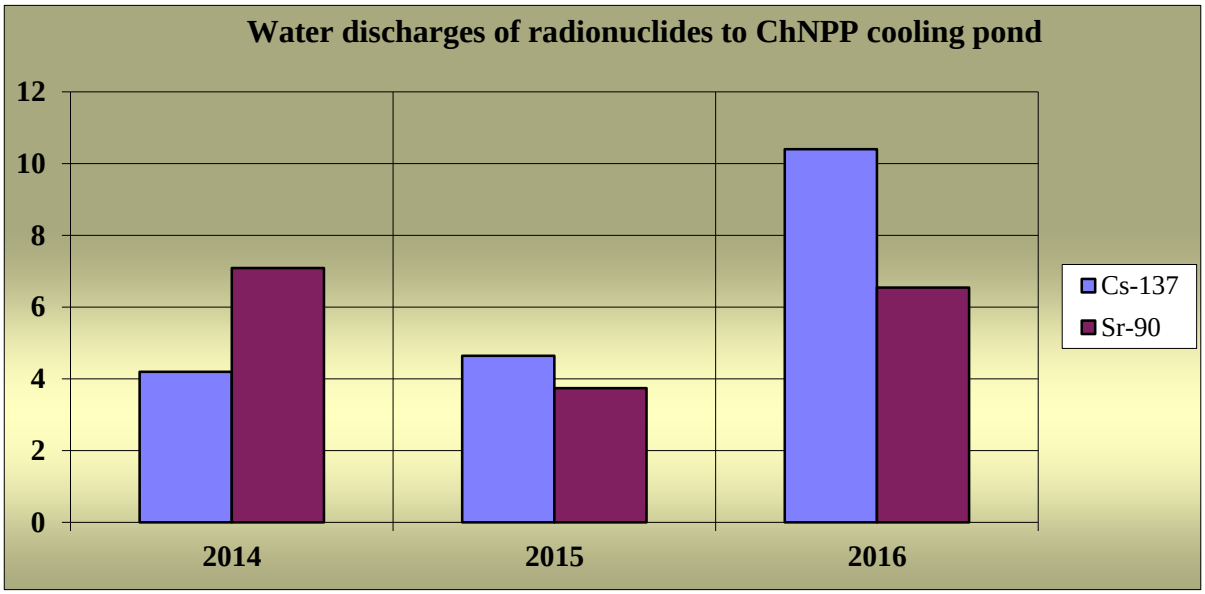


Figure L.8.14 – Radioactive Water Discharges to ChNPP Cooling Pond, GBq

Integrity Monitoring of Radwaste Storage Facilities on ChNPP Site (Observation Wells)

Contamination of groundwater is monitored using observation boreholes of the monitoring system for radwaste storage facilities on the ChNPP site. The maximum activity concentration of radionuclides determined with this monitoring is shown in Figures L 8.15-L 8.20.

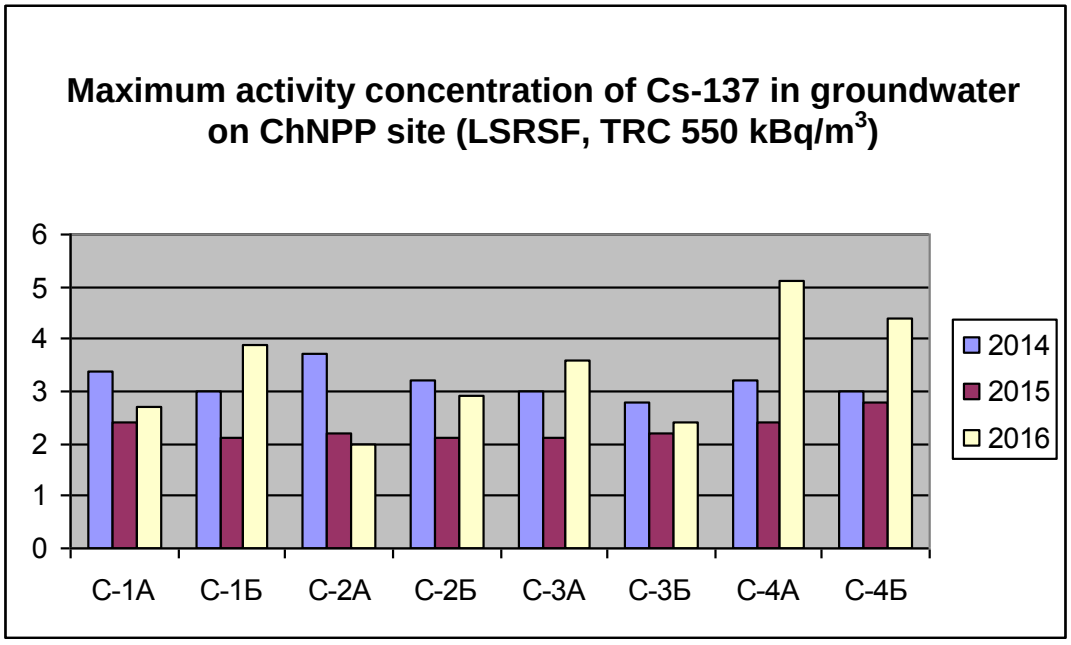


Figure L.8.15 – Maximum Activity Concentration of Cs-137 in Groundwater According to Observation Boreholes of the LSRSF Monitoring System

