REPORT ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2020

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Dear Readers!

The Report on Nuclear and Radiation Safety in Ukraine for 2020 is presented for your attention. The Report has been developed by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) using data submitted by entities in the area of nuclear energy. The Report analyzes the safety of nuclear installations, radioactive waste management facilities, and radiation sources, the safety of Chornobyl NPP decommissioning and Shelter transformation into an environmentally safe system, the use and production of radiation sources, the physical protection of nuclear installations, nuclear materials, radioactive waste, and other radiation sources, information on international cooperation, etc.

Hryhorii PLACHKOV
Chairman
Chief State Inspector on Nuclear and Radiation Safety of Ukraine

2020 became a year of challenges and needs to quickly adapt to realities in the context of restrictive measures implemented to prevent the spread of the COVID-19 acute respiratory disease caused by the SARS-CoV-2 coronavirus. The use of new mechanisms and tools for communication and interaction ensured an appropriate level of nuclear and radiation safety in Ukraine and allowed certain advances.

Thus, a significant and important event of the year was the adoption of the Law of Ukraine "On Amendment of Certain Laws of Ukraine on Nuclear Energy Use" No. 613-IX, which amended the Laws of Ukraine "On Basic Principles of State Oversight (Control) in Economic Activities" and "On Licensing of Economic Activities" to recover independence of the state nuclear regulatory body in making regulatory decisions on licensing and oversight, which confirms the fulfillment of international obligations.

Moreover in 2020, the National Science Center "Kharkiv Institute of Physics and Technology" received a permit for the initial startup of the "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" nuclear subcritical facility designed for scientific and applied research in the area of nuclear physics, radiation materials science, biology and chemistry and for the production of medical radioisotopes.

SNRIU issued an individual permit for trial commercial operation of the first startup package of the Shelter New Safe Confinement, whose purpose is to confirm that the systems, structures and components of the facility can perform in accordance with the design.

Within an individual permit to commission the Interim Spent Fuel Storage Facility issued to the Chornobyl NPP, hot tests of the facility were conducted.

The Seventh National Report of Ukraine on Fulfillment of the Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was developed and approved.

The invariability of the European integration course and conscientious fulfillment of the assumed international obligations allowed Ukraine to gain the status of an observer of the European Nuclear Safety Regulators Group (ENSREG) in 2020.

The detailed information on these and other achievements and events of 2020 can be found on the Report pages. Feedback is important to us, so we are waiting for your responses, suggestions and comments at pr@snriu.gov.ua.

TABLE OF CONTENTS

I. Development of Nuclear Legislation 9

II. Safety of Nuclear Installations 13

III. Emergency Preparedness and Response 29

IV. Radioactive Waste Management 37

V. Chornobyl NPP Decommissioning and Shelter Transformation 50

VI. Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources 57

VII. Safeguards and Nuclear Weapon Nonproliferation 63

VIII. Radioactive Material Transport 66

IX. Radiation Protection and Safety in Management of Radiation Sources 67

IX.1. State Regulation of Safety in Use and Production of Radiation Sources 67

IX.2 State Regulation of Nuclear and Radiation Safety in Use of Radiation Sources in Covid-19 Pandemic Conditions: Challenges, Risks, Problems, Solutions 73

IX.3. Optimization of Occupational Exposure. Establishment of Unified State System for Exposure Accounting and Control 76

X. Safety of Uranium Sites 78

XI. International Cooperation and European Integration 81

LIST OF ABBREVIATIONS

C(I)SIP – Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants
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 Disused Radiation Sources
CRME – Centralized Radwaste Management Enterprise
CSFSF – Centralized Spent Fuel Storage Facility
DSC – Double-Walled Dry Shielded Canister
DSFSF – Dry Spent Fuel Storage Facility
ENSDF – Engineered Near-Surface Disposal Facility for Low- and Intermediate-Level Short-Lived Waste
ENSREG – European Nuclear Safety Regulators Group
FCSE – Final Closure and Safe Enclosure
IAEA – International Atomic Energy Agency
IAEA IEC – Incident and Emergency Center
ICSRM – Industrial Complex for Solid Radioactive Waste Management
ISF – Interim Spent Fuel Storage Facility
ITDB - Illicit Trafficking Database
KhNPP – Khmelnitsky Nuclear Power Plant
KIPT – National Science Center "Kharkiv Institute of Physics and Technology"
LRTP – Liquid Radioactive Waste Treatment Plant
NFC – Nuclear Fuel Cycle
NPP – Nuclear Power Plant
NRS – Nuclear and Radiation Safety
NSC – New Safe Confinement
PSRR – Periodic Safety Review Report
Radwaste – Radioactive Waste
RBMK – Light-Water Graphite-Moderated Channel-Type Reactor
RICS – Radioactive Waste Interim Confinement Site
RNPP – Rivne Nuclear Power Plant
RWDS – Radioactive Waste Disposal Site
SAUEZM – State Agency of Ukraine on Exclusion Zone Management
SFA – Spent Fuel Assembly
SFP – Spent Fuel Pool
SIRG – Safeguards Implementation Review Group
SISP – State Interregional Specialized Plant
SkhidGZK – State Enterprise "Eastern Mining and Processing Plant"
SNF – Spent Nuclear Fuel
SNRIU IEC – Information and Emergency Center
SP – Startup Package
SRTP – Solid Radioactive Waste Treatment Plant
SRW – Solid Radioactive Waste
SUNPP – South Ukraine Nuclear Power Plant
USCPS – Unified State Civil Protection System
VITR-HLW – Long-Term Storage Facility for Vitrified High-Level Waste
VSC – Ventilated Storage Cask
VVER – Water-Cooled Water-Moderated Power Reactor
WENRA – Western European Nuclear Regulators' Association
ZNPP – Zaporizhzhya Nuclear Power Plant

I. DEVELOPMENT OF NUCLEAR LEGISLATION

The national nuclear legislation is updated and improved on a permanent basis through revision and development of regulations in the area of nuclear energy, considering international safety standards and EU legislation.

The Ukrainian legislation on the safety of nuclear energy governs all relations associated with the peaceful use of nuclear energy and assurance of nuclear and radiation safety (NRS).

The adoption of the Law of Ukraine "On Amendment of Certain Laws of Ukraine on Nuclear Energy Use" by the Verkhovna Rada of Ukraine on 19 May 2020 was an important event. This law amended the Laws of Ukraine "On Basic Principles of State Oversight (Control) in Economic Activities" and "On Licensing of Economic Activities" to ensure independence of the Ukrainian nuclear regulatory body in making decisions in authorizing and oversight activities.

The nuclear legislation system also includes regulations of the Cabinet of Ministers of Ukraine, establishing the mechanism for the implementation of laws and procedure for activities in the area of nuclear energy (without technical aspects).

Standards and rules on nuclear and radiation safety are an important component of the legislation on safety in nuclear energy. These documents establish criteria, requirements and conditions for the safe use of nuclear energy in all nuclear regulatory areas. Two regulations governing the safety of radioactive waste management were adopted in 2020:

- Requirements for the Structure and Contents of the Safety Analysis Report for Surface and Near-Surface Radioactive Waste Disposal Facilities;
- Requirements for the Structure and Contents of the Safety Analysis Report for Radioactive Waste Treatment Facilities.

SNRIU developed and approved the General Safety Provisions for the Design and Operation of Equipment and Piping of Nuclear Power Plants to improve legislative requirements on the safety of nuclear installations. The document was developed to replace regulations adopted in the former Soviet Union, specifically: PNAE G-7-008-89, PNAE G-7-009-89 and PNAE G-7-010-89.

SNRIU developed and approved the General Safety Provisions for Decommissioning of Nuclear Facilities to establish general requirements for

activities related to decommissioning of nuclear installations and replace the outdated General Safety Provisions for Decommissioning of Nuclear Power Plants and Nuclear Research Reactors, which did not fully consider up-to-date international safety standards and national nuclear standards and rules; in particular, reference safety levels of the Western European Nuclear Regulators' Association (WENRA).

In compliance with Cabinet Resolution No. 450 dated 6 June 2018, SNRIU was appointed the central executive body to establish the functional nuclear and radiation safety subsystem within the Unified State Civil Protection System. The Provisions on the Functional Nuclear and Radiation Safety Subsystem of the Unified State Civil Protection System were developed and approved in 2020.

SNRIU amended the Procedure for Nuclear Safety Training and Examination for Personnel and Officials of Entities Dealing with Individual Nuclear Activities to improve the procedure for NRS training and examination for personnel of the operating organization (operator) and legal entities subcontracted by the operating organizations.

In connection with adoption of new standards by the International Atomic Energy Agency (IAEA) related to the safety of radioactive material transport, SNRIU approved the Rules for the Safe Transport of Radioactive Material (PBPRM-2020) to replace the Nuclear and Radiation Safety Rules on Radioactive Material Transport (PBPRM-2006).

In 2020, SNRIU continued implementing the European Union legislation on safety of nuclear energy use, which was started back in 2014. In 2020, the implementation was carried out in the areas defined in Article 342 and Appendix XXVII-B, part "Nuclear Energy" of the Association Agreement between Ukraine, on the one part, and the European Union, the European Atomic Energy Community and their member states, on the other part, into national legislation, in particular in accordance with the following Directives:

- *Council Directive 2013/59/Euratom dated 5 December 2013 laying down basic safety standards for protection against the dangers arising from the effects of ionizing radiation;*

- *Council Directive 2006/117/Euratom dated 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel;*

- *Council Directive 2009/71/Euratom dated 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations;*

- *Council Directive 2014/87/Euratom dated 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations;*

- *Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.*

To implement Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from the effects of ionizing radiation, SNRIU:

- developed the draft Law of Ukraine "On Amendment of the Law of Ukraine on Nuclear Energy Use and Radiation Safety regarding Radiation Protection Expert". The draft law was submitted by the Cabinet of Ministers of Ukraine to the Verkhovna Rada of Ukraine and registered under No. 3869 on 16 July 2020. The draft law introduces practices for nuclear entities, other legal entities and individuals and state authorities to take advice of radiation protection experts on compliance with NRS legislation;

- developed Resolution "On Amendment of Cabinet Resolutions No. 440 dated 6 May 2001 and No. 591 dated 1 June" (regarding licensing procedure for uranium ore mining) that was adopted by the Cabinet of Ministers of Ukraine on 9 September 2020 under No. 803 to introduce Law of Ukraine "On Amendment of Certain Laws of Ukraine on Nuclear Energy Use" No. 107-IX dated 18 September 2019 adopted to implement Council Directive 2013/59/Euratom;

- developed and approved the English-Ukrainian Glossary of Terms in Nuclear Energy Use and placed it on the official SNRIU website;

- developed the Procedure for Establishing the Unified State System for Accounting and Control of Individual Doses, Action Plan for Establishing the Unified State System for Accounting and Control of Individual Doses and Provisions on the State Register of Radiation Sources, Individual Doses and Procedure on Payment for Services on Their Registration, approved by Cabinet Resolution No. 1141 "Some Issues in Establishing the Unified State System for Accounting and Control of Individual Doses" dated 18 November 2020.

SNRIU developed and approved the Form for Standard Document used in procedures for agreement of international shipments of radioactive material and spent nuclear fuel when the state of destination or state of transit is a member of the European Union, to implement Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel.

As a result of implementing Council Directive 2009/71/Euratom dated 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations and Council Directive 2014/87/Euratom dated 8 July 2014 amending Directive 2009/71/Euratom, SNRIU approved:

- General Safety Provisions for the Design and Operation of Equipment and Piping of Nuclear Power Plants;
- General Safety Provisions for Decommissioning of Nuclear Facilities.

The main regulations, international conventions and standards and rules that govern nuclear relations can be found on the official SNRIU website snriu.gov.ua under Nuclear Legislation/Legal Acts.

II. SAFETY OF NUCLEAR INSTALLATIONS

During 2020 (as in previous years), the main efforts of the regulatory body were aimed at ensuring:

- regulatory support of operation safety for NPP units and their long-term operation;
- safety regulation of nuclear fuel management;
- state safety oversight at the stages of construction and commissioning of new nuclear facilities;
- emergency preparedness and response to emergencies and accidents in case of their occurrence.

Regulatory Support to Operational Safety of NPP Units and Their Long-Term Operation

Currently, 15 NPP units are operated in Ukraine, of which 13 are VVER-1000 and 2 are VVER-440.

The operator of all operating NPPs in Ukraine is State Enterprise "National Nuclear Energy Generating Company Energoatom" (Energoatom).

In accordance with the requirements of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the provisions of the Convention on Nuclear Safety, the operating organization ensures stable and safe NPP operation. In addition, in accordance with the requirements of national standards and rules on NRS, IAEA recommendations, the operating organization should systematically implement measures to improve safety of existing NPPs also taking into account many years' experience and international practice.

Operational safety of NPP units is improved by Energoatom through implementing the measures envisaged by the Comprehensive (Integrated) Safety Improvement Program for NPPs (C(I)SIP) approved by Resolution of the Cabinet of Ministers of Ukraine No. 1270 on 7 December 2011 (as amended).

In accordance with this Resolution, Energoatom develops and agrees annual schedules for implementing safety improvement measures for power units with the Ministry of Energy of Ukraine, SNRIU and State Emergency Service (in terms of firefighting measures).

C(I)SIP validity period: 2012 - 2023.

C(I)SIP is financed by Energoatom and since 2015 also on account of EBRD/Euratom loan funds (Resolution of the Cabinet of Ministers of Ukraine No. 356 of 20 August 2014).

Control of implementing C(I)SIP measures is provided by SNRIU through:

- consideration and approval of annual schedules of implementing C(I)SIP measures;
- consideration of quarterly reports on implementing C(I)SIP measures and control of compliance with the deadlines;
- control of the scope of C(I)SIP measures planned for implementation before scheduled outage of Ukrainian NPP units;
- control of implementing planned C(I)SIP measures during kick-off meetings before the start-up of Ukrainian NPP units after scheduled outage with core refueling;
- control of the actual scope and quality of implementing C(I)SIP measures during inspections.

Within the regulatory support of C(I)SIP, SNRIU approved reports on the implementation of 68 measures.

In total, as of 31 December 2020, 997 reports on implementing C(I)SIP measures were approved by SNRIU of 1295 planned, that is, ~ 77%.

Safety Review and Long-Term Operation of NPP Units

As of 31 December 2020, long-term operation was provided for 12 power units out of 15.

NPP	Power unit	Reactor	Expiration of design/extended lifetime
ZNPP	1	VVER-1000/320	23 December 2015/23 December 2025
	2	VVER-1000/320	19 February 2016/19 December 2026
	3	VVER-1000/320	5 March 2017/5 March 2027
	4	VVER-1000/320	4 April 2018/4 April 2028
	5	VVER-1000/320	27 May 2020/27 May 2030

	6	**VVER-1000/320**	**21 October 2026**
SUNPP	**1**	**VVER-1000/302**	**2 December 2013/2 December 2023**
	2	**VVER-1000/338**	**12 May 2015/31 December 2025**
	3	**VVER-1000/320**	**10 February 2020/10 February 2030**
RNPP	**1**	**VVER-1000/213**	**22 December 2010/22 December 2030**
	2	**VVER-1000/213**	**22 December 2011/22 December 2031**
	3	**VVER-1000/320**	**11 December 2017/11 December 2037**
	4	**VVER-1000/320**	**07 June 2035**
KhNPP	**1**	**VVER-1000/320**	**13 December 2018/13 December 2028**
	2	**VVER-1000/320**	**7 September 2035**

Table. The decision on ZNPP-5 long-term operation was approved by Order of the SNRIU Board No. 01 of 4 January 2021

ZNPP-5 Long-Term Operation

The design lifetime of ZNPP-5 expired on 27 May 2020.

