REPORT

ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2023

State Nuclear Regulatory Inspectorate of Ukraine

2024

Dear Readers and Colleagues!

We present the Report on Nuclear and Radiation Safety in Ukraine for 2023. The report provides unbiased information on the state regulation of nuclear and radiation safety, promotion of conditions for the safe management of radioactive waste, spent nuclear fuel and radiation sources, and fulfillment of Ukraine's international obligations for the safe use of nuclear energy under the full-scale war unleashed by the russian federation against our independent and sovereign state.

The war has not only brought suffering to every Ukrainian family but has also necessitated severe adjustments in the operations of all enterprises, institutions and governmental bodies in Ukraine.

Since 4 March 2022, Europe's largest nuclear power plant, Zaporizhzhia NPP, has been under russian occupation. Over two years of control by the invaders, nuclear and radiation safety at the Zaporizhzhia NPP has significantly deteriorated because of the ignorance, cynicism and blackmail by the nuclear state, a member of the UN Security Council. In violation of all international laws and safety principles, regular army troops forcibly seized Europe's largest nuclear power plant used for the production of peaceful nuclear energy, comprising seven nuclear facilities, to turn it into a military stronghold. A shameful act by the russian military was the blowing-up of the Kakhovka hydroelectric power station dam on 6 June 2023 and the destruction of the Kakhovka reservoir, which served for almost 40 years as a reliable water supply source for the Zaporizhzhia NPP and ultimate heat sink for the cooling systems of six nuclear reactors and spent fuel pools.

All Zaporizhzhia NPP units, capable of generating 40 billion kW/h of electricity annually before the occupation, were in shutdown state in 2023. Concurrently, the number of operational events at the Zaporizhzhia NPP increased as a result of shelling by the occupiers, damage to power lines, presence of military units at the industrial site together with unqualified and unlicensed personnel unable to properly maintain and repair equipment and the occupation administration's maneuvers to alternately transfer the plant units to hot shutdown state in contradiction with the requirements of the SNRIU's licenses.

Air-raid alerts, cruise missiles and drones over other nuclear power plants in Ukraine, along with russian strikes on the state's energy infrastructure, blackouts and shelling-caused damage to power lines, affected the safety of nuclear facilities and caused damage to enterprises involved in the management of radioactive waste, spent fuel and radiation sources.

Nevertheless, despite the war, Ukraine's commitment to European integration has been and remains a priority in the development of nuclear energy and nuclear and radiation safety.

Implementation of the SNRIU's legislative initiatives for harmonization of the Ukrainian legislation on the safe use of nuclear energy with the European Union acquis resulted in 2023 in the introduction of the Law of Ukraine "On Amendment of the Law of Ukraine on Nuclear Energy Use and Radiation Safety Regarding Radiation Protection Expert" and the Law of Ukraine "On Amendment of Certain Laws of Ukraine on Human Protection against Ionizing Radiation".

In 2023, the Rivne NPP started trial operation of U.S. Westinghouse nuclear

fuel at one of its VVER-440 units. This marks significant progress towards breaking the russian federation's monopoly on nuclear fuel supplies for former USSR NPPs. Additionally, the commissioning of the Centralized Spent Fuel Storage Facility continued.

In line with the best regulatory practices, the SNRIU in cooperation with the SSTC NRS developed and approved the Provisions for Pre-licensing Review of Nuclear Facility's Design, allowing the regulator to conduct pre-licensing reviews of new nuclear facility designs and paving the way for the adoption of innovative technologies, new solutions and approaches in the development of nuclear power in Ukraine.

In September 2023, at the regular IAEA General Conference, 79 IAEA member states supported Ukraine, electing it as a member of the IAEA Board of Governors, the Agency's governing body.

A number of cooperation agreements were concluded with nuclear regulators from leading countries — Great Britain, Canada and USA — and their implementation was started. The scope of cooperation is diverse: ranging from the safe transport of radioactive materials and decommissioning of uranium mines to regulatory aspects and adaptation of Ukrainian legislation for the implementation of the latest nuclear facility designs, including small modular reactors.