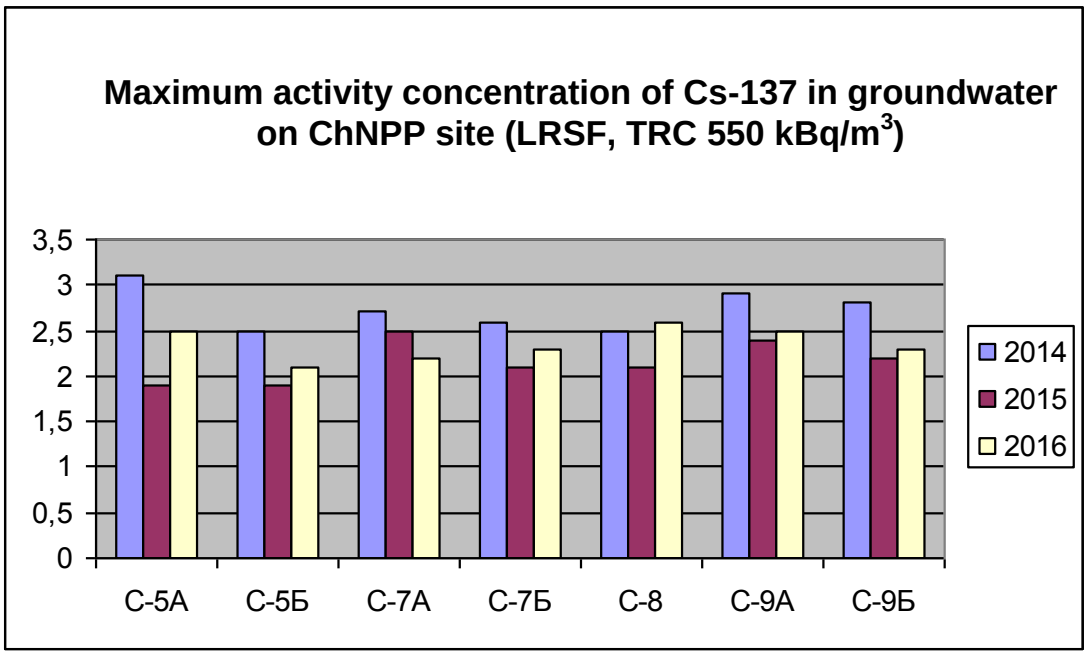


Figure L.8.16 – Maximum Activity Concentration of Cs-137 in Groundwater According to Observation Boreholes of the LRSF Monitoring System