The activities on long-term operation were performed by the operating organization in accordance with the following agreed by the SNRIU:

- Program for Preparation of ZNPP-5 for Long-Term Operation 05.MR.00.PM.23-17/N;
- Technical Solution No. 05.MR.00.TR.1057-18 “On Safe Operation of ZNPP-5 Nuclear Facility after Shutdown in 30 Fuel Campaign for Modernization Activities to Provide Long-Term Operation”.

SNRIU Order No. 208 of 22 May 2020 amended the License series EO No. 000196 to perform activities at life stage “operation of the Zaporizhzhya NPP nuclear facility” on ZNPP-5 operation in a shutdown state with complete fuel unloading from the reactor core to the spent fuel pool (SFP) for the period of implementing necessary organizational and technical measures by the operating organization to provide the possibility of its long-term operation.

The decision on ZNPP-5 long-term operation was approved by Order of the SNRIU Board No. 01 of 4 January 2021 and 5 January 2021 introduced relevant amendments to License EO No. 000196

Safety Review of RNPP-1, 2 and ZNPP-6

Pursuant to the requirements of Article 33 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", General Safety Provisions for Nuclear Power Plants and Requirements for NPP Safety Assessment, *the Energoatom* periodically reassess safety of NPP units and presents its results in the form of Periodic Safety Review Reports (PSRR).

Safety Review of RNPP-1, 2

According to para. 3.6.1 of License EO No. 000943 to perform activities at the stage of life cycle "operation of RNPP-1, 2 nuclear facilities", the operating organization had to periodically review safety of Unit 1 by 22 December 2019 and Unit 2 by 14 June 2021 and submit PSRR upon the review results to SNRIU.

During 2020, SNRIU involving the State Scientific and Technical Center for Nuclear and Radiation Safety" (SSTC NRS) provided the state NRS review of RNPP-1 PSRR, whose results were approved by Order of the SNRIU Board No. 8 of 10 December 2020.

The SNRIU Board justified the possibility of RNPP-1 safe operation at the capacity levels indicated in the design by 22 December 2030.

In 2020, SNRIU involving SSTC NRS provided consideration of all 14 safety factors of RNPP-2 PSRR and Section "Comprehensive Safety Analysis" submitted to SNRIU. Among them as of the end of 2020:

- reporting documents with the assessment results of 8 safety factors have passed the state NRS review and were improved by the operating organization according to its comments;
- reporting documents on 6 safety factors and Section "Comprehensive Safety Analysis" have passed the state NRS review, consideration of the comments according to the Review Conclusions are underway.

Safety Review of ZNPP-6

In accordance with para. 3.22 of License EO No. 000196 to perform activities at life stage "operation of ZNPP nuclear facility", as well as the Summary Schedule of the Activities on Periodic Safety Review for Ukrainian

NPP Units agreed by SNRIU, the operating organization should perform periodic safety review for ZNPP-6 and submit PSRR to SNRIU upon its results by 28 December 2020.

During 2020, SNRIU involving SSTC NRS provided consideration of all 14 safety factors of ZNPP-6 PSRR submitted to SNRIU. Among them as of the end of 2020:

- reporting documents on 5 safety factors and Section "Comprehensive Safety Analysis" pass the state NRS review;
- reporting documents on 9 safety factors have passed the state NRS review, consideration of its comments is underway.

According to the Detailed Schedule for Periodic Safety Review of ZNPP-6 approved by SNRIU, the deadline for completion of the periodic safety review for ZNPP-6 and approval of the complete set of PSRR documents by the SNRIU is 28 December 2021.

Safety Regulation in Construction of New Nuclear Facilities

A number of new nuclear facilities are currently under construction on the territory of Ukraine, in particular:

- Neutron Source – "Neutron Source based on a subcritical assembly driven by a linear electron accelerator" nuclear subcritical facility;
- ChNPP ISF-2 - dry spent fuel storage facility for long-term (over 100 years) storage of all nuclear fuel from the Chornobyl NPP;
- CSFSF - centralized dry spent nuclear fuel storage facility for long-term (over 100 years) storage of nuclear fuel at the Rivne, Khmelnitsky and South Ukraine NPPs.

Construction of "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" Nuclear Subcritical Facility (Neutron Source)

The nuclear facility is being constructed on the territory of National Science Center "Kharkiv Institute of Physics and Technology" (KIPT) in accordance with the License series EO No. 001018 to construct and commission the Neutron Source issued by SNRIU on 10 October 2013.

Safety regulation of construction and commissioning of the Neutron Source is implemented by monitoring compliance with the requirements of regulations, standards and rules on NRS in the course of construction and

installation activities, as well as the implementation of state review on NRS and approval of technical conditions and technical specifications for equipment important to safety, design and operational documents of the Neutron Source.

In the first half of 2020, SNRIU attention was focused on considering the KIPT Application to obtain an individual permit for the initial criticality of the Neutron Source, which was received on 10 February 2020. Within this procedure, SNRIU conducted an inspection of KIPT from 10 to 12 June 2020.

Taking into account the positive results of assessing the licensee's documents with justification materials and the above-mentioned inspection, SNRIU issued individual permit No. EO 001018/2/15 for the initial criticality of the Neutron Source to KIPT on 1 July 2020.

The activities on Neutron Source initial criticality were started by KIPT on 29 July 2020.

In total, 30 fuel assemblies out of 35 planned were loaded into the core of the Neutron Source.

At the same time, the initial criticality was suspended due to damage of one of the fuel assemblies prepared for loading on 5 October 2020.

As of 31 December 2020, determination of the root causes of fuel assembly damage and development of appropriate corrective measures aimed at preventing such event recurrence were not completed.

Westinghouse Nuclear Fuel

Until 2005, all nuclear fuel used at NPP units was exclusively of Russian production.

In order to avoid dependence on a monopoly supplier and diversify nuclear fuel sources, Ukraine has started qualification of nuclear fuel produced by Westinghouse (FA-W, FA-WR), which is carried out in accordance with the Work Program within the Nuclear Fuel Qualification Project for Ukraine in compliance with the Executive Agreement between the Governments of Ukraine and the United States on the Nuclear Fuel Qualification Project for Ukraine of 5 June 2000.

Safety regulation of Westinghouse fuel implementation is carried out through the state NRS review and approval of documents of the operating organization on safety justification for the use of Westinghouse fuel and modification of other systems important to safety, which are necessary for this fuel management.

As of 31 December 2020, the operation of Westinghouse nuclear fuel (FA-WR) is continued in the cores of 6 power units of Ukrainian NPPs: SUNPP-2, SUNPP-3, ZNPP-1, ZNPP-3, ZNPP-4 and ZNPP-5, and the cores of SUNPP-2, SUNPP-3 and ZNPP-5 are loaded exclusively with Westinghouse nuclear fuel.

It should be noted that on 30 September 2020, an agreement was signed between Energoatom and Westinghouse on nuclear fuel supply for RNPP units with VVER-440/213.

Spent Fuel Management Facilities

In the NPP process cycle, one of its important components is management of spent nuclear fuel (SNF) generated during operation of power units.

The period of nuclear fuel use in reactors is determined by the permissible burnup for fissile isotopes. After reaching the planned burn-up depth, nuclear fuel is unloaded from the reactor and is considered spent, since it cannot be directly used for energy production.

After unloading from the reactor core, SNF is reloaded into reactor spent fuel pools. In these pools, spent nuclear fuel is stored for the time required to reduce energy release caused by radioactive decay of fission products to permissible values. After SNF storage in SFP for a limited period, spent fuel assemblies (SFA) should be removed from the NPP unit and sent for storage (disposal) or reprocessing. This is due to the fact that SFP capacity of NPP units is limited and there should be always a free volume in them for nuclear fuel unloading from the reactor core or periodic inspections of the VVER reactor pressure vessel and internals.

At the same time, during SNF management, it is necessary to consider the factors determined by this material specifics: high level radioactivity and presence of valuable components in SNF (uranium, plutonium, germanium, erbium, palladium, zirconium, etc.), which in the future can be used also in other nuclear cycles (nuclear fuel for fast neutron reactors, MOX fuel for light water reactors). Considering the above, spent nuclear fuel does not belong to radioactive waste.

The current state of nuclear energy in the world shows that under the current technology development level, no final conclusions can be made on the economic feasibility of SNF reprocessing or disposal, that is, on the final stage of the nuclear fuel cycle (NFC). In this regard, in Ukraine, as in most countries developing nuclear energy, a “deferred decision” was introduced, which

provides long-term SNF storage. This approach will allow making a decision on the NFC final stage later, taking into account the development of technologies in the world and economic benefits for the state.

Currently, two temporary spent fuel storage facilities are operated in Ukraine: wet spent fuel storage facility – ChNPP ISF-1 and ZNPP dry spent fuel storage facility (DSFSF).

In addition, two more storage facilities are being constructed in Ukraine: dry spent fuel storage facility – ChNPP ISF-2 and centralized VVER spent fuel storage facility – CSFSF.

VVER Spent Nuclear Fuel Management

ZNPP was the first to face the lack of free places in SFP of NPP units for SNF. Solving this issue, ZNPP started in 1996 implementing the DSFSF project.

The DSFSF project was developed upon the licensed and repeatedly tested SNF storage technology of the Duke Engineering & Services (USA). The principle of SNF storage is as follows: 24 fuel cartridges with low energy release (<1 kW) after 5 years of storage in SFP are placed in a special basket, filled with helium (inert gas with high thermal conductivity) and sealed, then the basket is placed in a concrete ventilated storage cask (hereinafter - VSC). The storage facility is designed for 380 VSC, in which 9000 cartridges with SNF can be placed.

DSFSF Stage 1 with a capacity of 100 VSC was commissioned in 2001, and Stage 2 with a capacity of 280 VSC - at the end of 2011.

During 2020, SNRIU considered and agreed 4 technical solutions “On the content of loading multiplace sealed baskets with spent nuclear fuel”.

As of 31 December 2020, there are 163 ventilated concrete casks at DSFSF site.

In contrast to ZNPP, SNF of RNPP, KhNPP and SUNPP are currently transferred to the Russian Federation: SNF of VVER-1000 - for storage and SNF of VVER-440 (RNPP-1, 2) for processing.

In 2007, *the Energoatom* developed the Feasibility Study for Investments in the Construction of the Centralized Storage Facility for Spent Fuel of National VVER NPPs (the feasibility study), which was approved by Ordinance

of the Cabinet of Ministers of Ukraine No. 131-r of 4 December 2009 after a comprehensive state review.

These feasibility study proved the economic feasibility of long-term SNF storage in Ukraine compared with its transfer for processing to the Russian Federation and justified the construction of one centralized SNF storage facility compared to any other options for SNF storage.

On 9 December 2012, the Verkhovna Rada of Ukraine adopted the Law of Ukraine "On Spent Nuclear Fuel Management in Terms of Siting, Design and Construction of a Centralized Storage Facility for Spent Fuel of National VVER NPPs", which, among others, determined the territory of its location in the exclusion zone.

On 23 April 2014, by Ordinance No. 399-r, the Cabinet of Ministers of Ukraine issued a permit to Energoatom to develop a land management project for the allocation of land plots with a total area of 45.2 hectares located between former villages Stara Krasnytsia, Buryakivka, Chystogalivka and Stechanka, Kyiv region in the exclusion zone of the territory that was radioactively contaminated due to the Chornobyl accident, and with the subsequent provision of them to the mentioned enterprise for permanent use with a change in the purpose for CSFSF construction and branch railway.

On 3 November 2016, Ordinance of SNRIU Board No. 08 approved the Conclusion of the State Review on Nuclear and Radiation Safety of the Preliminary Report on CSFSF Safety Analysis.

On 7 June 2017, by Ordinance No. 380-r, the Cabinet of Ministers of Ukraine approved project "Construction of the Centralized Storage Facility for Spent Fuel of National VVER NPPs".

No.	Parameter	Number (fuel assemblies)
1	Design capacity	**16529**
1.1	VVER-1000 FAs	**12010**
1.2	VVER-440 FAs	**4519**
2	Design capacity of startup stage	**3616**
2.1	VVER-1000 FAs	**2511**
2.2	VVER-440 FAs	**1105**

Table. Main CSFSF technical characteristics

Activities on the CSFSF construction project are carried out in accordance with the conditions of License series EO No. 001060 to conduct “construction and commissioning of a nuclear facility: spent fuel storage facility (CSFSF)” issued by SNRIU on 29 June 2017.

Safety regulation of this storage facility construction and commissioning is provided by SNRIU through state NRS review and approval of technical specifications and design documents for systems and equipment important to CSFSF safety according to the established procedure, as well as NPP unit modification projects within their preparation for SNF unloading by equipment developed according to Holtec International technology.

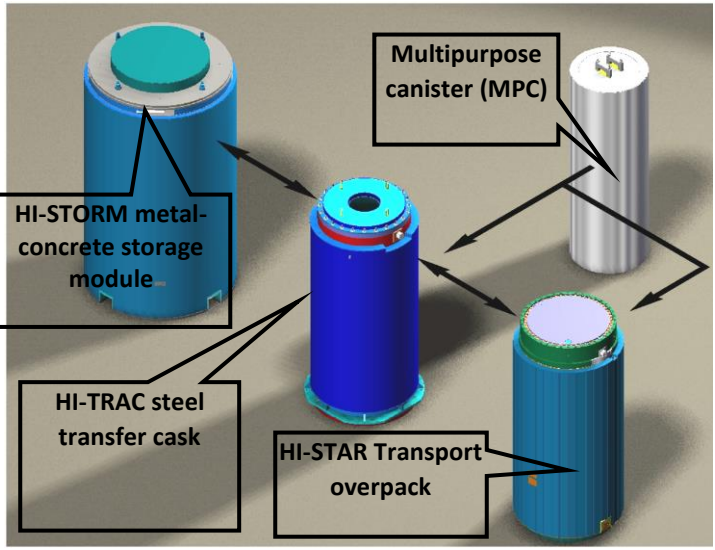


Figure. Main CSFSF equipment

As of 31 December 2020, in accordance with the CSFS Licensing Plan, SNRIU:

1. Pre-approved 17 technical specifications for equipment important to safety out of 17 developed according to the project.
2. Agreed 16 programs for testing equipment important to safety out of 17 developed according to the project.

3. Finally agreed 10 technical specifications for equipment important to safety out of 17 developed according to the project.

4. Conclusions of State NRS Review of modification projects were approved for:

- Rivne NPP Units 1, 2;
- Rivne NPP Units 3, 4;
- Khmelnitsky NPP Units 1, 2.

5. Manufacturing, testing (with the participation of a regulatory body representative) and supply of the main equipment important to safety is underway, in particular:

- MPC-31 multi-purpose canister: 3 were supplied to the customer (*the Energoatom*);
- MPC-85 multi-purpose canister: 1 MPC-85 was supplied to the customer;
- HI-STAR transport overpack: 1 overpack out of 5 envisaged by the project was supplied to the customer, 1 more is under preparation for factory acceptance tests;
- HI-STORM storage module: manufactured, factory acceptance tests were conducted of four HI-STORM provided by the project of the CSFSF Startup Package (SP): 3 for VVER-1000 SNF and 1 for VVER-440 SNF.

6. The following support equipment of systems important to safety was manufactured, duly tested and supplied to the customer:

- docking device;
- device for lifting MPC inner cover;
- device for lifting MPC with SNF;
- bracket of the device for MPC lifting;
- HI-STAR lifting beam;
- HI-TRAC lifting beams;
- additional radiation protection shield for HI-TRAC.