In spite of the war, Ukraine remains a transparent and responsible signatory to the Agreement between Ukraine and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. In 2023, IAEA experts conducted 70 inspections and 14 technical visits and received five complementary accesses to verify declared nuclear material. All of them were completed without any comments. Since February 2023, at the initiative of the Ukrainian Government, permanent IAEA monitoring missions were established at all Ukrainian NPPs to independently and competently assess the impact of the full-scale war unleashed and waged by russia on the safety of peaceful nuclear facilities.

The year 2023 was fraught with military challenges and threats to nuclear and radiation safety in Ukraine. However, there has been a growing recognition by the civilized world of the truly cruel and cynical force that Ukraine was confronting. The support of international partners through all available mechanisms — evident both at international platforms discussing nuclear and radiation safety and in direct assistance to Ukrainian enterprises and the SNRIU — remains crucial, helping Ukraine to maintain the capability to ensure safety and perform state regulatory functions. Individual protection means, radiation reconnaissance and dose monitoring devices, and computer hardware and software are significant contributions from partners and donors to nuclear and radiation safety in Ukraine for mitigating the adverse effects of russia's military aggression and occupation.

I am grateful to all Ukrainian experts who continue to perform their important duties in ensuring nuclear and radiation safety in the war conditions. I extend my gratitude to our international partners for their support and assistance. I am convinced that nuclear energy is the future, with its share in global electricity production continuing to grow year after year. Currently, at the Ukrainian Zaporizhzhia NPP occupied by russia, we are facing a crucial question: will humanity be able to guarantee the safety of nuclear facilities tomorrow? The future of nuclear energy primarily depends on whether the civilized world can find mechanisms to prevent the forcible seizure of nuclear facilities and hold accountable the aggressor country that occupies these nuclear facilities in an independent state, turns them into military bases, violates all principles of nuclear safety and peaceful use of nuclear energy and acts against common sense and natural instinct for self-preservation, attempting to impose its distorted reality on the world.

Sincerely Yours
Chairman – Chief State Inspector
for Nuclear and Radiation Safety of Ukraine

Oleh KORIKOV

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LIST OF ABBREVIATIONS

Association Agreement	–	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
C(I)SIP	–	Comprehensive (Integrated) Safety Improvement Program for NPPs
ChNPP	–	Chornobyl NPP
CLRS MDM	–	Central Laboratory for Radiation Safety and Medical Dose Monitoring
CPS	–	Central Production Site
CRME	–	Central Radioactive Waste Management Enterprise
CSFSF	–	Centralized Spent Nuclear Fuel Storage Facility
DIA	–	Dnipro Interregional Affiliate
DSA	–	Norwegian Radiation and Nuclear Safety Authority
DSFSF	–	Dry Spent Nuclear Fuel Storage Facility
DWSC	–	Double-Wall Shielded Canister
Energoatom	–	Joint Stock Company "National Nuclear Energy Generating Company Energoatom"
FCSE	–	Final Closure and Safe Enclosure of Chornobyl NPP Units 1, 2 and 3
HERCA	–	Heads of the European Radiological Protection Competent Authorities
HMP	–	Hydrometallurgical Plant
IAEA	–	International Atomic Energy Agency
IAEA IEC	–	Incident and Emergency Center of the International Atomic Energy Agency
ICSRM	–	Industrial Complex for Solid Radioactive Waste Management
ISAMRAD	–	Support and Assistance Mission on the Safety and Security of Radioactive Sources in Ukraine
ISF	–	Interim Spent Nuclear Fuel Storage Facility
KhIA	–	Kharkiv Interregional Affiliate
KhNPP	–	Khmelnytsky NPP
KIPT	–	National Scientific Center "Kharkiv Institute of Physics and Technology"
LRSF	–	Liquid Radioactive Waste Storage Facility
LRTP	–	Liquid Radioactive Waste Treatment Plant
NEA	–	Nuclear Energy Agency
Neutron Source	–	"Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" Nuclear Subcritical Facility
NPP	–	Nuclear Power Plant
NRS	–	Nuclear and Radiation Safety
NSC	–	New Safe Confinement
OIA	–	Odesa Interregional Affiliate
PCP	–	Prydniprovsk Chemical Plant
PNPP	–	Pivdennoukrainsk NPP
PPS	–	Physical Protection System
PSA	–	Probabilistic Safety Assessment
Radwaste	–	Radioactive Waste
RICS	–	Radioactive Waste Interim Confinement Sites in the Exclusion Zone