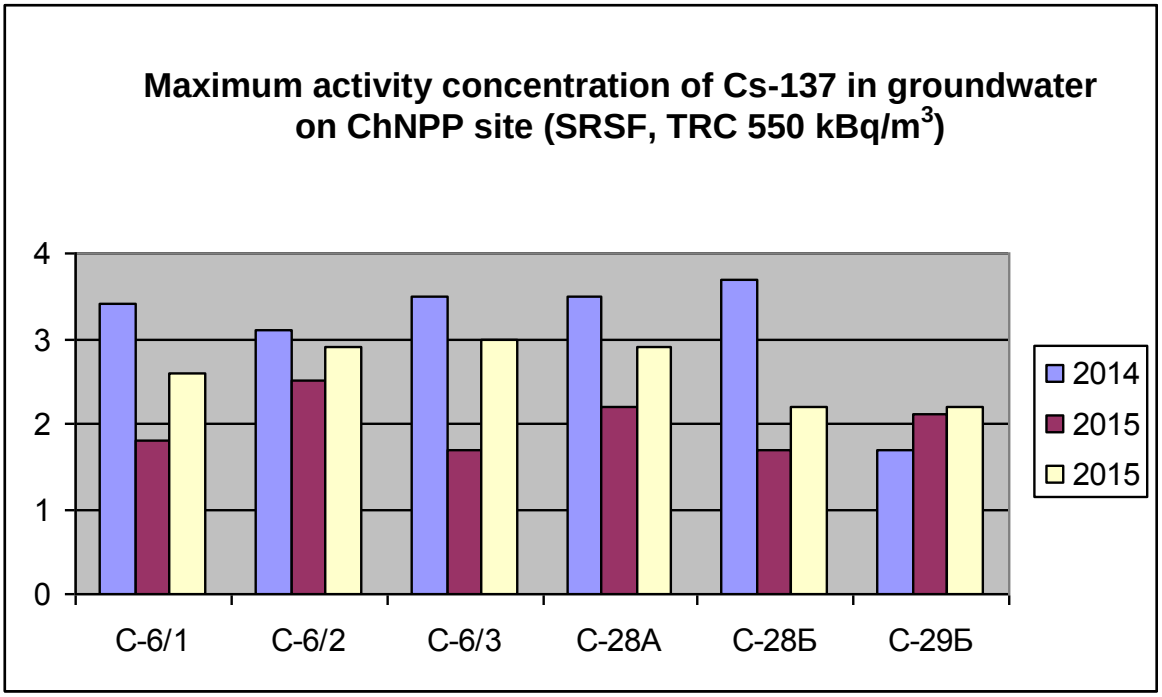


Figure L.8.17 – Maximum Activity Concentration of Cs-137 in Groundwater According to Observation Boreholes of the SRSF Monitoring System

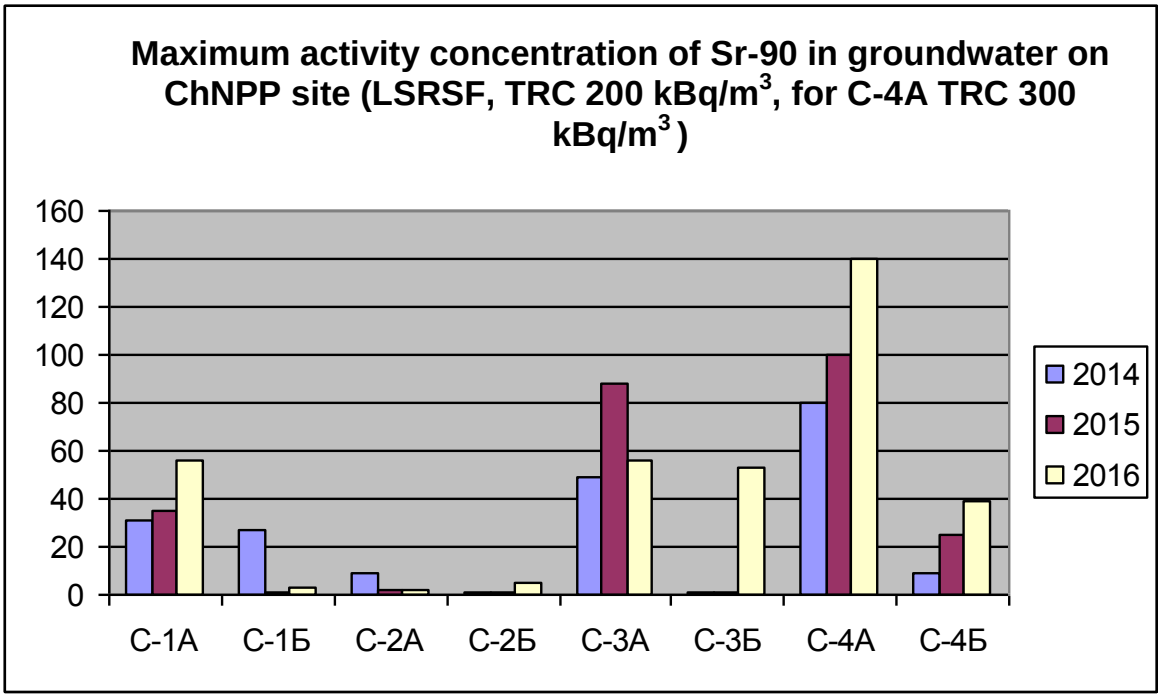


Figure L.8.18 – Maximum Activity Concentration of Sr-90 in Groundwater According to Observation Boreholes of the LSRSF Monitoring System