On 18 December 2020, SNRIU received an application from *the Energoatom* for amending license EO 001060 to carry out activities at life stages “construction and commissioning of the Centralized Storage Facility for Spent Fuel of National VVER NPPs (CSFSF)” in terms of supplementing the list of positions, in which performance of organizational and administrative

functions related to CSFSF NRS is possible only if the SNRIU license obtained according to the established procedure is available.

RBMK Spent Nuclear Fuel Management

RBMK (high-power channel reactor) design provided the following SNF management plan:

- after being used in the reactor, nuclear fuel was reloaded into reactor SFP, where it was stored for at least 1.5 years to reduce radioactivity and residual heat release;
- after storage in SFP, RBMK fuel is transferred to wet spent fuel storage facility.

Until 10 September 2020, all ChNPP SNF was stored in ISF-1 SFP. After the start of ISF-2 commissioning, a part of SNF was transported to ISF-2 for storage.

At ChNPP-1, 2, 3, SNF is absent and further use of SFPs of these units for SNF storage is not foreseen.

There is no fresh nuclear fuel at the ChNPP site.

Chornobyl NPP Interim Spent Fuel Storage Facility (ISF-1)

ISF-1 is operated in accordance with the conditions of SNRIU License series EO No. 000859 to conduct activities at life stage "operation of a nuclear facility: spent fuel storage facility" of 25 June 2008.

In the period from 14 April to 6 June 2016, State Specialized Enterprise "Chornobyl NPP" (ChNPP), in accordance with the conditions of an individual permit series OD No. 000040/9 issued by SNRIU on 14 April 2016 transported all damaged SNF stored in SFPs of Units 1; 2 to ISF-1.

Currently, the operating organization of ChNPP is implementing measures aimed at eliminating deviations from the requirements of new regulation NP-306.2.221-2019 "Safety Requirements for Nuclear Fuel Management".

Figure. ISF-1 room with SFP canyon for storage of damaged SNF

At the same time, ISF-1 lifetime determined upon the results of the safety review performed in 2015 expires at the end of 2025. Therefore, to ensure long-term safe storage of all SNF at the ChNPP site, a new dry storage facility is being established.

Chornobyl NPP Interim Spent Fuel Storage Facility (ISF-2)

ISF-2 is designed for acceptance, preparation for storage and directly long-term storage (within 100 years) of all spent fuel accumulated during ChNPP operation.

ISF-2 project is financed with the Nuclear Safety Account established by donor countries.

Activities on ISF-2 construction completion and commissioning are performed by ChNPP in accordance with the conditions of License EO No. 001002 to perform ISF-2 construction and commissioning issued by SNRIU on 20 February 2013.

Safety regulation of construction and commissioning of this storage facility is implemented by SNRIU through state NRS review and approval of the following:

- technical specifications for systems and equipment important to safety;
- testing programs for systems and equipment important to safety and direct participation of SNRIU representatives in testing these systems and equipment;
- ISF-2 operational and technical documents (operating procedures, operating instructions, etc.).

As of 31 December 2020, SNRIU in accordance with the ISF-2 Licensing Plan: finally agreed 28 technical specifications for equipment important to safety out of 41 developed according to the project, and 4 technical specifications for systems important to safety out of 7 developed according to the project.

On 25 August 2020, SNRIU made a decision to issue an individual permit No. EO 001002/1/15 to ChNPP for commissioning an intermediate spent fuel storage facility.

On 10 September 2020, ChNPP in accordance with the conditions of this individual permit, the following activities and operations were initiated:

- SNF unloading from ISF-1;
- preparation, loading, transfer from ISF-1, transport to ISF-2, unloading of spent fuel at ISF-2;
- activities and operations during ISF-2 commissioning.

The ISF-2 commissioning program envisages full loading and installation for storage of two double-walled dry shielded canisters (DSC).

The first DSC was installed for long-term storage on 18 November 2020 and the second one on 14 December 2020.

Start of ISF-2 operation is planned by ChNPP in the second quarter of 2021.

NPP Operational Events

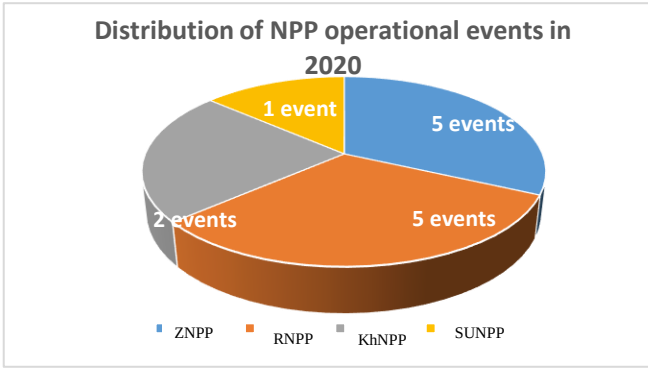
Accounting and analysis of NPP operational events is an integral part of the operational experience feedback system, which in turn is a separate issue of NPP safe operation.

During the year, SNRIU received and considered 19 informational messages on events occurred at Ukrainian NPPs:

- 13 – on NPP operational events;
- 6 – deviations in NPP operation.

Since 2007 only 1 operational event was recorded at ChNPP (3 July 2013), statistical data on NPPs in commercial operation are provided further in the report.

The events occurred in 2020 were categorized by the International Nuclear Event Scale (INES):



- P03 "Inoperability of safety systems or safety system trains in the amount that violates their redundancy" - level 1 – 1;

- P05/1 "Reactor shutdown with scram (preliminary protection) or reactor power limiter during operation of the power unit caused by: failures of equipment (components); human errors and/or erroneous decisions, natural or man-induced external events"- 3;

- P05/2 "Disconnection of the power unit from the grid with automated emergency systems, protection of the turbine unit and turbine generator during operation of the power unit caused by: failures of equipment (components); human errors and/or erroneous decisions, natural or man-induced external events" - 4;

- P08 "NPP power decrease to 25 % and more of the previous power level caused by: failures of equipment (components); human errors and/or erroneous decisions, natural or man-induced external events"- 3;

- P09 "Actuation of any safety system or safety system train in standby in any reactor operating state that has not led to incidents of categories P05, P07/1, P07/2 and P08" – 1;

- P10 "Inoperability of safety system train(s) for a period not exceeding that allowed by the Technical Specifications for Safe Operation" – 1.

A significant part (84.6%) of NPP operational events occurred during the year led to reactor shutdown, unloading or disconnection of the power unit from the grid (categories P05, P08). This reduces the residual design life for equipment of systems important to safety and decreases the regulated number of load cycles of reactor components.

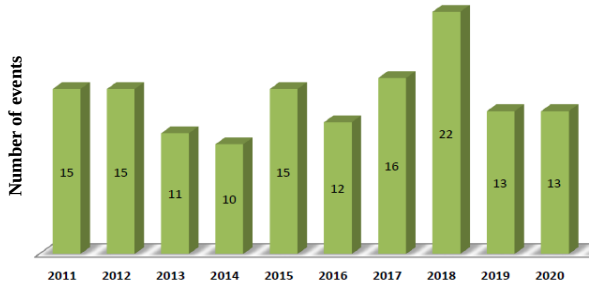


Figure. Dynamics of operational events at Ukrainian NPPs (without ChNPP events) from 2011 to 2020

Abnormal Occurrences

Abnormal occurrence is a deviation from normal operation that may be caused by failure of equipment, external impact, human error or procedural drawbacks. Several abnormal occurrences can be detected during an event. The event investigation commission identifies direct and root cause of each abnormal occurrence.

Abnormal occurrences are divided into three groups:

1) abnormal occurrences caused by equipment failure.
2) abnormal occurrences caused by procedural drawbacks.
3) abnormal occurrences caused by human error.

During 13 operational events at Ukrainian NPPs in 2020, 18 abnormal occurrences were recorded. Their analysis revealed that 52% of abnormal occurrences were associated with equipment failures, 22% with procedural drawbacks, and 13 with human errors. For 13% of abnormal occurrences during NPP operational events, the event investigation commissions did not identify root causes.

III. EMERGENCY PREPAREDNESS AND RESPONSE

Maintaining an adequate level of emergency preparedness and response to nuclear and radiation incidents is one of the fundamental safety principles in the use of nuclear energy, which were met on a priority basis at the national and international levels, even under the pandemic.

According to the Resolution of the Cabinet of Ministers of Ukraine No. 450 of 6 June 2018, the SNRIU is the central executive body that forms a functional subsystem of nuclear and radiation safety of the unified state civil protection system (USCPS). This component of USCPS, except SNRIU and SSTC NRS, includes all nuclear entities, since they ensure failure-free operation during their activities by meeting NRS requirements and licensing conditions.

SNRIU improves its own system of preparedness for response and provides oversight of licensees' emergency preparedness by agreement of emergency plans, review of safety assessment reports, inspections and regulatory assessment of training.

In 2020, webinars have become a new format for educational and training events to support response preparedness capabilities. For the first time, such a remote event using the Webex platform was organized and held on 1 April 2020 jointly with the IAEA Incident and Emergency Center (IAEA IEC) for representatives of central executive authorities, organizations and institutions with responsibilities for emergency response to nuclear and radiological emergencies. To establish interagency cooperation, a wide range of participants are provided with the data on up-to-date international warning and information exchange systems, procedures to provide assistance at the request of member countries and coordinate actions with other international organizations within the Joint Plan of International Organizations for Radiation Accident Management, approaches to assessment, predicting development of events and informing civil society in the event of real radiological hazards, or those that are perceived by society as potential threats.

In addition to the personnel of the SNRIU Information and Emergency Center (SNRIU IEC), experts of the State Scientific and Technical Center for Nuclear and Radiation Safety, State Emergency Service of Ukraine, Ministry of Internal Affairs, Ministry of Energy and Coal Industry of Ukraine, Ministry of Environmental Protection and Natural Resources of Ukraine, State Agency of Ukraine on Exclusion Zone Management, Ukrainian Hydrometeorological Center, operating organizations of nuclear facilities, other licensees took part in the activities to support emergency preparedness. Training courses on emergency preparedness are freely available on the IAEA website at: https://www.iaea.org/ru/temy/avariynaya-gotovnost-i-reagirovanie.

Under cooperation with the Joint Research Center of the European Commission (JRC), webinar "Radiation monitoring and early warning systems of EU" was organized and held on 7 July 2020. Technical, organizational and legal conditions for accession of Ukraine to the ECURY system established by EU to support emergency response to nuclear and radiological emergencies require additional development at the interagency level

Other events and measures aimed at supporting the capabilities of effective response include:

- approval and signing of the Protocol on Implementing Procedures for Prompt Notification of Nuclear Accidents and Information Exchange on a Nuclear Facility between the State Nuclear Regulatory Inspectorate of Ukraine and Norwegian Radiation and Nuclear Safety Authority on 3 December 2020;
- development of scenarios and programs of two exercises, which provide verification and testing of interaction procedures at the interagency, state and international levels with the support of the Norwegian Radiation and Nuclear Safety Authority (exercises due to quarantine restrictions were postponed to 2021);
- revision, taking into account the latest IAEA publications and up-to-date tools of international information exchange, and approval of updated job descriptions for IEC personnel on 19 December 2020.

The draft General Emergency Plan of the Centralized Radwaste Management Enterprise (CRME), emergency plans for radwaste processing and storage of Radon subsidiaries, emergency plans of the NSC-Shelter and ISF-2, Provisions on Preparation, Conduct and Assessment of Joint General Plant Emergency Exercises of the Chornobyl NPP were considered and approved within the licensing process.

Pursuant to the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Event of a Nuclear Accident or Radiological Emergency in accordance with paragraph 2 of Resolution of the Cabinet of Ministers of Ukraine No. 1570 of 2 October 2003 "On Determining the Competent National Authorities to Comply with International Conventions in Nuclear Energy Use" and relevant intergovernmental bilateral treaties with other countries, SNRIU:

1) provides round-the-clock duty and communication maintenance in accordance with the Regulations for Interaction of the Monitoring Group of Nuclear Facilities of the Emergency Response, Communication and Information Technology Service of the Emergency and Technical Center of Energoatom with SNRIU;

2) prepares information reports on NPP unit condition, reports on NPP operational events, posts them on the SNRIU official website and sends monthly statistical reports to the Cabinet of Ministers of Ukraine;

3) analyzes information messages on incidents occurred in other countries within the INES-NEWS international information system and the Unified System for Information Exchange in Incidents and Emergencies (USIE);

4) provides information exchange with the IAEA and competent authorities of other countries in the framework of emergency training, exercises and real events;

5) tests communication with competent authorities and/or communication points of other countries within the intergovernmental

agreements on prompt notification of nuclear accidents, information exchange and cooperation in the area of nuclear safety and radiation protection;

6) provides the participation of Ukraine in 3 IAEA international exercises: ConvEx-2a (12 May 2020), ConvEx-2b (24-26 March 2020) and ConvEx-2c (9 December 2020) with partial activation of the SNRIU IEC and interaction with the State Emergency Service of Ukraine (SESU) and Ukrainian Hydrometeorological Center;

7) provides participation of SNRIU personnel in international emergency exercises without IEC activation: ConvEx-1a (14 October 2020) and ConvEx-1b (10 March 2020) to test continuous availability of national communication points and ability of national competent authorities to respond promptly to notifications and to check access rights to the USIE web portal;

8) provides participation in the 10th meeting of representatives of the competent authorities under the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Event of a Nuclear Accident or Radiological Emergency, which was held online from 15 to 19 June 2020 with the presentation of assessment results for radiological consequences of fires in the exclusion zone occurred in April 2020;

9) provides participation in IAEA workshop "Implementation of the IRMIS International Radiation Monitoring Information System" with a presentation of topic "Secondary increase of radioactive cesium-137 in the surface air as a result of forest fires in the ChNPP exclusion zone". The workshop was also attended by experts from the Center for Prediction of Radiation Accident Consequences of the Ukrainian Hydrometeorological Center with presentation "Radiation monitoring system of Ukraine and communication with international information systems".

The SESU Ukrainian Hydrometeorological Center provides transfer of the measurement data of gamma radiation equivalent dose rate from NPP ARMS points, exclusion zone, from the radiometric observation network of the hydrometeorological service to the IAEA IEC IRMIS system on a daily basis.

The SNRIU is responsible for the transfer of radiation monitoring data to the IAEA IEC under emergency mode.

For reference: The IRMIS International Radiation Monitoring Information System was established by IAEA to support implementing the Convention on Early Notification of a Nuclear Accident as a mechanism for the global exchange of large amounts of radiation monitoring data. IRMIS helps competent authorities, international organizations and IAEA IEC to exchange information during a nuclear or radiological emergency and analyze radiation monitoring data to assess hazards, determine protective actions, inform the public and support transparency of data processing.

Under interaction coordination of IAEA and other international organizations working in NRS area, SNRIU analyzed the information of IAEA Thematic Safety Area (TSA) No. 4 "Radiation protection of the public and the environment", which is one of the thematic safety areas within the IAEA Radiation Safety Information Management System (RASIMS) as a basis to continue forming a unified state automated radiation monitoring system in Ukraine by integration of existing facility and departmental systems based on up-to-date information technologies.

In order to implement the priority tasks and measures of the Annual National Program under the auspices of the NATO-Ukraine Commission for 2020 approved by Decree of the President of Ukraine No. 203/2020 of 26 May 2020, SNRIU in cooperation with other executive bodies implements current European HERCA-WENRA approaches to responding to nuclear and radiological emergencies, which are based on early notification mechanisms, agreed criteria and procedures for implementing protective measures and assessing transboundary impact and require strengthening of interagency coordination mechanisms.