RITEG	–	Radioisotope Thermoelectric Generators
RNPP	–	Rivne NPP
RWDS	–	Radioactive Waste Disposal Site
RWTP	–	Solid Radioactive Waste Treatment Plant
Safeguards Agreement	–	Agreement between Ukraine and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons
SE	–	State Enterprise
SESU	–	State Emergency Service of Ukraine
SF	–	Safety Factor
SFM	–	Spent Filter Materials
SIRG	–	High-Level Safeguards Implementation Review Group
SkhidGZK	–	Skhidny Mining and Processing Plant
SMR	–	Small Modular Reactor
SNRIU IEC	–	Information and Emergency Center of the State Nuclear Regulatory Inspectorate of Ukraine
SRSF	–	Solid Radioactive Waste Storage Facility
SRW	–	Solid Radioactive Waste
SSE	–	State Specialized Enterprise
SSTC NRS	–	State Scientific and Technical Center for Nuclear and Radiation Safety
State Register of Sources and Doses	–	State Register of Radiation Sources and Individual Exposure Doses
UPP	–	Uranium Processing Plant
US NRC	–	United State Nuclear Regulatory Commission
VVER	–	Water-Cooled Water-Moderated Power Reactor
WENRA	–	Western European Nuclear Regulators' Association
ZNPP	–	Zaporizhzhia NPP

I. STATE REGULATION OF NUCLEAR AND RADIATION SAFETY

The assurance of nuclear and radiation safety and security of nuclear facilities, nuclear materials, radioactive waste and other radiation sources is an important aspect in the use of nuclear energy.

The establishment and implementation of state policy in the safe use of nuclear energy is entrusted to the State Nuclear Regulatory Inspectorate of Ukraine, a central executive body whose activities are directed and coordinated by the Cabinet of Ministers of Ukraine.

In 2023, under martial law on the territory of Ukraine related to the ongoing large-scale armed aggression of the russian federation against Ukraine, the State Nuclear Regulatory Inspectorate of Ukraine continued its activities and implemented its tasks and functions in compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine, approved by Resolution of the Cabinet of Ministers of Ukraine No. 363 dated 20 August 2014.

In 2023, the SNRIU staffing list included 278 employees (among them: 163 at the headquarters, 21 at on-site nuclear safety inspectorates and 94 at regional nuclear and radiation safety inspectorates).

The actual number of SNRIU employees was 184 (among them: 110 at the headquarters, 14 at on-site nuclear safety inspectorates and 60 at regional nuclear and radiation safety inspectorates).

Throughout the year, 25 employees were appointed, including 6 employees appointed as state inspectors, in accordance with Article 10 of the Law of Ukraine "On the Legal Regime of Martial Law", for a fixed period. 31 employees were dismissed, including 11 state inspectors.

167 experts (91 % of the total number of employees) improved their qualifications through training of various types and formats.

The SNRIU activities for 2023 are set forth in the Report on Activities of the State Nuclear Regulatory Inspectorate of Ukraine in 2023, approved by Resolution of the SNRIU Board No. 01 dated 22 February 2024 "On Activities of the State Nuclear Regulatory Inspectorate of Ukraine in 2023 and Priority Areas for 2024", posted on the SNRIU's official website (https://snriu.gov.ua/).