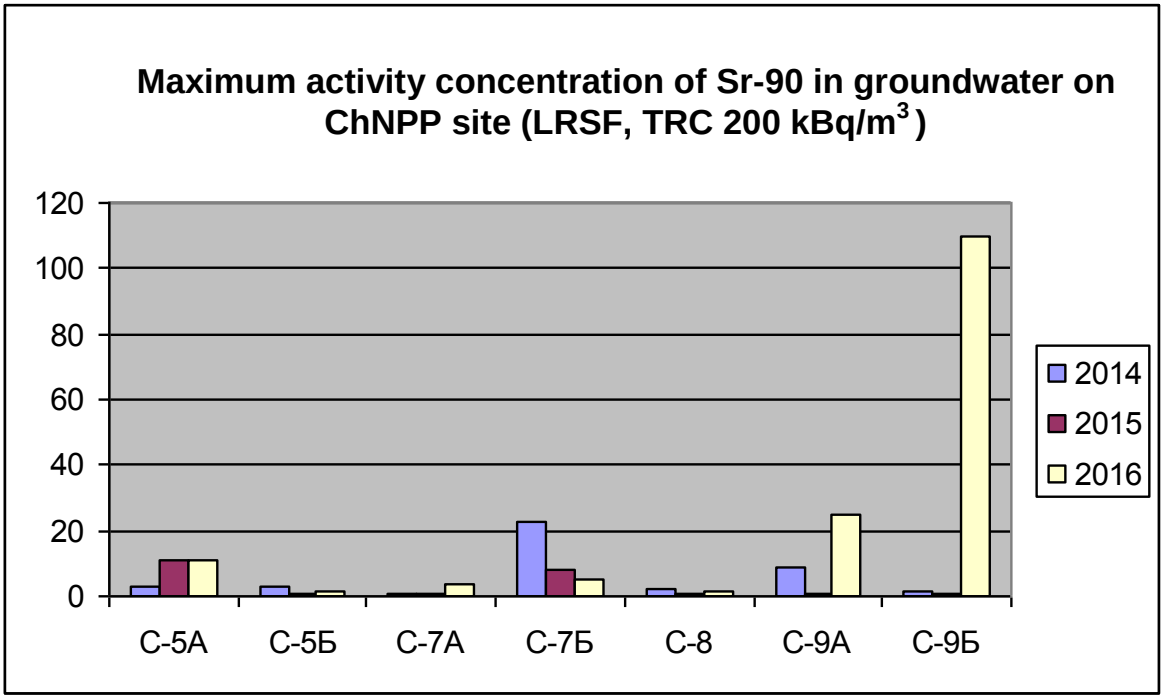


Figure L.8.19 – Maximum Activity Concentration of Sr-90 in Groundwater According to Observation Boreholes of the LRSF Monitoring System

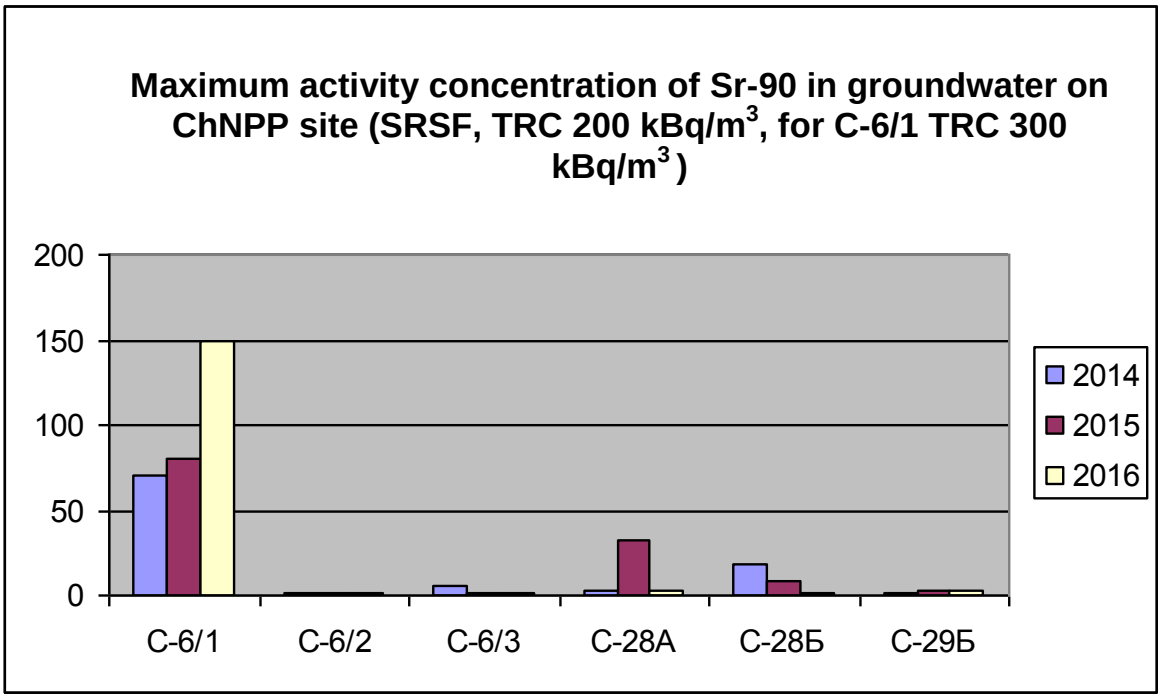


Figure L.8.20 – Maximum Activity Concentration of Sr-90 in Groundwater According to Observation Boreholes of the SRSF Monitoring System

Annex 9. Shelter

1. 1. General Information

The accident that occurred at Chornobyl unit 4 on 26 April 1986 became the largest and severest catastrophe in the history of nuclear energy. The explosion destroyed the reactor core, protective barriers and safety systems. The destruction of unit 4 and the magnitude of consequences were such that the accident was evaluated as level 7 on the International Nuclear Events Scale (INES).