According to the HERCA-WENRA approach, assessment of radiological consequences in different countries should be harmonized. To achieve this goal and provide scientific and technical support to the SNRIU in the performance of emergency response and assessing compliance of protection measures with

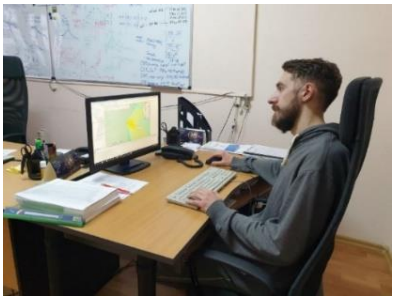
existing radiation risks, SSTC NRS participates in the following international projects:

Benchmarking on Assessment of Radiological Consequences (BARCO) – comparative analysis of the results of predicting radiological consequences performed by a number of software tools and assessment of approaches to the use of existing software tools and methodological approaches.

IAEA Coordinated Research Project CRP J15002 – Effective Use of Dose Projection Tools in the Preparedness and Response to Nuclear and Radiological Emergencies, which develops recommendations on the joint use of decision support systems and mobile laboratories.

EC Project INSC U3.01/18 (UK/TS/58) Assistance to Ukrainian Regulatory Body - Task H2 "Implementation of the HERCA-WENRA approach to improve interstate coordination of protective actions in the event of a nuclear accident" by:

- review of the current status of implementing the JRODOS decision support system in SNRIU IEC and identification of existing gaps in terms of collecting and preparing data necessary to model and interpret relevant results;
- development of requirements for completeness and format of the input data necessary for radiation impact assessment using JRODOS decision support system in SNRIU IEC, improvement of information exchange with other platforms or systems (ECURIE, USIE, IRMIS) taking into account European experience;



- comparison of the results of atmospheric dispersion modeling and prediction of exposure doses for the public on the basis of several emergency models using a chain of models of local transfer of the JRODOS (RIMPUFF, DIPCOT and LASAT) decision support system and recommendations on their application by SNRIU IEC experts.

Response to Fires in Natural Ecosystems of the Exclusion Zone

SNRIU provided response to real events that did not directly affect safety of nuclear facilities and activities in nuclear energy use, but caused increased media attention and public concern and required appropriate information support, in particular due to fires in natural ecosystems of the exclusion zone occurred from April to May 2020.

Under cooperation with SSTC NRS, Ukrainian Hydrometeorological Center, Ukrainian Hydrometeorological Institute, Central Geophysical Observatory, Energoatom, Radon, ChNPP and Ecocenter, the analysis and prediction of situation progression was provided for international information exchange, assessment of potential radiological consequences and informing the public and the media through the SNRIU official website.

The analysis of measurement results of radiation characteristics indicates that the event did not have significant radiological consequences for the public and the environment outside the exclusion zone and was not accompanied by additional radioactivity releases into the environment in the existing exposure situation due to the Chornobyl accident of 1986. At the same time, fires in natural ecosystems in radiation contaminated areas were accompanied by a secondary increase of artificial radionuclides accumulated in vegetation and soils, their transport (mainly ^{137}Cs) over considerable distances, as reported by the regulatory authorities of European countries (in particular, IRSN report of France).

Taking into account the lessons of responding to these events, SNRIU initiated implementation of the unified IRIX format for international information and radiation monitoring data exchange. Relevant amendments were made to the format of providing the information of the Ecocenter to SAUEZM, as well as backup data transmission channels were exercises from RNPP in IRIX format to IAEA IEC for emergency modes and training.

IV. RADIOACTIVE WASTE MANAGEMENT

Management of Radioactive Waste in Exclusion Zone

The Centralized Radioactive Waste Management Enterprise (CRME), appointed as operating organization at all lifecycle stages of radioactive waste disposal facilities, implements its priority activities related to radioactive waste management in Exclusion Zone (except for ChNPP site) and also radioactive waste processing and long-term storage, in particular:

- operation of two symmetric modules of engineered near-surface disposal facility for solid radioactive waste (ENSDF) constructed at Vektor site;
- operation of 21A Buryakivka Radioactive Waste Disposal Site (RWDS);
- maintenance of existing management facilities for Chornobyl-origin radioactive waste constructed during the first years of Chornobyl accident mitigation: Buryakivka RWDS, Pidlisny RWDS, ChNPP Stage III RWDS (including their monitoring, upgrade, stabilization, safety improvement, inspection, safety review, remediation) and also maintenance, inspection, monitoring and elimination of trenches and pits of radwaste interim confinement sites (RICS) in Exclusion Zone;
- operation of Vektor CLTSF (in part of comprehensive ("hot") tests with the use of radioactive waste in the form of disused radiation sources of different types);
- radioactive waste transport.

The following is planned in Exclusion Zone in compliance with Radioactive Waste Management Strategy:

- commissioning of engineered near-surface disposal facilities for low- and intermediate level short-lived radwaste, generated as a result of Chornobyl disaster, of two types: SRW-1 designed for radioactive waste disposal in reinforced concrete containers, and SRW-2 – module for unpacked and large-size radioactive waste disposal;

- design and construction of pre-disposal long-term storage facilities (over 30 years) for long-lived high-level radioactive waste in geological repository within Vektor Stage 2 including vitrified radwaste;
- selection of site for geological repository for long-lived high-level radioactive waste disposal.

Engineered Near-Surface Disposal Facility for Low- and Intermediate-Level Short-Lived Waste

ENSDF was constructed in 2009 in the framework of the project of ChNPP Industrial Complex for Solid Radioactive Waste Management (ICSRM) designed for disposal of radioactive waste packages of ChNPP Liquide Radioactive Waste Treatment Plant (LRTP) and Solid Radioactive Waste Treatment Plant (SRTP). The disposal facility consists of two parallel sections, each includes 11 reinforced concrete sections (modules) arranged with the central drainage gallery, two movable frame structures with bridge cranes. The disposal facility capacity makes 50210 m^3 of radwaste packages.

In compliance with separate technical decisions agreed with the SNRIU, in addition to ChNPP radwaste ENSDF accepts radioactive waste of other waste generators.

In 2020, the State Specialized Enterprise "Central Enterprise for Radioactive Waste Management" continued filling of two symmetric modules in ENSDF (A1 and D1) in compliance with the license for operation of radioactive waste disposal facility. Since the beginning of operation, ENSDF accepted for disposal 1343.01 m^3 of radwaste packages with total activity of 8.68E+12 Bq. The first two layers of radwaste packages in A1 and D1 modules were concreted.

Measures on control of the state of building structures of disposal facility modules and central drainage gallery arranged under disposal facility are implemented in the framework of disposal facility operation. Also, contemporary ENSDF safety assessment methodologies are implemented.

Figure. ENSDF

Figure.
Concreting of layers in ENSDF sections

Buryakivka Radioactive Waste Disposal Site (RWDS)

Buryakivka RWDS includes 30 near-surface radioactive waste disposal facilities (trenches). All 30 trenches are totally filled and preserved. Additional 21A disposal facility (trench) was constructed in 2018 to expand production capacities of Buryakivka RWDS.

In 2020, CRME continued the operation of 21A disposal facility at Buryakivka RWDS and also maintenance of 30 preserved radioactive waste disposal facilities (trenches) in the framework of the license for operation of radioactive waste disposal facilities.

The total amount of radioactive waste in 30 trenches at Buryakivka RWDS makes 690,000 m^3 and total activity makes 2.54E+15 Bq. 19378.50 m^3 of radioactive waste with total activity of 1.63E+12 Bq were accepted for disposal to trench 21A at Buryakivka RWDS as of the end of 2020.

Pidlisny RWDS and ChNPP Stage III RWDS

These disposal facilities were constructed in 1986-1988 under the primary measures aimed at Chornobyl accident mitigation.

During 2020, CRME conducted routine activities to ensure safety of radioactive waste disposal facilities at Pidlisny RWDS and ChNPP Stage III RWDS.

In 2020, plugging of the wells arranged in the eastern wall of A-1 module of Pidlisny RWDS was conducted in compliance with technical decision agreed with the SNRIU.

Figures. Pidlisny RWDS and ChNPP Stage III RWDS

Radwaste Interim Confinement Sites (RICS)

RICS are territories adjacent to ChNPP with a total area of about 10 hectares on which trenches and pits for radwaste confinement were constructed during the emergency measures aimed at Chornobyl accident mitigation. Such radwaste are mainly building structures, household items, upper layer of the soil, etc., contaminated in emergency release. Nine RICS are located on the territory of the exclusion zone: Yaniv Station, Naftobaza, Pischane Plato, Rudy Lis, Stara Budbaza, Nova Budbaza, Prypiat', Kopachi and Chystohalivka. Estimated quantity of RICS

trenches and pits is from 800 to 1000. It is necessary to clarify exact location of the part of these trenches.

CRME conducts RICS survey considering the level of hazardous environmental impact to eliminate the most hazardous trenches and pits.

According to the investigation results, radwaste from the most hazardous RICS trenches and pits was redisposed in Buryakivka RWDS. In 2020, 4750 m^3 of radioactive waste were redisposed in compliance with "Technical Decision on Redisposal of Radioactive Waste from T107, T108, T109 Trenches at Nova Budbaza RICS and Adjacent Territory" agreed with the SNRIU.

Radioactive Waste Disposal Facilities: SRW-1 and SRW-2 at Vektor Site

Two near-surface facilities for SRW disposal with a total capacity of 19 200 m^3 are at final stage of construction at Vektor site:

- SRW-1 is a facility for disposal of short-lived low- and intermediate-level radwaste in reinforced concrete containers (acceptance capacity is of 9800 m^3);
- SRW-2 is a facility for disposal of short-lived low- and intermediate-level large and bulk radwaste, radwaste in drums, craft bags, cargo cages (acceptance capacity of 9400 m^3).

In 2020, in view of termination of activity of the State Specialized Enterprise for Capital Construction Management of the Exclusion Zone (CCMEZ) and as a result of this enterprise reorganization by means of its integration into CRME, the CCMEZ license for construction of radioactive waste disposal facilities: SRW-1 and SRW-2 at Vektor site, was reissued for CRME (as legal successor).

In compliance with the license conditions CRME performed works related to inspection of the current state of buildings and equipment and maintenance. Also, there were developed the programs of acceptance tests of systems and equipment important to safety of radioactive waste disposal facilities (SRW-1 and SRW-2) and infrastructure.

Figure. SRW-1 and SRW-2

Centralized Long-Term Storage Facility for Disused Radiation Sources (CLTSF)

CLTSF is a key element in improving the entire system for the management of radiation sources in Ukraine. CLTSF shall ensure centralized location of radioactive waste in the form of disused radiation sources of different types and structures that are currently accumulated on sites of RADON ASSOCIATION specialized radwaste management facilities and radiation sources used in medicine and industry after being transferred into a category of radioactive waste.

CLTSF operation includes acceptance, processing (conditioning) of radioactive waste, waste as disused radiation sources of different types and categories and placement of prepared packages containing such radwaste according to radiation type for long-term storage during 50 years.

During 2020, CRME continued conduction of CLTSF comprehensive hot tests with the use of disused radiation sources.

21167 disused radiation sources with total activity of 1.36E+14 Bq were accepted for storage since the beginning of CLTSF operation.

In compliance with the schedule agreed with the SNRIU, 100 disused radiation sources with total activity of 8.31E+11 Bq were accepted for storage during 2020.

Figure. Centralized Long-Term Storage Facility for Disused Radiation Sources

Figure. Section for storage of disused radiation sources at CLTSF

Construction and Commissioning of the Long-Term Storage Facility for Vitrified High-Level Waste Resulting from Reprocessing of VVER-440 Spent Fuel to Be Returned from the Russian Federation

In April 2020, considering the results of the comprehensive state review and positive conclusion of the state review on NRS, implementation of the project "Construction of the interim spent fuel storage facility for vitrified high-level waste (HLW) returned from the Russian Federation after reprocessing of spent fuel from Ukrainian NPPs" was approved by the Order of the State Agency of Ukraine on Exclusion Zone Management.

The project envisages construction of the long-term storage facility for vitrified HLW (VITR-HLW) resulting from reprocessing of Rivne NPP VVER-440 spent fuel that will be returned from the Russian Federation.

The VITR-HLW is designed for vitrified HLW acceptance, preparation and long-term storage. Design capacity of the VITR-HLW constitutes 260 m^3 of HLW. This facility storage module includes: 4 working sections and 2 backup sections. Four working sections includes 224 cells for HLW (each cell

contains two packages with three 200-liter barrels each) what is enough for 260 m^3 of HLW.

HLW acceptance period envisaged by the design makes 15 years and HLW storage period makes 100 years.

In 2020, based on the results of consideration of application and attached documents, the SNRIU decided to issue for CRME a license for radioactive waste processing and storage according to which CRME is allowed to build long-term storage facility for HLW returned from the Russian Federation after reprocessing of spent fuel from Ukrainian NPPs with VVER-440 and infrastructure at the storage facility site which is technologically interconnected to the storage facility.

Figure. Overall layout of the Storage Facility for Vitrified HLW

Construction of Geological Repository for Radioactive Waste Disposal

In compliance with the Strategy for Radioactive Waste Management in Ukraine it is envisaged the construction of the repository for high-level and long-lived waste disposal in deep geological formations.

National Target Environmental Program for Radioactive Waste Management envisages tasks and measures on construction of such geological repository.

Project INSC U.04.01/14B "Development of the National Plan for the Geological Disposal of Radioactive Waste in Ukraine and its Implementation Schedule" was launched in 2018 in the framework of Commission's Instrument for Cooperation in Nuclear and Radiation Safety. State Agency of Ukraine on Exclusion Zone Management (SAUEZM) is the Beneficiary of this project, the End User is CRME. Project objective is to develop the national plan of actions on construction, operation and closure of geological repository in Ukraine. In 2020, the works under this project were continued.

The implemented measures were aimed at selection of sites for geological repository and development of design concept. As a result of fulfillment of

recommendations of the projects financed by European Union there was achieved progress in establishing national organization for radwaste management (CRME) which shall become national operator of geological repository in future. The CRME organizational structure includes geological repository team which shall implement the state policy on construction of geological repository in Ukraine.

Management of Radioactive Waste on Ukrainian Territory

Safe storage or disposal of radiation sources at the end of their lifetime is an important condition for their safe use in order to avoid their loss or access of the public.

Disused radiation sources are declared as radioactive waste and become the state property. Their further management is carried out by the state specialized enterprises on radioactive waste management of Ukrainian State Corporation RADON (USC RADON) subordinated to the State Agency of Ukraine on Exclusion Zone Management.

In April 2019, Resolution of the Cabinet of Ministers of Ukraine approved a decision on liquidation of Ukrainian State Corporation RADON. In this connection, SAUEZM established the State Specialized Enterprise RADON ASSOCIATION (RADON ASSOCIATION) by means of reorganization of Ukrainian State Corporation RADON. RADON ASSOCIATION includes Central Production Site located in Kyiv four regional affiliates located in Dnipro, Lviv, Odesa and Kharkiv. According to this reorganization, unbalanced affiliates were established using material and technical basis and human resources. These affiliates (State Interregional Specialized Plants) continue the activities of the following specialized radioactive waste management enterprises: Central Production Site; Dnipropetrovsk SISP; Lviv SISP; Odesa SISP; Kharkiv SISP.