Rule-Making

The legislation of Ukraine pertaining to nuclear energy comprehensively regulates all aspects related to the peaceful use of nuclear energy and the assurance of nuclear and radiation safety.

Despite the challenges that Ukraine faced because of the russian military invasion, efforts to develop and improve the national nuclear legislation continued on a permanent basis in 2023. Under implementation of legislative initiatives prepared for aligning the national legislation of Ukraine for the safety of nuclear energy with the EU acquis in 2023:

– Law of Ukraine No. 2758-IX "On Amendment of the Law of Ukraine on Nuclear Energy Use and Radiation Safety Regarding Radiation Protection Expert" dated 16 November 2022 entered into force on 11 December 2023. This law is aimed at establishing an institute of radiation protection experts for providing consultation to entities that use nuclear energy, as well as other legal entities and individuals, regarding compliance with legislative requirements for nuclear and radiation safety. The Law establishes basic qualification requirements for persons who intend to become radiation protection experts and identifies the body to recognize the competence of such experts. The institute of radiation protection experts will improve the efficiency of radiation protection for personnel and the public;

– Law of Ukraine 3344-IX dated 23 August 2023 "On Amendment of Certain Laws of Ukraine on Human Protection against Ionizing Radiation" entered into force on 17 September 2003. The amendments to the Laws of Ukraine "On Nuclear Energy Use and Radiation Safety" and "On Human Protection against Ionizing Radiation" are aimed at bringing a number of their provisions in line with the EU acquis, in particular with Council Directive 2013/59/Euratom and international safety standards. The provisions of the Law clarify and specify powers of the Cabinet of Ministers of Ukraine, central executive authorities, local executive bodies, and the National Commission for Radiation Protection of Ukraine; introduce three exposure situations (planned, existing and emergency); establish basic exposure limits for effective and equivalent doses for personnel and the public; introduce boundary doses in planned exposure situations for personnel and the public, reference levels for existing and emergency exposure situations, etc.

Moreover, to urgently resolve the legislative ambiguity concerning the powers of the President of Ukraine and other governmental bodies in the safe use of nuclear energy for making decisions on the development and approval of the design-basis threat for nuclear facilities, nuclear materials, radioactive waste and other radiation sources in Ukraine, the SNRIU developed the draft Law "On Amendment of the Law of Ukraine on Physical Protection of Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Radiation Sources regarding the Powers of the State Nuclear Regulatory Authority, which is currently under review of the Verkhovna Rada of Ukraine (Reg. No. 10036 dated 12 September 2023).

In line with the Rule-Making Plan of the Verkhovna Rada of Ukraine for 2023, approved by Verkhovna Rada Resolution No. 2910-IX dated 7 February 202, for aligning nuclear energy legislation with specific provisions of the EU acquis, which in turn meets the obligations under the Association Agreement regarding nuclear energy, the draft Law of Ukraine "On the National Nuclear Regulatory Commission" was developed, with the goal of legally establishing the state nuclear regulatory authority as a central executive body with a special status, intended to enhance the effectiveness of its activities and independence in making regulatory decisions, considering documents of the European Union acquis, IAEA publications and experience in the state regulation of nuclear and radiation safety.

The nuclear legislation system also includes legal acts of the Cabinet of Ministers of Ukraine, which establish the mechanism for implementing laws and the procedure for activities in the area of nuclear energy.

In 2023, Cabinet Resolution No. 268 dated 10 March 2023 "On Amendment to the Statute of the State Nuclear Regulatory Inspectorate of Ukraine" was developed and approved by the Cabinet of Ministers of Ukraine to expand the SNRIU's powers in making decisions on the recognition of competences or refusal to recognize competences of persons intending to become experts in radiation protection.

In the area of nuclear facility safety, the following new regulations were approved and implemented:

– Requirements for the Structure and Contents of Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities;

– Requirements for Maintenance of Systems Important to NPP Safety.