To isolate the destroyed reactor within the shortest possible period (from May to November 1986), ChNPP unit 4 was preserved and a protective structure was built around it - Shelter.

The preservation of the destroyed unit 4 was intended to decrease its environmental impact and protect the ruined reactor from external effects.

The East European Leading Research and Design Institute for Energy Technologies (Saint Petersburg) was the general designer of the Shelter. The design was completed and modified during construction.

Along with construction, great efforts were made to decontaminate the territory, which decreased the exposure dose rate on the ChNPP s.

The Shelter is the ChNPP destroyed unit 4 that lost its functions. Emergency measures were taken at unit 4 to mitigate consequences of the accident, and activities are continued to monitor its state and nuclear and radiation safety.

The Shelter is not a facility created in compliance with regulations and rules or standards for siting, design, commissioning, operation and decommissioning of nuclear facilities (or radioactive waste storage facilities). The current state of the Shelter does not and cannot fully comply with safety standards and rules in force in the area of nuclear energy and general industrial safety requirements.

Some part of structures constructed in 1986 rests on destroyed components of the ChNPP unit 4 building, whose strength could not be assessed because of complex radiation conditions and obstructions. After use of remote concreting methods, concrete masses spread over coverings of the building and overloaded them. Remote assembling in some cases did not ensure tight fitting of structures and reliable connection with supports.

According to the Law of Ukraine “On Ratification of the Convention on Nuclear Safety”, the Shelter is not subject to this Convention because of its unique nature resulting from the global consequences of the Chornobyl catastrophe and because of impossibility to reach a high safety level at the Shelter in compliance with the Convention.

All nuclear and radioactive materials in the Shelter are radioactive waste. In compliance with the Radiation Safety Standards of Ukraine, the Shelter, in its current state, is qualified as a place for surface storage of uncontrolled radwaste (temporary storage of uncontrolled radwaste in the stage of stabilization and reconstruction).

The accident-related radwaste, representing open radiation sources that are located in the Shelter in great amounts without reliable protective barriers, poses a high current and potential hazard for personnel, the public (including future generations) and the environment. The main task of all Shelter-related activities is to control these sources and protect individuals and the environment against their radiological impact.

2. 2. Shelter Operating License

Shelter-related activities are conducted under a license issued by the SNRIU. The license establishes the scope and conditions of the authorized activity and provides for Shelter transformation into an environmentally safe system, in particular, in the framework of the international Shelter Implementation Plan (SIP).

According to this license, any activity at the Shelter is intended to protect personnel, the public and the environment against the impact of radioactive materials located in the Shelter or on its site. Any activity at the Shelter for another purpose is prohibited.

The license will remain valid until the Shelter New Safe Confinement is completed. The license determines a list of officials charged with organizational and administrative functions associated with nuclear and radiation safety, Shelter physical protection, nuclear material and radioactive waste located at the Shelter.

The license identifies 23 conditions for Shelter operation.

The ChNPP has currently implemented all special terms of the license and deals with general terms of activities. In particular, the licensee:

- submits semiannual and annual reports on Shelter safety;
- ensures storage of all records on accounting of radwaste removed outside the Shelter;
- ensures physical protection of nuclear and radioactive material against unauthorized actions in compliance with current legislation;
- during any activities that affect Shelter safety, develops, justifies and approves relevant technical decisions that become valid after their agreement with the SNRIU;
- conducts certain activities or operations (determined by license terms) for Shelter transformation into an environmentally safe system under individual authorizations issued by the SNRIU.

During 2011-2016, the SNRIU issued eight individual written authorizations in compliance with the license for important activities on construction, installation/dismantling, commissioning and operation of facilities on the Shelter site.

Compliance with the license and individual authorizations is monitored by the SNRIU in the framework of state supervision.

After commissioning of the New Safe Confinement (NSC) is completed, ChNPP shall obtain a license for NSC operation including the Shelter.

After this license is granted, Licence EO No. 000033 for operation of the Shelter will be cancelled.

Within preparation for future operation of NSC including the Shelter, SNRIU Board meeting was held on 1 December 2016 to consider approaches to licensing of NSC operation.

Taking into account the purpose of NSC and Shelter, gradual change in the Shelter as it transforms within the confinement, status of these facilities, their uniqueness, current regulations on issues of licenses/authorization in nuclear energy, and lack of direct provisions on licensing of these facilities, the SNRIU Board determined that issue of licenses for individual activities would be the most appropriate approach:

- processing and storage of radwaste that exists and generates in Shelter transformation into an environmentally safe system, within operation of NSC including the Shelter.