In September 2020, the SNRIU reissued the licenses for radioactive waste processing and storage for Central Production Site, Dnipropetrovsk SISP, Lviv SISP, Odesa SISP and Kharkiv SISP of RADON ASSOCIATION.

In compliance with conditions of these licenses the Central Production Site, Dnipropetrovsk SISP, Lviv SISP, Odesa SISP and Kharkiv SISP of RADON ASSOCIATION perform the following:

- operation of facilities for solid radwaste storage in containers;
- maintenance, inspection and monitoring of closed radwaste disposal facilities that were filled in previous period (up to 1996) according to disposal technology;
- collection, conditioning and transport of radwaste to disposal facilities;
- operation of decontamination stations for overalls, underwear and individual protection means;
- keeping of state system for radwaste accounting;
- participation in mitigation of radiation.

Radwaste storage facilities operated by Central Production Site, Dnipropetrovsk SISP, Lviv SISP, Odesa SISP and Kharkiv SISP of RADON ASSOCIATION are hangar-type buildings for storage of radwaste and disused radiation sources in containers. These buildings were constructed at SISP sites in the 1990s after making a decision on SISP transfer to the radwaste storage technology.

Closed radwaste disposal facilities filled by 1996 in compliance with radwaste storage technology are a system of near-surface reinforced concrete module-type facilities with capacity of 200 m^3 and 400 m^3. They were constructed according to standard designs in the 1960s-1970s. RADON ASSOCIATION performs maintenance, monitoring and safety review of these disposal facilities to make decisions on safety of each specific facility, defines periods during which these facilities can ensure reliable radwaste isolation and makes process decisions on radwaste retrieval and closure of facilities.

Currently, RADON ASSOCIATION experts in cooperation with international experts develop technical decision on radwaste retrieval from the most problematic facilities in the framework of the European Union Project U4.01/14C "Comprehensive Safety Assessment of Radioactive Waste Management Sites Operated by Radon and Design of Remediation of Certain Sites".

The overall objective is to retrieve radioactive waste from RADON Kyiv SISP Storage Sites No. 5, 6, 7 since these sites are within the capital of Ukraine. During project implementation in 2019-2020, an international consultant developed the "Standard Solution for Radwaste Retrieval and Remediation of RADON Kyiv SISP Storage Sites No. 5, 6, 7" and "Safety Assessment of SRW Storage Facility No. 5 of RADON Kyiv SISP".

The proposed technical solutions to retrieve the abovementioned radwaste provide their preliminary sorting and placement in protective containers. This shall ensure their further safe storage before processing, long-term storage or disposal at Vektor facilities.

During 2020, the Central Production Site, Dnipropetrovsk SISP, Lviv SISP, Odesa SISP and Kharkiv SISP of RADON ASSOCIATION received radwaste from 66 nuclear entities which generates radioactive waste or waste resulted from mitigation of radiation accidents and incidents.

In 2020, RADON SISPs transferred to CLTSF 100 radiation sources for long-term storage. RADON SISPs are involved in emergency actions of competent authorities for mitigation of emergencies associated with the detection of orphan sources and radioactive materials in illicit trafficking.

All such radiation sources are transferred to the storage/disposal facilities of the Central Production Site, Dnipropetrovsk SISP, Lviv SISP, Odesa SISP and Kharkiv SISP of RADON ASSOCIATION where their safe and controlled storage, as well as localization from release to the environment and places accessible for the public is provided.

Legacy Radioactive Waste

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. Transfer of these legacy storage facilities to the ecologically safe state (remediation) by retrieval 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 implementation of this task, the Cabinet of Ministers of Ukraine has concluded an Implementation Agreement with NATO Support Agency for Management of Radioactive Waste resulting from implementation in Ukraine of military programs of the former USSR.

At the end of April 2020, in the framework of this agreement, LLC NT-ENGINEERING carried out activities on radwaste retrieval from Tsybuleve radwaste storage facility in Kirivogradskyy Region in compliance with agreed project and SNRIU license for processing of the radwaste from Kirivogradskyy Region.

24 m^3 of concreted radwaste stored inside three large size containers and also 4.62 m^3 of radwaste stored in the form of fragmented soil and structures inside seven big-bag type packages, which specific activity made 81.45 kBq/kg for Cs-137, 2.5 kBq/kg for Sr-90, 0.023 kBq/kg for Pu-239+240, were retrieved from Tsybuleve radwaste storage facility.

The abovementioned three containers with radioactive waste packages were transported to Exclusion Zone and located at specially equipped site on the territory of 100-1 Buryakivka RWDS; radwaste in the form of fragmented soil and structures were disposed at 21A Buryakivka RWDS.

After radwaste retrieval from the Tsybuleve storage facility, radiation survey of the site and access road was carried out. It showed that dose rate of gamma radiation, flux density of alpha-, beta-particles and neutrons on the surface of the working areas comply with remediation criteria and are within background

values. In corresponding soil samples obtained during excavation of storage facility pit, content of the main radionuclides also complies with background levels. Site remediation was completed on its territory: the pit was backfilled, trees were planted.

Upon completion of abovementioned works, LLC NT-ENGINEERING prepared the report on the results of the performed works in compliance with technical decision “Remediation of the Radwaste Disposal Facility Site in Ukraine. Radwaste Management at Tsybuleve Radwaste Storage Facility Site”. The SNRIU conducted analysis of this document and based on its results concluded that works on radwaste retrieval and site remediation were performed in compliance with technical documentation for safety justification agreed with the SNRIU. The final state of Tsybuleve Radwaste Storage Facility site complies with established radiation criteria.

V. CHORNOBYL NPP DECOMMISSIONING AND SHELTER TRANSFORMATION

Chornobyl NPP Decommissioning

The only operating organization in Ukraine having a license to perform activities at the stage of nuclear installation decommissioning is Chornobyl Nuclear Power Plant (ChNPP).

ChNPP Units No. 1, 2 and 3 are being decommissioned in accordance with License No. EO 000040, issued by the SNRIU on 22 March 2002.

On 3 November 2020, a decision was made to renew the above license. The reason for reissuing this license was the licensee's intention to amend the license, which requires conducting a review of the applicant's capability to comply with the conditions of the declared activity, in connection with:

- finalization of the operation termination stage and transition to the stage of final closure and safe enclosure (FCSE) (2015);
- completion of SNF transfer, including damaged fuel, to ISF-1 (2016);
- implementation of a decentralized heat supply system to cover the thermal energy needs of ChNPP buildings and structures (2016);
- completion of decommissioning of the Chornobyl NPP spent fuel pool (2019);
- the need to update the license wording.

The license validity period is until completion of decommissioning of the ChNPP nuclear facilities (tentatively until 2065, in accordance with the Law of Ukraine on the National Program for Decommissioning of the Chornobyl NPP and Transformation of the Shelter Object into an Environmentally Safe System).

The license conditions provide for the following decommissioning stages:

- operation cessation (completed);
- final closure and safe enclosure (provisionally by 2028));
- safe storage (provisionally until 2045);

- dismantling (provisionally until 2065).

At present, the FCSE stage of units No. 1, 2 and 3 is being implemented at the ChNPP, which is carried out in accordance with the individual License No. OD 000040/8 of 31 March 2015 issued by the SNRIU.

The ChNPP implements the FCSE stage in compliance with the Program for Implementation of the Final Closure and Safe Enclosure Stage at ChNPP Units 1, 2, 3 and the project Final Closure and Safe Enclosure of ChNPP Units 1, 2, 3.

As part of the FCSE stage, the ChNPP dismantles equipment that is not important for safety and is not subject to further safe storage.

A significant amount of radioactively contaminated materials and equipment that can be further exempted from regulatory control is generated during dismantling.

The activities on construction and commissioning of the facility for clearance of materials from regulatory control after their decontamination are ongoing at the ChNPP in the framework of a European Commission project.

Figure. Facility for clearance of materials from regulatory control

In 2020, as part of the trial operation of this facility, ChNPP developed standards, methodologies and procedures for clearance of materials from regulatory control. Based on results of the state NRS review, the SNRIU agreed these documents, namely:

- Trial Commercial Operation of the Facility for Clearance of Radioactive Materials from Regulatory Control;
- Decision of Nuclide Vector Application at the Stage of Trial Commercial Operation of the Facility for Clearance of Radioactive Materials from Regulatory Control;
- enterprise standards The Procedure for Preparation of Radioactive Materials for Clearance from Regulatory Control and The Procedure for Clearance of Radioactive Metal from Regulatory Control.

The operating organization has started trial commercial operation of the facility for clearance of radioactive materials from regulatory control.

Radioactive Waste Management Facilities at Chornobyl NPP

Radioactive waste accumulated during Chornobyl NPP operation and accident mitigation in 1986 and generated during decommissioning of Units 1, 2 and 3 and Shelter transformation into an environmentally safe system is stored in radioactive waste storage facilities at the Chornobyl NPP site: solid radwaste storage facility, liquid radwaste storage facility, solid and liquid radwaste storage facility, or is transferred for disposal to Buryakivka RWDS disposal facilities.

According to the ChNPP information, in 2020, 0.30 m^3 of liquid radwaste was generated and sent for temporary storage (filter perlite pulp). As of the end of 2020, 13143.89 m^3 of evaporation bottoms; 4114.82 m^3 of spent ion-exchange resins; 2298.08 m^3 of filter perlite pulp and sludge; 145.3 m^3 of contaminated oil-fuel mixture, were accumulated in liquid radioactive waste storage facilities.

Low- and intermediate-level solid radwaste generated during decommissioning and the Shelter transformation into an environmentally safe system was transferred to Buryakivka RWDS facilities for disposal. During 2020, 1500 m^3 (1746,32 t) of low-level radwaste was transferred to Buryakivka RWDS.

A series of radioactive waste management facilities were constructed and are being commissioned at the ChNPP site under international technical assistance projects. Commissioning of these facilities will allow processing of the accumulated and generated radwaste to bring it to the state acceptable for safe disposal.


Figure. LRTP and SRTP at the ChNPP site

The technological process involves the treatment of liquid radioactive waste in the form of evaporation bottoms in evaporators, pulp of spent ion-exchange resins, perlite pulp and sludge.

ChNPP currently processes evaporation bottoms at LRTP and performs preparatory activities for reprocessing of ion-exchange resins. The packages with concreted liquid radioactive waste are transferred after reprocessing for disposal in the engineered near-surface disposal facility for solid radioactive waste (ENSDF) in the exclusion zone.

Shelter Transformation into Environmentally Safe System

During 2019, the SNRIU implemented its priority activities such as safety assessment and licensing for the construction of the first startup package of the New Safe Confinement (NSC SP-1).

The design lifetime of the NSC is 100 years.

According to License EO 000033 for the Shelter operation issued by the SNRIU on 30 December 2001, ChNPP should receive an individual permit for NSC SP-1 trial commercial operation.

To carry out safety assessment of NSC SP-1 documentation, the SNRIU reviewed and agreed in 2020:

documents concerning seismic stability of the NSC main crane system;

Tightness Analysis of the NSC Main Protective Structure for Compliance with Requirements of Design Documentation. Explanatory Note;

Shelter NSC Emergency Plan;

Technical Decision on Selection the Option for Reconstruction of the Part of the Shelter Deaerator Stack and Turbine Hall Protruding Beyond the NSC Enclosing Circuit.

In June 2020, the ChNPP submitted to the SNRIU an application and updated documents for issuance of an individual permit for trial commercial operation of the NSC SP-1. Based on the review results of the submitted documents, a positive conclusion of the state NRS review was prepared.

In the period from 14 to 17 July 2020, the SNRIU with involvement of the SSTC NRS carried out an inspection of the ChNPP to verify completeness and reliability of information contained in the above documents, and to assess capability of the Chornobyl NPP to implement the declared activities in compliance with NRS requirements,

Based on the review and inspection results, on July 24, 2020, the SNRIU issued an individual permit for trial commercial operation of NSC SP-1.

The scheduled period of trial and commercial operation is one year.

The objective of the NSC SP-1 trial commercial operation is to confirm that the NSC SP-1 systems, structures and components and the facility as a whole

function in accordance with the design, drawbacks revealed during trial commercial operation are eliminated, and the NSC is ready for safe operation in all design modes.

In 2020, the activity of the Chornobyl Shelter Fund in Ukraine, which financed implementation of the International Shelter Implementation Plan (SIP) projects, the main of which was the NSC SP-1, was completed, The SNRIU drew the attention of the ChNPP and SAUEZM, as the management authority, to the need to continue measures on the Shelter transformation into environmentally safe system, in particular, NSC SP-2: Infrastructure for Dismantling Shelter Unstable Structures.

The activities are performed at the Shelter under the license establishing the scope and conditions of the authorized activities to transform the Shelter into an environmentally safe system. The license is valid until the commissioning of the Shelter NSC.

The nuclear and radiation safety of the Shelter is ensured by a system of administrative and technical measures during current operation of the facility and in implementing the projects for its transformation into an environmentally safe system.

The nuclear and radiation safety of the Shelter is assessed based on the results of routine measurements of parameters characterizing fuel-containing materials, radiation situation at 36 the work sites and in the adjacent territory, activity of contaminated water of the Shelter. Releases from the facility into the atmosphere and effluents into hydrogeological environment, the condition of the civil structures of the Shelter are also subject to control.

Radiation and dose monitoring is provided during the activities at the Shelter, and the dose loads of personnel of the ChNPP and contracting organizations are recorded.

According to the ChNPP, in 2020 the average individual dose of ChNPP personnel who worked at the Shelter or visited the site and the facility premises constituted 1.19 mSv and the average level of individual doses of contractor

personnel was 1.79 mSv. No exceeded reference levels of individual annual exposure doses to ChNPP and contractor's personnel were recorded.

Solid and liquid radwaste is generated during the activities at the Shelter and in the adjacent territory.

The main solid radwaste is soil, scrap metal, mixed construction debris; secondary waste includes used individual protective means and waste generated after decontamination.

During the reporting period, the ChNPP and contractors removed in total 18.6 m^3 (7.6 t) with total activity of 4.79x108 Bq from the Shelter and NSC territory to Buryakivka RWDS, which is lower than corresponding indicators for 2019 by 113.7 m^3 (82.24 t) in volume and weight and by 6.61x1010 Bq by the activity. The main reason for decrease in the amount of generated solid radwaste is completion of the major NSC construction activities.

The generation sources of liquid radioactive waste (radioactive water) are decontamination of premises, equipment and tools, dust suppression, changing room operation.

During 2020, 79 m^3 of radioactive water with total activity of 1.643x109 Bq were collected and pumped from the Shelter rooms to prevent radioactive substance release into the groundwater and improve the radiation situation. The total volume of pumped water decreased almost in 4 and total activity in 2.4 times compared with 2019, which can be related to the changes in temperature and humidity because of the NSC arch placed in the design position.

VI. PHYSICAL PROTECTION OF NUCLEAR INSTALLATIONS, NUCLEAR MATERIALS, RADIOACTIVE WASTE, AND OTHER RADIATION SOURCES

Measures to Improve Effectiveness of State Physical Protection System

In Ukraine, which has a highly developed nuclear energy infrastructure, physical protection of nuclear installations and radioactive materials is an important area in the field of nuclear energy use.

The priorities of the state policy in the field of nuclear energy use in terms of security are aimed at fulfilling Ukraine's international obligations to achieve the main physical protection goals: minimizing the risks of sabotage, theft or any other unlawful withdrawal of radioactive materials and strengthening the regime of nuclear weapons nonproliferation.