The Requirements for qualification of in-service nondestructive testing systems for NPP equipment and piping were also amended. The amendments concern the employment of experts qualified and certified in non-destructive testing in the Certification Body on a permanent basis, and the establishment of requirements for personnel qualification and certification.

The following documents on the safe transport of radioactive materials were approved and implemented:

– Requirements for the Structure and Content of Safety Analysis Reports on Packaging Design;

– Requirements for Management System for the Safe Transport of Radioactive Materials.

Amendments were made to the questionnaire required for individuals seeking permission to perform special activities at nuclear facilities and with nuclear materials, radioactive waste and other radiation sources (to be filled out by citizens of Ukraine) to improve the procedure for special checks to provide individuals with the necessary permits.

To maintain the operations of enterprises, institutions and organizations that are important for the safe use of nuclear energy under martial law, the SNRIU approved criteria for identifying enterprises, institutions and organizations critical for the national economy.

Licensing

The Law of Ukraine "On Authorizing Activities in Nuclear Energy" defines the specific features of authorizing activities in this area. Nuclear and radiation safety is among the top priorities.

Pursuant to this Law, activities on the use of nuclear energy should comply with established nuclear and radiation safety regulations and rules and should undergo a comprehensive safety assessment before a decision is made to issue or refuse to issue an authorization document.

Article 12 of the Law of Ukraine "On Authorizing Activities in Nuclear Energy" establishes procedure for issuing licenses for activities in this area and determines deadlines for making relevant decisions.

To implement the provisions of the Law of Ukraine "On Amendment to Certain Laws of Ukraine to Improve Authorizing Activities in Nuclear Energy" (No. 2755-IX) enacted in 2022:

– Cabinet Resolution No. 648 dated 27 June 2023 introduced amendments to the sample license form in the use of nuclear energy and its description;

– Cabinet Resolution No. 647 dated 27 June 2023 introduced amendments to Cabinet Resolution No. 440 dated 6 May 2001 "On Approval of the Procedure for Collecting Fees for Authorizing Procedures in Nuclear Energy" and Cabinet Resolution No. 591 dated 1 June 2011 "On Approval of the List of Paid Administrative Services Provided by the State Nuclear Regulatory Inspectorate of Ukraine and the Fees for Their Provision".

In connection with martial law in Ukraine, the Government adopted Resolutions No. 165 dated 28 February 2022 "On Suspending the Deadlines for Providing Administrative Services and Issuing Authorizing Documents" and No. 314 dated 18 March 2022 "Some Issues of Economic Activities under Martial Law" to suspend the deadlines for providing administrative services and timeframes for applying for public services, as legally established, for the duration of martial law and to extend the validity periods of authorizing documents. In accordance with Cabinet Resolution No. 828 dated 8 August 2023, timeframes for the provision of administrative services and the issue of authorizing documents were extended.

At the same time, the SNRIU continued reviewing applications from licensees to issue, amend or extend the authorizing documents, considering comprehensive safety assessments of relevant facilities and activities in the use of nuclear energy.

Information on the number of the SNRIU's authorizing procedures in 2023 is given in Table 1.

State Oversight and Enforcement

In 2023, state oversight of compliance with nuclear and radiation safety requirements was exercised with limitations related to the imposition of martial law in Ukraine by Decree of the President of Ukraine No. 64/2022 dated 24 February 2022.

Pursuant to Resolution of the Cabinet of Ministers of Ukraine No. 303 dated 13 March 2022 "On the Termination of State Oversight (Control) and State Market Oversight in Conditions of Martial Law" (with amendments), the SNRIU terminated scheduled inspections for the period of martial law. If there is a threat that has an adverse effect on the rights, legitimate interests, human life and health, environmental protection and state security, as well as in order to fulfill Ukraine's international obligations, unscheduled inspections and surveys may be performed under the SNRIU's decision within martial law.