3. Shelter Transformation into Environmentally Safe System

Shelter transformation into an environmentally system requires substantial financial and material resources and international assistance to solve this widespread problem.

An important step to solve the Shelter safety problem is Ukraine's interaction with G7 States and European Commission.

The international program for Shelter transformation into an environmentally safe system, Shelter Implementation Plan (SIP), was developed under joint efforts of governments and experts of these countries during 1997.

The SIP is funded through contributions to the Chornobyl Shelter Fund, which is administered by the European Bank for Reconstruction and Development.

The Shelter Implementation Plan includes 22 tasks governed by five safety objectives:

– decrease the probability of Shelter collapse (stabilization of structures);

– mitigate consequences of collapse;

– improve nuclear safety;

– increase safety of personnel and the environment;

– implement the strategy of long-term measures on Shelter transformation into an environmentally safe system.

Shelter transformation into an environmentally system (SIP tasks and projects) is structured into the following main areas:

– develop safety programs and plans;

– create an infrastructure for projects;

– stabilize the Shelter;

– equip the Shelter with systems;

– develop the strategy for removal of fuel-containing materials (FCM);

– construct the New Safe Confinement (NSC).

Systems for organizational, methodological and technical measures for safe implementation of SIP projects were introduced under safety programs and plans. The radiation protection program, radioactive waste management program and emergency plan were developed.

The creation of an additional infrastructure is needed for safe implementation of SIP projects. The main completed projects include a changing room for 1430 places, an air lock at Shelter elevation +5.8, a site for temporary storage of process materials, a small construction site and administrative building, a facility for decontamination of vehicles and external engineering communications and auxiliary structures.

An important element of the additional infrastructure included construction of a special working platform (site) for assembling the New Safe Confinement for the Shelter. To decrease the negative Shelter effect on personnel, this platform was constructed in the west from the Shelter at a distance more than 200 meters. After planned safety measures were completed, the site was given the status of 'free' access zone. This status allows personnel to get access to the platform according to simplified procedures, perform activities with minimum use of individual protection means and increase their effectiveness.

Seven emergency stabilization measures on Shelter structures were implemented during 2005-2008. These structures were the most unreliable and hazardous in terms of consequences from potential collapse. The main objective of Shelter stabilization is to decrease the risk of collapse involving potential large release of radioactive dust to the atmosphere.

After completion of these measures, the ChNPP developed the "Summary Executive Report on Stabilization Measures (Safety Assessment Report)" to analyze the stabilization measures and the reliability of the Shelter as a whole and provide recommendations on further Shelter operation.

It was concluded that the safety of Shelter structures substantially increased although its level did not fully comply with regulatory requirements. The safety level can be considered acceptable for a period no more than 15 years from the date of official completion of activities (29 October 2008).

The new safe confinement for the Shelter shall be constructed within this period, and the most unstable Shelter structures shall be dismantled after its commissioning.

The following projects have been implemented to equip the Shelter with systems:

- modernized dust suppression system (MDSS);
- additional system for operating radiation monitoring of Shelter personnel (ASORM);
- integrated automated monitoring system (IAMS);
- modernized physical protection system;
- fire protection system (FPS).

The "Strategy for Management of Fuel-Containing Materials and Radioactive Waste of the Shelter. Plan of Further Actions" was developed within SIP. To develop the final version of the Strategy for FCM Management, additional measures on FCM monitoring shall be identified and completed and sources for their funding shall be found.

4. Construction of New Safe Confinement (NSC) for Shelter

The Shelter new safe confinement (NSC) is the main SIP project.

The confinement is a protective structure including process equipment for dismantling of unstable Shelter structures and 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.

According to the design decisions, the NSC represents an arch structure, consisting of tubular metal structures, and two layers of the protective shell, the distance between which is about 12 meters (annual space). The arch structure hermetically connects to the western and eastern end walls.

Geometrical dimensions of the NSC arch are: 164 m in length, 257 m in width, 110 m in height.

The envisaged operating period of the NSC is 100 years.

The NSC project is divided into two startup stages (SS):

- NSC SS-1 – protective structure with process life support systems and necessary infrastructure;
- NSC SS-2 – infrastructure for dismantling of unstable Shelter structures.

Construction and installation activities at NSC SS-1 are under completion and preparations for the development of NSC SS-2 design decisions are underway.

The design documentation on NSC SS-1 passed state reviews, including reviews on nuclear and radiation safety, and was properly approved.

NSC SS-1 is implemented through individual projects combined in 6 licensing packages (LP).

Preparations for NSC SS-1 have been completed under the LP1-LP3 licensing packages: the territory has been prepared and cleared for construction, foundations for NSC installation and transport zones have been created and the working platform for assembling NSC structures has been constructed and accepted in operation.