In the framework of the oversight activities, SNRIU inspectors carried out in 2020 scheduled inspections of the physical protection systems of South Ukraine NPP, Zaporizhzhya NPP, Rivne NPP, unscheduled target inspections of the nuclear research Institute of the National Academy of Sciences of Ukraine, Central Enterprise for Radioactive Waste Management, State Specialized Enterprise Ecocenter, and National Science Center Kharkiv Institute of Physics and Technology.

To prevent the threat of sabotages, thefts, and other illegal actions by internal offenders, the SNRIU has reviewed: thirty interaction plans in case of sabotage, physical protection assurance plans, fifty four certificates on establishing physical protection level, one hundred eighty five lists of positions of employees whose work requires drawing up admission permits to perform special activities, design basis threats were reviewed and agreed. Eleven SNRIU inspectors and seventeen Heads of private enterprises using radiation sources were granted admission permits to perform special activities.

Five permits for using land and water reservoirs located in the controlled areas of nuclear installations and radwaste management facilities were issued.

Project for Improving Security of Radiation Sources

The following activities were carried out in the framework of the Project for Improving Security of Radiation Sources implemented with the support of the United States Government through the U.S. Department of Energy:

• upgrading of hardware means of physical protection systems of oncological clinics, facilities using high-level radiation sources, radwaste storage facilities in Ukraine;

• elimination of malfunctions of communication systems (data transmission lines) and their trial operation;

• initial inspection of the physical protection systems of facilities for decision-making on their upgrading.

SNRIU inspectors visited the following facilities: radwaste disposal facility of the Kharkiv interregional branch of the Ukrainian State Specialized Enterprise Radon Association, Kharkiv regional oncological center, Vektor CLTSF, CRME, Kyiv clinical oncological center, Kyiv bone marrow transplant center and transport and storage premises of USIE Izotop.

The SNRIU operational duty group ensured the continuous operation of the Central Monitoring Station, to which 32 facilities are connected, and 5 facilities are connected to the Vektor Monitoring Station.

The final third stage of the Program for Search and Securing Orphan Radiation Sources has been implemented, namely: physical examination of such radiation hazardous facilities to search, detect and return under the regulatory control orphan radiation sources was carried out in: PJSC SUMYKHIMPROM, some territories in Rubizhne, Luhansk region, certain locations on the territory of the former Prydniprovsk Chemical Plant, Kamianske town, Dnipropetrovsk region.

Detection of Radioactive Materials in Illicit Trafficking

Nineteen information notifications on the cases of revealed illicit trafficking of radioactive materials in Ukraine were sent within the information exchange with the IAEA database on incidents and illicit trafficking of nuclear and other radioactive materials (ITDB) in 2020.

Seven incidents with radiation sources were recorded: six radionuclide sources were lost (two in the Northern region, one in the Western region (the Uzhhorod National University lost the radiation source type IBN-7, serial No. 659 with maximum activity 2.5 x 10^{10}Bq), three ones in the Eastern region). One radiation source was found in the Central region. Four cases of radioactive contamination of scrap metal (Central and Southeastern regions) were identified, eleven radiation sources were detected in illicit trafficking (seven in the Western region, four in the Northern region).

Fifty six radioisotope smoke detectors of RID type, containing radioactive isotope Pu-239, were seized from illicit trafficking. In March 2020, thirty four RID-1 radioisotope smoke detectors were detected at one of the recreation centers in Kyiv.

In May 2020, an engineer from one of the city's enterprises was detained by law enforcement officers for the attempt to sell 17 RID-1 and RID-6M radioisotope smoke detectors, which he stole from his work place.

Smoke detectors

Two cases of supply of radioactively contaminated scrap metal with natural radionuclides radium-226 were detected by the metallurgical enterprises PJSC “Metallurgical Plant” Azovstal” (Mariupil, Donetsk region) and PJSC "Electrometallurgical Plant "Dniprospetsstal” named after A. Kuzmin” (Zaporizhzhya) during acceptance of scrap metal. The Dnipropetrovsk interregional branch of the state specialized enterprise “Radon Association” removed radiation-hazardous scrap metal fragments and brought them to the

state safe for the public and the environment. On 12 March 2020, during the incoming dose monitoring performed by the specialists of the radiation safety service of PJSC "ArcelorMittal Kryvyi Rih" (Dnipropetrovsk region, Kryvyi Rih) at the "Promyslova" station", the automated control system "Kordon" detected a car with scrap metal with an increased γ-radiation level. The maximum dose rate of γ-radiation on the surface of the railway carriage constituted 1.03 μGy/h. The departure station was Rozhnyatov, the cargo supplier was "UkrMetAlliance" LLC.

During sorting of scrap metal, a fragment of a drillpipe weighing 120 kg, 100 mm in diameter, 10.5 m long, contaminated with the radionuclide radium-226 with specific activity 8.3x104 Bq/kg, and estimated total activity 1x107 Bq was withdrawn. The maximum exposure dose rate at a distance of 0.1 m from the surface constituted 5.5 μSv/h, the average exposure dose rate at a distance of 0.1 m from the surface was 0.7 μSv/h, the beta particle flux density was 20-150 particles per cm^2 per minute. The scrap metal supplier UkrMetAlliance LLC transferred the drillpipe fragment to the radioactive waste disposal site of the Dnipro interregional branch of SSE Radon Association

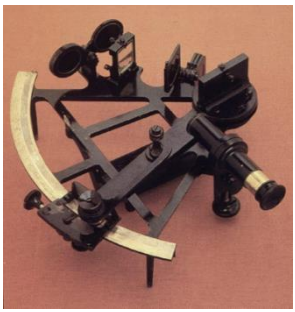
On 25 March 2020, the automated control system "Kordon" got actuated during the incoming radiation monitoring performed by the specialists of the radiation safety service of PJSC "ArcelorMittal Kryvyi Rih" (Dnipropetrovsk region, Kryvyi Rih). The actuation occurred during weighing a truck with a semitrailer at the copra shop weighing station. The maximum dose rate of γ-radiation on the surface of the side of the semitrailer was 5.0 μSv/h. The cargo arrived from Kyiv. The cargo supplier was UkrMetAlliance LLC.

An industrial gamma radiation source type IGI-Ts-3 with equivalent dose rate 62.0 μSv/h at a distance of 1.0 m and estimated activity of $6.0x10^8$ Bq was withdrawn from the semitrailer during scrap metal sorting process, and was

transferred by the scrap metal supplier (UkrMetAlliance LLC) to the radwaste disposal site of the Dnipro interregional branch of the Radon Association.

In October 2020, a citizen of Ukraine was detained at the Porubne state border checkpoint, Chernivtsi region, while trying to bring a gyrohorizon device out of Ukraine.

In October 2020, a sextant with the equivalent dose rate significantly exceeding the established limits was detected in a postal item at the Lviv airport.



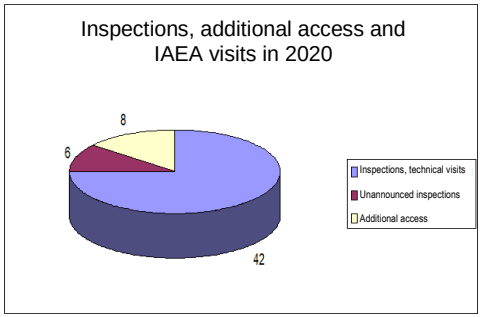
As the gamma radiation exposure dose rate of the detected items exceeded the established sanitary limits, they were withdrawn and sent for further safe and secure storage at the Radon Association.

SNRIU experts take an active part in the events held with the support of international organizations, in particular, in the joint operation codenamed “Orion-II” held in autumn 2020, with the support of the European Union Border Assistance Mission to Ukraine and the Republic of Moldova (EUBAM) and was aimed at countering illegal trafficking of firearm, explosives, chemical, biological and radioactive materials across the Ukraine-Moldova state border.

From 30 September to 1 October 2020, representatives of the SNRIU, with the support of EUBAM, took part in practical exercises to combat the illicit trafficking of radioactive materials at the Mamaliga-Kriva checkpoint (Ukraine-Republic of Moldova).

VII. SAFEGUARDS AND NUCLEAR WEAPON NONPROLIFERATION

In 2020, Ukraine carefully fulfilled the obligations under the Agreement between Ukraine and the IAEA for the Application of Safeguards in Connection with the Treaty on the Nonproliferation of Nuclear Weapons (hereinafter – the Agreement). This is confirmed by the fact that Ukraine obtained a broader conclusion upon the results of using IAEA safeguards. This means that no undeclared nuclear activities have been revealed in Ukraine and all nuclear materials are used for peaceful purposes.



The IAEA carried out scheduled and unscheduled inspections, as well as additional access to Ukrainian enterprises (see the diagram) in 2019, to confirm the declared listing of nuclear materials and the absence of undeclared nuclear activities.

SNRIU State Inspectors participated in all IAEA inspections.

In addition, IAEA inspectors and technical personnel carried out technical visits to NPPs. As a rule, installation, replacement and setup of remote monitoring equipment, testing of IAEA equipment were usually performed during such visits. In particular, testing handling operations using Holtec Company equipment for spent nuclear fuel transport were performed during the year at Rivne NPP, Khmelnitsky NPP and South-Ukraine NPP. The use of technical means for the purposes of safeguards significantly reduce the number of IAEA inspections in the state.

The state regulatory authority has been keeping the state information database of nuclear materials for 25 years to record information on the quantity and composition of nuclear materials in any balance area or in an individual

enterprise. 178 reports on nuclear materials and 11 preliminary notifications on export/import of nuclear materials were received, processed and finalized in the database in the reporting period for sending to the IAEA. In addition, other information under the Agreement was regularly submitted as well, namely: information about the structure, maintenance schedules, information of exposure doses of IAEA inspectors, etc.

The information on export supplies of agreed equipment and non-nuclear material from Ukraine was provided to the IAEA on a quarterly basis to implement the Additional Protocol to the Agreement. An annual information update was conducted under the Additional Protocol to the Agreement (34 declarations). The activity on collecting information required for responding to IAEA inquiries in accordance with the requirements of Article 2 (a) (i) of the Additional Protocol for Research and Development Related to the Nuclear Fuel Cycle and Non-Nuclear Material was carried out.

Every year the key issues of the implementation of the Safeguards Agreement and Additional Protocol are analyzed during the meetings of the joint Ukraine-IAEA High-Level Working Group on the consideration of safeguards application in Ukraine. On 08 July 2020, a Working Group meeting was held in the SNRIU office. Representatives of the IAEA, SNRIU, Ministry of Energy and Coal Industry of Ukraine, Ministry of Foreign Affairs, State Service of Export Control of Ukraine, State Agency of Ukraine on Exclusion Zone Management, Energoatom, Chornobyl NPP participated in the meeting. Current issues of application of the IAEA safeguards in Ukraine and measures necessary to increase the effectiveness of safeguards implementation were discussed:

- implementation of complementary access, unscheduled inspections;
- the procedure for using the ChNPP ISF-2 mailbox;
- review of infrastructure of the IAEA equipment installed in NSC;
- removal of the obsolete IAEA equipment from Chornobyl;
- using FDET device at NPP for spent fuel transfer to dry storage facilities;
- updating information on the CSFSF design;

- construction status of ISF-2, NSC and CSFSF;

- status of the subcritical assembly in the National Science Center Kharkiv Institute of Physics and Technology;

- discussion of measures planned at the previous High-Level Safeguards Implementation Review Group (SIRG).

On 9 July, an IAEA delegation, with the participation of representatives of the Nuclear and Radiation Safety Inspectorate in the Exclusion Zone, visited the CSFSF site, the Shelter, and the ISF-2 to clarify technical issues related to implementation of safeguards. The main purpose of the visit was to check the technical issues of safeguards implementation, the mailbox procedure at the ISF-2, examination of the Agency's equipment at the Shelter.

In addition to the IAEA, the SNRIU exchanged information about international transfers of nuclear materials in previous year with the Euratom according to the Agreement between the European Atomic Energy Community and the Cabinet of Ministers of Ukraine for Cooperation in the Peaceful Uses of Nuclear Energy, and submitted preliminary notifications and annual report on international transfer of nuclear materials to the Canadian Nuclear Safety Commission under the Agreement between the Government of Ukraine and the Government of Canada for Cooperation in the Peaceful Uses of Nuclear Energy.

Therefore, the SNRIU ensures efficient functioning of the state system of accounting and control of nuclear materials, as well as consistent compliance of Ukraine with requirements of international agreements on nuclear weapon nonproliferation.

VIII. RADIOACTIVE MATERIAL TRANSPORT

Transport of radioactive materials is one of the important individual activities in nuclear energy use.

Radioactive materials are transported by public routes; therefore, it is necessary to ensure safety of such transport. Safety regulation for transport of radioactive materials is being provided, administrative and technical measures are being applied to achieve this goal. The regulatory framework is being developed and updated, licensing and oversight is being conducted.

Transport of radioactive materials is licensed, for the import, export and transit of radioactive materials through the territory of Ukraine, a permit is issued for international transport of radioactive materials, design of packaging and special conditions for transport of radioactive materials are approved.

In 2020, 82 permits for international transport of radioactive materials were issued (amended, extended), including 3 permits for the removal of spent nuclear fuel; 14 licenses to transport radioactive materials; 12 certificates of approval of packaging design and special transport conditions.

During the year, 5 surveys were carried out: Chornobyl NPP, Energoatom (Emergency Technical Center, Atomremontservis), Ihor Momot Main Staff Training Center of the State Border Guard Service of Ukraine, Ukrainian Center for Radiation Safety, LLC. The surveys were carried out to verify completeness and accuracy of the information in the documents attached to the applications for issuing or amending licenses. Based on the survey results, the ability of enterprises to conduct the declared activities was confirmed and positive decisions were made.

IX. RADIATION PROTECTION AND SAFETY IN MANAGEMENT OF RADIATION SOURCES

IX.1. STATE REGULATION OF SAFETY IN USE AND PRODUCTION OF RADIATION SOURCES

The priority of man and environment protection impact of ionizing radiation is one of the main principles of state policy in the field of nuclear energy use and radiation protection.

Activities associated with radiation sources may be permitted only after an economic entity confirms its capability to comply with requirements of radiation safety rules and standards and safety justification of radiation source use.

The SNRIU ensures regulatory control over activities of 4,531 entities using radiation sources, including 2,749 entities engaged in the use of radiation sources that are not exempted from licensing and possess appropriate licenses.

During 2020, 165 licenses were issued, 63 licenses were canceled, and 293 licenses for the right to conduct activities involving the use of radiation sources were extended. In addition, 1 license for the right to conduct activity on radiation sources production was cancelled, 5 licenses were extended and 1 license for this type of activity was issued.

In Ukraine, there is a single information and computer accounting system for registration and control over radiation sources, which is the State Register. The registration of radiation sources in the State Register is carried out in accordance with the Procedure for State Registration of Radiation Sources, approved by Cabinet Resolution No. 1718 of 16 November 2000.

As of 31 December 2020, 25,248 radiation sources are being in use in Ukraine, information on which is entered in the State Register of Radiation Sources (8,728 are sealed radionuclide sources and 16,520 are non-radionuclide installations generating irradiation). Merely 13,767 items of X-ray diagnostic equipment are used in medicine alone.

In 2020, 450 sealed radiation sources were registered, 938 out of this number are non-radionuclide radiation sources. In the course of the year, 904 radiation sources were deregistered, namely:

- 558 radionuclide sources (554 of them were transferred to specialized radwaste management enterprises);
- 346 non-radionuclide installations were decommissioned with impossibility of their recovery.

A tightness test was performed for 1610 sealed radionuclide radiation sources.