The existing ventilation stack of ChNPP Stage II (VS-2) prevented the future establishment of the NSC into its designed position. This ventilation stack was finally dismantled in November 2013 under the LP4 licensing package.

The dismantling work was preceded by construction and commissioning of a new ventilation stack of ChNPP Stage II in October 2013, which is intended to perform functions of VS-2 and constructed not to impede NSC structures.

The main activities on NSC construction are carried out within LP5-LP6 licensing packages:

- construction of NSC foundations in the main (service) area has been completed;
- mounting of the arch and its internal and external shells has been completed;
- arch has been moved from the mounting site to the design position above the Shelter;
- construction of NSC arch end walls is under completion;
- NSC main cranes have been installed and partially tested;
- auxiliary buildings and structures are being constructed and mounted in the local area:
- process building,
- electrical building,
- fire-fighting pump station,
- access gateways for fire teams,
- diesel generator units,
- sewage treatment plants etc.;
- systems for management of solid and liquid radwaste, heat and water supply, drainage, ventilation and air conditioning, decontamination, transport, etc. are being installed;
- construction of roads and sidewalks on the adjacent territory is underway.

An important stage in the construction of NSC was its transfer from the mounting area and installation into the design position over the Shelter. On 14-27 November 2016, this unique structure with a total weight of more than 36,200 tons was moved to 327 meters by special technology and installed over the Shelter.

The NSC arch sliding allowed substantial improvement of Shelter current safety:

- metal structures of the arch shield powerful radiation sources in the Shelter; as a result, after installation of the NSC arc in the design position, gamma dose rate on the Shelter site around NSC decreased by almost twice;

- atmospheric precipitations have ceased to flow into the Shelter, which are one of the main factors causing degradation of its structures, creation of nuclear-hazardous compositions of fuel-containing materials, as well as transport of radioactive substances within and beyond the Shelter;
- effects of wind and snow loads on the Shelter have been prevented after arch sliding, which significantly reduces the risks of damage (collapse) of Shelter structures.

NSC SS-1 is to be completed by the end of 2017, and then this facility will be managed by ChNPP.

The main task after NSC SS-1 commissioning for the near years is to implement NSC SS-2, dismantle unstable Shelter structures, ensure radwaste management and further retrieval/transfer of fuel-containing materials into controlled state.

Recovery of partially damaged wall panels and roof of the Shelter turbine hall with an area of about 600 m^2 caused by the abnormal event on 12 February 2013 was completed at the end of March 2015.

Detailed information on the abnormal event is provided in NRU-2014 (Annex 9).

5. Shelter Radioactive Waste Management

According to evaluations, there is radwaste with the following basic characteristics inside the Shelter and on its site:

No.	Radwaste type (storage place)	Physical state	Activity category	Amount, m^3	Total activity, TBq	Nuclide composition, %
1.	Solid radwaste[1] located in the Shelter and on its site that formed during the accident and mitigation measures	Fresh and spent fuel assemblies, lava-like fuel-containing materials, dust, metallic equipment and assembling structures etc.	Solid radwaste of all categories	630,000 – 665,000	5.21E+5	Mixture of radionuclides typical of spent nuclear fuel from the core (uranium, cesium, strontium, cobalt, transuranium elements – plutonium, americium etc.)
2.	Post-accident waste[1] located inside the Shelter (uncontrolled leakages and water accumulations in rooms of block B)	Water accumulations and leakages (including sediments in water accumulations)	Liquid radwaste of all categories	~ 500	~ 59.3	Mixture of post-accident radionuclides: cesium, strontium, plutonium, uranium etc.

Notes:

[1] Data in the table are tentative and based on research work conducted at the Shelter.

[2] Amount of liquid radwaste changes annually depending on the intensity of precipitations getting into the Shelter. After NSC is commissioned, uncontrolled ingress of liquid waste to Shelter rooms under the NSC arch is expected to be terminated. Currently (after arch sliding), regular monitoring of change in water level in lower Shelter elevations is conducted and water activity concentration and radionuclide composition are measured.

Solid and liquid radwaste is generated during Shelter routine activities and transformation into an environmentally safe system.

Radwaste management at the Shelter is part of radwaste management at the ChNPP.

Solid radwaste (soil, scrap metal, mixed construction waste, spent individual protection means) is mainly generated during routine activities to maintain the Shelter in a safe state and during SIP projects.

This solid radwaste is mainly of low and intermediate level, and sometimes high-level waste is revealed. Strontium-90, cesium-137, cesium-134 and transuranium elements are the main nuclides that contribute to contamination. Shelter solid radwaste is managed in compliance with ChNPP documents in force. Low- and intermediate-level waste is collected, sorted (if needed, large radwaste is fragmented) and transferred to the *Buryakivka* RWDS or stored in temporary storage facilities on the ChNPP site. High-level radwaste is collected and fragmented using equipment for remote solid waste treatment and is transported to the temporary storage of high-level waste on the ChNPP site.

Shelter liquid radwaste results from decontamination of rooms, equipment and tools, dust suppression, operation of changing rooms, and natural factors such as penetration of precipitations through non-tight places in Shelter structures (before NSC sliding over Shelter) and moisture condensation.

Liquid radwaste, including that of the Shelter, is collected through the ChNPP piping system.

There are liquid radwaste accumulations inside the Shelter that result from uncontrolled water leakages and dust suppression activities.

The radionuclide and chemical composition of this liquid radwaste depends on location. The radionuclide composition of water in Shelter rooms includes Cs^{134}, Cs^{137}, Sr^{90}, $Pu^{239-240}$, Am^{241} and organic and film-forming compounds.

The main tasks to improve the existing system for Shelter liquid radwaste management are:

– collection of waters from blocks B and block of reactor compartment auxiliary systems and their treatment;

– rapid determination of α-activity of liquid radwaste prior to transfer to the ChNPP chemical department for further treatment;

– removal of transuranium elements, organic and film-forming compounds from liquid radwaste.

In the framework of international cooperation, ChNPP developed the project for constructing an industrial facility for removal of transuranium elements and organics from water. In December 2016, SNRIU provided positive conclusions of nuclear and radiation safety review for this project. See also Subsection H.4 of this Report.

To solve issues associated with Shelter liquid radwaste management, the ChNPP developed the "Conceptual Technical Decision on Liquid Radwaste Management and Shelter Transformation into an Environmentally Safe System" in 2006 and agreed it with the SNRIU. To comply with this decision, the ChNPP developed a plan of measures and implemented them partially.

6. Regulatory Body's Documents for Shelter Activities

The SNRIU, in its Shelter-related activities, is governed by the Laws of Ukraine, Cabinet resolutions and ordinances and regulations in the area of nuclear energy.

To explain the policy for state regulation of nuclear and radiation safety of the Shelter, the regulatory body approved the "Statement on the Policy for Regulation of Nuclear and Radiation Safety of the Chornobyl Shelter" in 1998. It determined the main principles of nuclear and radiation safety during Shelter transformation into an environmentally safe system, specifically:

– management principles;
– radiation protection;
– radwaste management;
– general technical principles.

In 2001, the SNRIU developed “Requirements for the Structure and Contents of the Safety Analysis Report for Projects of the Shelter Implementation Plan”. According to this document, the ChNPP develops safety analysis reports on projects submitted to the nuclear regulatory body with the documentation package to obtain an authorization for specific activities or operations at the Shelter.

During 2005-2006, the SNRIU developed, with involvement of international experts, the “Fundamental Safety Principles under the Shelter Implementation Plan” and “Guideline on Using Safety Fundamentals during Regulatory Activity under the Shelter Implementation Plan”.

In October 2010, the regulation “Conditions and Procedure for Issuing Individual Written Authorizations for Activities or Operations on Shelter Transformation into an Environmentally Safe System” developed by the SNRIU was put in force. This document identifies activities or operations to be conducted under individual authorizations at the Shelter and establishes conditions and procedure for issuing, amending, rejecting, terminating and cancelling authorizations for activities or operations on Shelter transformation into an environmentally safe system.

Annex 10. Uranium Mining and Milling Waste

Operating period	Tailing pit	Area, ha	Volume of tailing, mln. t / mln. m^3	Total activity, 10^{12} Bq	Uranium content, mg/kg
Tailing pits of *SkhidGZK*					
1959-1970	Scherbakivska (old basin)	614.9	7.640/7.119	79.318	5 - 10
1979 – until present	Scherbakivska (new basin)		44.027/39.558	445.120	6 - 8
1964 – until June 1990 1991-1996 (occasionally)	Iron ore quarry	55.0	15.94/12.40	93.300	10
PChP tailing pits registered on *Baryer* Books					
1949 - 1954	Western	4.0	0.77/0.35	180	700
1951 - 1954	Central Yar	2.4	0.22/0.10	104	630
1956 - 1990	South Eastern	3.6	0.33/0.15	67	22
1968 - 1983	Sukhachivske Section 1	90.6	19.0/8.60	710	80
1983 – until present	Sukhachivske Section 2	70.0	9.60/5.50	270	80
1960 - 1991	Base C	34.0	0.3/0.10	440	1000
1954 - 1968	Dniprovske	73.0	12.0/5.84	1400	230
1982	Blast Furnace 6	0.2	0.04/0.02	11	-
1965- 1990	Lanthanum Fraction	0.06	0.007/0.003	0.86	-