Distribution of Radiation Source Owners According to Ukrainian Regions

Region	Owners of radiation sources, total	Owners of radionuclide radiation sources	Owners of generating (non-radionuclide) radiation sources
Northern region			
Kyiv city	439	43	396
Kyiv region	189	33	156
Vinnytsia region	144	9	139
Zhytomyr region	125	17	108
Chernihiv region	85	5	80
Cherkasy region	108	6	102
Total	1090	109	981
Eastern region			
Kharkiv region	309	65	290
Poltava region	145	23	134
Sumy region	189	12	185
Total	643	100	609
Central region			
Dnipropetrovsk region	395	51	370
Kirovograd region	77	6	76
Total	472	57	446

Southern-Eastern region			
Donetsk region	466	56	410
Zaporizhzhya region	188	16	172
Luhansk region	218	23	195
Total	872	95	777
Northern-Western region			
Volyn region	105	9	98
Rivne region	136	6	133
Ternopil region	111	3	109
Khmelnytsky region	145	9	139
Total	497	27	479
Western region			
Zakarpatsky region	85	4	85
Ivano-Frankivsk region	187	14	177
Lviv region	235	24	226
Chernivtsi region	65	6	65
Total	572	48	553
Southern region			
Odesa region	218	38	199
Mykolayiv region	91	9	88
Kherson region	105	6	102
Total	414	53	389

Transfer of Radiation Sources across the Customs Border of Ukraine

In total, in 2020, according to the data received from the State Register, 117 radionuclide radiation sources subject to state registration were imported to Ukraine.

In 2020, radiation sources users that received sources under direct contracts with foreign manufacturers or suppliers were nuclear power plants, mining and metallurgical plants, cement plants, cardboard and paper companies and companies conducting geophysical research and others.

The main suppliers of radionuclide radiation sources to Ukraine were the State Enterprise "USIE Izotop" and Severodonetsk Research and Production Association "Impulse", which, in particular, imported 50 fast neutron sources with the radionuclide Am-241, which constituted about 42.7% of all imported radiation sources.

117 sealed radiation sources out of those imported to Ukraine were taken for preliminary registration. For the end of the reporting year, 83 imported radiation sources were registered, which is 71% of the total number of imported radiation sources, which are subject to state registration. Other owners and suppliers of radiation sources were subject to enforcement measures in accordance with the legislation.

According to the application areas, radiation sources imported in 2020 were distributed as follows: 82% of radiation sources were intended to be used in industry, customs and other controls; 18% in medicine.

In addition, in 2020, the State Register received 45 reports on import to Ukraine of radionuclide generators Tc-99m, which are used in medical practice, with a total activity of 2474 GBq.

In 2020, 24 spent radionuclide radiation sources were exported outside Ukraine (the ones registered in the State Register) and 177 items of non-radionuclide installations manufactured in Ukraine (50 items intended for medical purposes and 127 energy spectrometers).

Production of Radiation Sources in Ukraine in 2020

In 2020, 16 Ukrainian entities had valid licenses for the right to produce radiation sources.

In 2020, the radiation sources producers were CJSC Kyiv Production Association "Medaparatura" (14 non-radionuclide radiation sources); LLC "Research and Production Company KRAS" (1 non-radionuclide radiation source) LLC X-ray equipment plant "Quantum"; "RADMIR" company (48 non-radionuclide radiation sources); Elvatech LLC.

Other enterprises possessing radiation sources production licenses did not provide information to the State Register.

In 2020, the Nuclear Research Institute of the National Academy of Sciences of Ukraine produced 5 items of tritium targets of the MT type (radionuclide H-3) with activity of 9.26 GBq, which were exported outside Ukraine.

According to the reports provided, in 2020, Elvatech LLC produced 143 items of non-radionuclide installations (16 items for domestic needs and 127 items were exported abroad).

State Safety Regulation in Use of Radiation Sources in Medicine

Medicine is the most common field of radiation sources application in Ukraine. Out of 2720 licensees in the field of nuclear energy use, which had the right to conduct activities involving the use of radiation sources in 2020, 2001 licensees were health care institutions.

In Ukraine, as well as around the world, there is a tendency to increase the incidence of oncology, which according to statistics of the Ministry of Health of Ukraine takes second place among other major diseases, thus increasing the number of diagnostic and treatment procedures using radiation sources.

X-ray examination remains the main disease diagnostic method.

According to the State Register, 13,767 X-ray diagnostics devices were used in Ukraine in 2020. equipment for X-ray diagnostics (9 697 of them are X-ray diagnostics machines, 521 mammography units, 2901 are dental X-ray machines, 637 are computed tomography scanners and PET tomography scanners, 11 radiation sources belong to other medical equipment), 132 devices for gamma therapy (41 items for contact therapy), 24 devices for X-ray therapy, 33 electron accelerators.

The activities on increasing the effectiveness of radiation protection in medicine and ensuring compliance with Article 17 of the Law of Ukraine On Human Protection against Impact of Ionizing Radiation, which entered into force on 24 February 2020, banning import, production and commissioning X-

ray machines, computed tomography scanners and other medical equipment involving the use of radiation sources that does not meet the established requirements continued in 2020.

The SNRIU has prepared methodological clarifications on application of the provisions of Article 17 of the Law of Ukraine on Human Protection against Ionizing Radiation, which contain explanations of some new terms used, examples of radiological equipment with technical specifications and photo illustrations. These methodological clarifications are recommended as a reference material for institutions and organizations that manufacture or put into operation medical radiological equipment, and SNRIU departments exercising supervision and licensing of production and use of medical radiation sources, conducting state nuclear and radiation safety reviews of designs of medical radiation sources. The methodological clarifications are available at: https://www.uatom.org/normativno-pravova-baza-zabezpechennya-radiatsijnoyi-bezpeki.

In addition, the SNRIU obliged all national manufacturers of medical radiological equipment to bring the technical conditions for production of this equipment into compliance with requirements of the legislation.

The SNRIU constantly checks the compliance of medical radiological equipment with the legislation requirements during authorizing and supervising activities.

In 2020, the regulatory support was provided the commissioning of new equipment for radiation therapy (linear accelerators) and X-ray diagnostic equipment in 92 health care institutions.

IX.2. STATE REGULATION OF NUCLEAR AND RADIATION SAFETY IN USE OF RADIATION SOURCES IN COVID-19 PANDEMIC CONDITIONS: CHALLENGES, RISKS, PROBLEMS, SOLUTIONS

In 2020, the SNRIU ensured continuous implementation of the nuclear and radiation safety state regulation functions of with the use of communication and information systems.

The existing system of state nuclear and radiation safety regulation includes clear and systematic work of both the regulatory authority and entities using radiation sources. However, introduction of anti-pandemic measures in response to the COVID-19 spread hazard required rapid adaptation to reality and performance of its functions in full at the same time.

It should be noted that in accordance with the current Radiation Safety Standards (NRBU-97) in force in Ukraine, the established group two radiation and sanitary regulations are aimed at restricting human exposure to medical irradiation, and radiation protection in this case is based on the justification, optimization and non-exceedance principles. Two of these principles, namely justification and optimization, went through great trials during COVID-19. Prior to the widespread use of rapid testing and PCR test systems, radiographic methods, in particular, computer tomography examinations for indirect COVID-19 diagnostic were used (and still continue to be used). In fact, in some regions of the country computer tomography examinations of the chest have almost become a screening method of X-ray diagnostic.

That is, on the one hand, we have signs of violation of the basic radiation safety principles, and on the other hand, NRBU-97 does not offer us any alternative. Indeed, we also cannot consider the situation as “emergency exposure”, since it lacks the main feature of a radiation accident: loss of regulatory control over the radiation source.

And here we have the priority: real threat to human life and health from COVID-19 or potential hazard to human health coming from radiation diagnostic methods. In the pandemic context, the current radiation safety standards in the country turned out to be insufficient.

According to the SNRIU estimates, during COVID-19 the risks and challenges for entities using radiation sources are as follows:

- temporary or permanent loss of qualified personnel in licensees’ organizations;

- potential loss of control over radiation sources due to economic (financial difficulties, temporary or complete closure of enterprises) and organizational (suspension of service providing on staff training, radiation monitoring, maintenance and repair, radwaste management, etc.) factors;
- deliberate, forced restriction of application of radiation safety rules and standards by licensees.

At the same time, the SNRIU started facing a number of challenges, in particular:

- temporary loss of qualified personnel in the regulatory body;
- restrictions of the possibility to implement state supervisory measures;
- potential loss of regulatory control over radiation sources due to limitations in effective and reliable communication between the regulator and the licensee;
- carry out regulatory functions in pandemic conditions, when not all regulatory provisions of rules and standards can be applied;
- compliance with the ethics of enforcement measures.

In 2020, the inspection plan could not be implemented in full scope because of restrictions imposed on business trips, and prohibition on visiting certain medical institutions. At the same time, the SNRIU tried to find alternative ways of conducting inspections, in particular, by conducting remote inspections, etc.

The SNRIU lacked procedures on conducting activities in pandemic conditions, so the activity reconfiguration was implemented quite rapidly, in particular:

- the SNRIU launched the activity on improving the communication strategy in pandemic conditions to enhance interaction at all levels: in the regulatory authority, with licensees, other regulatory authorities and the public;
- the SNRIU developed the procedures for participation in webinars, training courses and other national and international events to maintain the proper qualification of the regulatory staff;
- the SNRIU set up remote work of its employees and improved possibility to use its information and telecommunications system, including electronic document management with possibility to receive, sign,

send documents, receive applications from licensees and related documents in electronic form, by e-mail, etc.;

- the official SNRIU website was updated with the information accessible for licensees and with prompt informing on the information availability;
- the regulatory procedures for inspection and licensing activities, necessary resources, competences required for performing regulatory functions in new conditions were analyzed, strengths and weaknesses were assessed;
- the activity on introduction of new IT tools of state regulation, namely: “Register of Radiation Sources”, “Radwaste Accounting”, "Accounting of Individual Exposure Doses”, “Electronic Licensing”, “State Supervision”, knowledge portals, remote training courses, etc.

IX.3. OPTIMIZATION OF OCCUPATIONAL EXPOSURE. ESTABLISHMENT OF UNIFIED STATE SYSTEM FOR EXPOSURE ACCOUNTING AND CONTROL

Ukraine takes the leading place in the world in the use of nuclear and radiation technologies for peaceful purposes. Radiation sources are used in almost all areas of human activity: nuclear energy generation, medicine (for diagnostic and treatment), industry, science and education, etc. In addition, after the Chornobyl disaster, unique facilities appeared in the Exclusion Zone in Ukraine: the Chornobyl nuclear power plant and the Shelter, storage facilities for high-level radwaste and other radiation-hazardous facilities.

Total number of entities possessing valid licenses in the field of nuclear energy use constituted 3,409 as of 31 December 2020. One of the important measures to optimize the radiation protection of personnel exposed to occupational exposure is the accounting and control of individual doses.

Absence of a unified state accounting and control system of individual exposure doses, in particular of the state register of individual exposure doses does not allow applying an effective mechanism for tracking exposure doses received by personnel, identifying risks of individual exposure in various fields, introducing mechanisms for occupational exposure optimization. In addition, there is still no control over compliance with the unity of methodological approaches to individual dose monitoring and evaluation of the results obtained.

That is why central executive bodies, which, according to the legislation, bear responsibility for ensuring nuclear and radiation safety of personnel and the public, are deprived of an effective tool to control safe use of nuclear and radiation technologies, and compliance with basic radiation protection principles, including optimization.

In this regard, Ukraine does not fully comply with the basic international principles and requirements of radiation protection of personnel, organization and control, accounting for occupational exposure doses, exposure of the public, what does not meet the requirements and practices of the European Union.

In order to enhance the radiation protection level of personnel, the SNRIU developed in 2020 the Procedure for creating a unified state accounting and control system of individual exposure doses and the Action Plan for its implementation, approved by the Cabinet of Ministers of Ukraine under registration No. 1141 of 18 November 2020: Some Issues in Establishing the Unified State System for Accounting and Control of Individual Doses. Implementation of this Resolution will ensure establishment of a unified system of accounting and control of individual exposure doses, which will facilitate enhancing radiation safety level under nuclear energy use, will ensure control of non-exceeding of basic dose limits established for corresponding personnel categories, dose constraints and reference exposure levels in situations of planned, existing and emergency exposure, will ensure optimization of personnel exposure under conducting activities in the field of nuclear energy use.

The above Cabinet Resolution approved the Action Plan for Establishing the Unified State System for Accounting and Control of Individual Doses. To implement the Action Plan, SNRIU developed in 2020 the first revision of the draft Cabinet Resolution "On Amendment of Cabinet Resolution No. 1718 dated 16 November 2000", which provides for establishing the procedure for accounting and control of individual exposure doses, providing information on the doses received by employees, requirements for information content, and the procedure for using the State Register**.**

X. SAFETY OF URANIUM SITES

Ukraine belongs to the leading uranium mining countries in the world and has 12 explored endogenous uranium deposits with total reserves capable to meet the needs of operating Ukrainian NPPs for another 100 years.

In 2020, Ukraine produced about 850 tons of uranium oxide concentrate. The largest uranium deposits are located mainly within the Kirovohrad oblast.

As of 2020, the full cycle of uranium ore mining and processing is carried out by only one enterprise: State Enterprise "Eastern Mining and Processing Plant" (SkhidGZK). The SkhidGZK includes three operating mines: Smolinska, Inhulska and Novokostiantynivska.

The Smolinska mine develops the Vatutinske deposit, Inhhulska the Michurinske and Tsentralne deposits, Novokostiantynivska mine develops the Novokonstiantynivske deposit, which is the largest in Europe. The Severynske deposit is in reserve and a number of deposits is prepared for exploration. Uranium ore at all mines of the SkhidGZK is mined by underground method.

The Tsentralne and Michurinske deposits are located near Kropyvnytskyi. The Inhulska mine developing these deposits has been in operation since 1969. Ore is mined at a depth of 420 m.

The Vatutinske uranium deposit is located in the Smolino village, Malovyskiv region, Kirovohrad oblast. It belongs to the sodium-uranium formation of hydrothermal-metasomatic deposits. The deposit has been in operation since 1973. Its reserves are about 30 thousand tons in terms of enriched raw materials. The uranium content is 1.7 times higher than in Michurinske and Tsentralne deposits, but the most productive part of the deposit is depleted, mining is currently carried out at a depth of 640 m. Decommissioning of the Smolinska mine is expected by 2025.

The Novokonstiantynivske uranium ore deposit is located near the Oleksiyivka village, Malovyskiv region, Kirovohrad oblast. The mine is in trial and commercial operation. Currently, ore is mined at a depth from 180 to 300

m. The design capacity of the deposit is 1500 thousand tons of uranium ore per year with a further increase to 2500 thousand tons per year.

Processing of uranium ores and obtaining uranium concentrate (U_3O_8) is carried out at the Hydrometallurgical Plant in Zhovti Vody.

During processing of uranium ores, this plant generates waste (tailings) with a high content of naturally occurring radionuclides, which are placed using a pulp piping in a specially equipped Balka Shcherbakivska tailing storage facility located at a distance of about 5 km from Zhovti Vody.

From 1949 to 1991, the former Prydniprovskyi Chemical Plant processed uranium-containing blast furnace slag, uranium concentrates and uranium ore from various deposits in the Soviet Union and Eastern Europe. Seven tailing storage facilities (Zakhidne, Tsentralnyi Yar, Pivdenno-Skhidne, Dniprovske, Sukhachivske (first and second sections) and Lantanova Fraktsiia) and two uranium waste storage facilities (DP-6 and Baza C) were formed on the territory of the former plant and beyond its boundaries. Up to 42 million tons of uranium ore processing waste with a total activity of $2.7x10^{15}$Bq (average specific activity is 6.4 kBq/kg) have been accumulated in tailing storage facilities, and up to 0.2 million tons of uranium production waste with a total activity of $4.4x10^{14}$Bq (average specific activity is 2.2 MBq/kg) have been accumulated in DP-6 and Baza C uranium waste storage facilities. The exposure dose rate is from 30 to 35000 μR/g.

Since 1991, State Enterprise “Barrier” has been implementing liquidation and remediation measures at the facilities and industrial site of the former Production Association “Prydniprovskyi Chemical Plant” within the State Targeted Environmental Program for Bringing Uranium Facilities of the Prydniprovskyi Chemical Plant to a Safe State approved by the Cabinet of Ministers of Ukraine for every 3-4 years in accordance with the license for relevant activities.

In 2020, SNRIU conducted continuous regulatory support of the State Targeted Environmental Program of Priority Measures to Bring the Facilities and Site of the Former Prydniprovskyi Chemical Plant to a Safe State for 2019-

2023 approved by Resolution of the Cabinet of Ministers of Ukraine No. 756 of 21 August 2019. The state review on NRS was provided for 8 projects on bringing the facilities and site of the former Prydniprovskyi Chemical Plant to a safety state.

In 2020, SNRIU amended the license of SkhidGZK for uranium ore processing No. OJ 000932 of 16 June 2015 to extend the validity of this license for uranium ore processing. The license was extended until 16 June 2023.

The participation in implementing the following was continued:

- international technical assistance projects “Implementation of Urgent Measures to Eliminate an Emergency State of the Prydniprovskyi Chemical Plant in Kamyanske (former Dniprodzerzhynsk) in Ukraine” implemented at the expense of the European Commission and “Risk Reduction, Control of Radioactive Contamination and Improvement of Environment Monitoring System at the Prydniprovskyi Chemical Plant in Ukraine” funded by the Government of Norway;

- project “Decommissioning of Irradiation Facilities and Safe Storage of Radiation Sources” within the cooperation program between SNRIU and GRS of Germany.

XI. INTERNATIONAL COOPERATION AND EUROPEAN INTEGRATION

2020 has become an unprecedented year for the global community bringing the largest challenge of the global spread of COVID-19 since the Second World War. The lack of experience in response and necessary tools to overcome the global pandemic led to implementing serious restrictive measures by all countries of the world, which in turn affected international cooperation in NRS regulation.

Due to the introduced restrictions, the implementation of international cooperation projects and programs, holding international conferences, workshops, training, meetings both in bilateral format and under the auspices of international organizations and associations was suspended for a certain period. Countries focused on resolving domestic issues. The main task of all regulators was to protect the health of employees and support functioning of the state oversight system for NRS.

Figure. IAEA Imagebank

Nevertheless, over time, understanding the potential consequences of such isolation has led to a fundamental transformation and rethinking of approaches to implementing international cooperation. Up-to-date digital technologies in 2020 have become almost the only and irreplaceable way of communication and interaction. Digital technologies have also become a unique tool for international cooperation, which allowed restoration of international

communication and continuation of experience exchange on NRS regulation, as well as experience exchange on regulatory system functioning in the context of a global pandemic.

The Declaration on the 75th anniversary of the United Nations adopted by the General Assembly on 21 September 2020 states: “The COVID-19 pandemic has reminded us in the most powerful way that we are closely interconnected and only as strong as our weakest link”, therefore international cooperation implementation and development in the area of nuclear safety is in the interests of all countries.

International Atomic Energy Agency

The most transformative 2020 was for international government organizations, among which the IAEA plays a central role in the area of peaceful nuclear energy use. In 2020, all IAEA activities, except verification, were transferred to online format. Many events were canceled or postponed to a later and more favorable period.

One of the few events held in the usual format was the International Conference on Nuclear Security, which took place on 10-14 February 2020 in Vienna. The conference was attended by 141 member countries with the largest representation in the ministerial segment. The Ministerial Declaration of the Conference reaffirmed the central role of IAEA in international cooperation to ensure security of nuclear and other radioactive material.

In April 2020, in response to the global pandemic challenge, the IAEA launched an ambitious project to assist member countries in detecting and diagnosing COVID-19. More than 1500 items of relevant equipment were transferred free of charge to 125 countries, including Ukraine.

Figures. Ukraine received equipment from IAEA to detect and diagnose COVID-19

In order to prevent future IAEA pandemics, cooperation project on veterinary early diagnosis of animal diseases ZODIAC has been initiated (IAEA General Conference Resolution GC(64)/RES/12). The ZODIAC project is aimed at establishing an international network of laboratories and supporting member countries by strengthening their preparedness to respond to initial and repeated detection of zoonotic diseases by using molecular biology, nuclear technologies, enhanced capabilities to detect, monitor and respond to emerging pathogens that may transform into zoonotic diseases and subsequent pandemics. Ukraine has supported the ZODIAC project and will take an active part in its implementation.

The IAEA online training and skill improvement program in the context of the pandemic was significantly developed and expanded. Currently, the program covers a wide range of issues from nuclear energy to nuclear safety and security, from non-proliferation safeguards to nuclear technologies and their application, and it is open to anyone. IAEA has also prepared a series of webinars for member countries on various aspects of preventing and overcoming COVID-19, which are available at https://www.iaea.org/topics/health/infectious-diseases/covid-19/webinars.

Despite the restrictions imposed by countries, IAEA continued to implement safeguards in member countries to prevent the transfer of nuclear material from peaceful use. Under the assistance of member countries, IAEA was able to provide actual inspections at nuclear facilities, including in Ukraine. On 8 July 2020, the SIRG meeting was held in Kyiv. The IAEA delegation was headed by Mr. Haroldo Barroso Jr., Director, Division of Operation C, IAEA Department of Safeguards. The current issues of applying IAEA safeguards in Ukraine were discussed during the meeting. IAEA representatives visited the site of CSFSF, NSC and ISF-2. *For more detailed information on applying IAEA safeguards in Ukraine, see section VII. Safeguards of non-proliferation of nuclear weapons.*

The COVID-19 pandemic has negative impact on review processes under international safety instruments deposited by IAEA. Thus, the Eighth Review Meeting on Implementing the Countries' Obligations under the Convention on Nuclear Safety scheduled for 21-31 March 2020 has been canceled. By the decision of the management of the Eighth Review Cycle, with the unanimous support of the parties to the Convention on Nuclear Safety, the Eighth Review Meeting was postponed to 2023 and merged with the Ninth Review Meeting.

An organizational meeting to prepare for the Seventh Review Meeting on considering the implementation of the obligations by the countries under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was held late in September 2020 and online. The Fourth Extraordinary Meeting under the Joint Convention scheduled for May 2020 was canceled, and the Seventh Review Meeting under the Joint Convention was postponed to 2022.

In 2020, Ukraine continued improving its national legislation taking into account IAEA Safety Standards. Ukrainian experts took an active part in the work of the Nuclear Safety Standards Committee (NUSSC), Radiation Safety Standards Committee (RASSC) and the Nuclear Security Guidance Committee (NSGC). During the year, SNRIU defined as a responsible organization ensured active interaction and information exchange with the IAEA Database on illicit trafficking of nuclear and radioactive materials and radiation sources (ITDB).

Cooperation of EU Countries in Nuclear and Radiation Safety Regulation

The online format using up-to-date technologies allowed continuation of implementing current projects of SNRIU cooperation with the European Commission within the Instrument for Nuclear Safety Cooperation INSC. According to the schedules, project "Strengthening capabilities of the State Nuclear Regulatory Inspectorate of Ukraine in regulation of nuclear activities, licensing and analysis of severe accidents for nuclear facilities" (U3.01/14-15, U3.01/18 (UK/TS/51-58), which, inter alia, is aimed at elaborating a strategy for development of SNRIU regulatory capabilities and planning of SNRIU resources, implementation of HERCA-WENRA approaches to improve interstate coordination of implementing protective measures during nuclear accidents, support of regulatory activities on radwaste management, decommissioning and remediation, as well as support of licensing nuclear fuel diversification for Ukrainian NPPs.

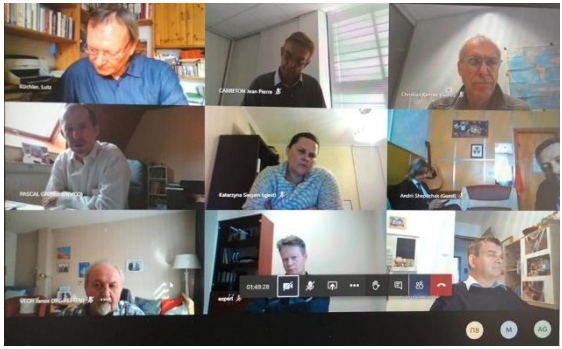


Figure. Working meeting within Task H1 of project UK/TS/51-58

In 2020, WENRA, whose full member Ukraine has been since 2015, was transferred to the online format. According to the timelines, the work was underway in three WENRA working groups: Reactor Harmonization Working Group (RHWG), Working Group on Waste and Decommissioning (WGWD), Working Group on Research Reactors (WGRR).

On 4-5 November 2020, the online autumn WENRA plenary session was held. Due to quarantine restrictions, this plenary meeting was the first meeting of WENRA members and observers in 2020. During the meeting, participants

shared the news about events occurred in the countries since the previous meeting in November 2019, including the experience of countries in NRS regulation under quarantine restrictions, changes in legislation, organizational changes in regulatory bodies, main technical achievements at nuclear facilities of the member states, etc. During the meeting, participants also discussed the implementation status of strategic tasks in accordance with the Association's Strategy focusing on strengthening the communication component to promote WENRA achievements beyond the association. They also draw a special attention to the issues on preparing for the ENSREG 2nd topical inspection planned for 2023, as well as a number of issues on current activities.

Figure. WENRA plenary meeting

In accordance with the voluntary commitments, in July 2020, Ukraine submitted the Updated National Action Plan upon Stress-Test Results to the European Nuclear Safety Regulators Group (ENSREG).

Since Ukraine takes an active part in ENSREG work, in particular in implementing the measures upon stress test results for Ukrainian NPP units in accordance with the requirements, procedure and scope of stress tests for European NPPs developed by WENRA and agreed by the European Commission and ENSREG, as well as taking into account the work of Ukrainian experts as invited experts in assessing stress-test results of other countries, including the Republic of Belarus and Armenia and Ukraine's participation in the first thematic peer review on ageing management organized by the European

Commission and ENSREG on the basis of WENRA proposals, ENSREG management invited Ukraine to apply for observer status in ENSREG. On 9-10 November 2020, during the ENSREG Plenary Session, Ukraine's application for observer status was approved. This achievement in 2020 was a clear confirmation of Ukraine's foreign policy, whose one of the key priorities was European integration and opened new opportunities to approximate to the standards of NRS regulation within the EU.

Bilateral Cooperation Program

Despite the pandemic, bilateral cooperation continued. Among the main SNRIU partners in 2020 were the United States, Sweden, Norway and other countries.

An experience of cooperation was the visit of a Japanese delegation to Ukraine on 18-19 February 2020 consisting of representatives of the Japanese regulatory body NRA and Mitsubishi Heavy Industry,

Ltd. The purpose of the visit was to familiarize with the peculiarities of SNF storage technology at ISF-2 and approaches to implementing the relevant regulatory oversight. During the trip, the Japan colleagues visited ChNPP, as well as directly ISF-2, where they had the opportunity to familiarize with practical approaches to SNF storage and storage technology peculiarities.

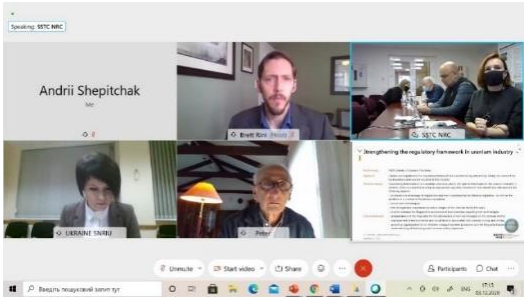
The start of a new area of cooperation with the United States of America became the visit of the Ukrainian delegation on 27 – 31 January 2020 to Corvalis (Oregon, USA). SNRIU Chairman Hryhorii Plachkov, representatives

of SSTC NRS, U.S. Department of State, Argonne National Laboratory, U.S. Department of Energy and representatives of the NuScale Power company met to discuss the prospects for technical cooperation in licensing and implementing small modular reactor (SMR) technology in Ukraine. Upon the meeting results, SSTC NRS and NuScale Power signed the Memorandum of Understanding, which provided a comparative analysis of the Ukrainian regulatory NRS requirements and requirements implemented in the NuScale Power SMR project to be performed by the parties. The results of this activities will contribute to preventing potential obstacles for possible further licensing of the mentioned project in Ukraine.

Figure. Signing of the Memorandum of Cooperation between SSTC NRS and NuScale Power (USA)

In 2020, the implementation of cooperation projects was continued with the U.S. State Department: “Improving Cybersecurity in the State Nuclear Regulatory Inspectorate of Ukraine” and “Combating Illegal Use and Trafficking of Radioactive Material in the Eastern Region of Ukraine. Task 1. Extraordinary Inventory of Radioactive Materials (INVENTORY)”, U.S. Department of Energy: “Improving Integrity of Radiation Sources Used in Ukraine”, and U.S. Nuclear Regulatory Commission: “Technical Assistance to the State Nuclear Regulatory Inspectorate of Ukraine by USA”.

On 2-3 December 2020, a meeting of experts from SNRIU, SSTC NRS and representatives of the U.S. Nuclear Regulatory Commission took place to



discuss the results of bilateral cooperation in 2019-2020 and plan new areas of cooperation.

During the meeting, SNRIU presented the information on long-term operation of NPP units, including the issues of implementing C(I)SIP, implementing the National Action Plan upon Stress-Test Results. In turn, at the request of the Ukrainian party, American colleagues shared the information on the first world experience in approving the small modular reactor design, approaches and regulatory practices of pre-licensing consideration of nuclear facility documents from the technology manufacturer, practical measures to determine regulatory requirements for emergency planning zones, experience in resuming the construction of encased power units, etc. The meeting participants discussed the results of Ukraine participation in the programs on using CAMP, CSARP and RAMP codes and other issues.

On 3 December 2020, during the online meeting, the Protocol on the Practical Implementation of the Procedures for Prompt Notification of Nuclear Accidents and Information Exchange on NFs was signed between the State Nuclear Regulatory Inspectorate of Ukraine and the Norwegian Radiation and Nuclear Safety Authority. The meeting was attended by representatives of the Ministry of Foreign Affairs of the Kingdom of Norway and the Embassy of the Kingdom of Norway in Kyiv. The purpose of signing the Protocol is to continue and intensify bilateral cooperation between the regulatory authorities of

Ukraine and the Kingdom of Norway on the procedures for prompt notification of nuclear accidents and information exchange on NFs.

In 2020, four new cooperation projects with the Norwegian Radiation and Nuclear Safety Authority were launched. They are aimed at assessing regulatory threats in Ukraine, developing requirements for the release of radioactive materials from regulatory control, developing requirements and rules for safe management of spent sealed radiation source recognized as radwaste and establishing a system for management and compliance with the rules of safe transport of radioactive materials.

The impact of COVID-19 on nuclear and radiation safety in countries will be analyzed and relevant conclusions will undoubtedly be made by the international community over time, while for Ukraine the priority remains clear: to protect the public and the environment against negative radiation effects through meeting the requirements of national legislation, full implementation of the international obligations and active international cooperation.

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