Under wartime conditions, the SNRIU inspectors exercised state oversight of compliance with nuclear and radiation safety requirements in accordance with the Procedure for State Oversight of Compliance with Nuclear and Radiation Safety Requirements, approved by Cabinet Resolution No. 824 dated 13 November 2013 through:

– analysis of information on nuclear and radiation safety of facilities subject to state oversight;

– inspections and surveys;

– issue of mandatory prescriptions and orders upon detection of incompliance with

nuclear and radiation safety requirements based on analysis of information on nuclear and radiation safety of facilities subject to state oversight;

– application of enforcement measures established by legislation to legal entities and individuals upon detection of incompliance with nuclear and radiation safety requirements and/or failure to comply with prescriptions or orders.

State oversight of nuclear facilities is exercised by NPP nuclear safety inspectorates on a permanent basis. In addition to the key state oversight measures, they carry out activities identified in para. 18 of the Procedure for State Oversight of Compliance with Nuclear and Radiation Safety Requirements, approved by Cabinet Resolution No. 824 dated 13 November 2013, through daily monitoring.

In 2023, the SNRIU inspectors conducted one inspection and six surveys of facilities subject to state oversight. Two state inspections (ChNPP and CRME) were conducted to check physical protection systems of nuclear facilities, nuclear materials, radioactive waste and other radiation sources and interaction plans in case of sabotage.

Upon inspections and analysis of information on nuclear and radiation safety at facilities subject to state oversight, seven mandatory prescriptions were issued to eliminate incompliance with nuclear and radiation safety requirements. Furthermore, three resolutions were issued to restrict operation of facilities subject to state oversight as revealed incompliance with nuclear and radiation safety requirements could not be eliminated.

Administrative penalties for the violation of nuclear and radiation safety regulations and rules and failure to comply with legal requirements (prescriptions) to eliminate violations of nuclear and radiation safety legislation were applied to officials of enterprises, institutions and organizations in accordance with Articles 95 and 188[18] of the Code of Administrative Offences of Ukraine. In 2023, the Chief State Inspector for Nuclear and Radiation Safety of Ukraine and his deputies held eight individuals administratively liable and imposed fines for a total amount of 6,970 UAH.

If violations that are subject to liability under Article 17[1] of the Law of Ukraine "On Authorizing Activities in Nuclear Energy" are revealed, financial sanctions are applied to the nuclear entities concerned. In 2023, the Chief State Inspector for Nuclear and Radiation Safety of Ukraine and his deputies applied financial sanctions to 30 entities for a total amount of 1,624,000 UAH.

II. SAFETY OF NUCLEAR FACILITIES

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

There are 15 power units in Ukraine at the operational life stage: 13 VVER-1000 units and 2 VVER-440 units, with a total installed capacity of 13,835 MW.

In accordance with the Law of Ukraine "On the Joint Stock Company "National Nuclear Energy Generating Company Energoatom" and Resolution of the Cabinet of Ministers of Ukraine No. 1420 dated 29 December 2023, the Joint Stock Company "National Nuclear Energy Generating Company Energoatom", whose 100 percent of shares are owned by the state, was established by transforming the State Enterprise "National Nuclear Energy Generating Company Energoatom".

The company is the legal successor of all property and non-property rights and obligations of the State Enterprise "National Nuclear Energy Generation Company Energoatom" from the date of its state registration as the operating organization (operator) for the existing NPPs in Ukraine.

Separate entities of the State Enterprise "National Nuclear Energy Generating Company Energoatom" continue to function as its subdivisions (branches, representative offices) from the day of the company's state registration, including the Zaporizhzhia NPP, Rivne NPP, Pivdennoukrainsk NPP and Khmelnytsky NPP.

Since 4 March 2022, as a result of armed seizure, the ZNPP site has been under control of the russian military forces. In connection with violation of nuclear and radiation safety requirements, the operation of ZNPP Units 1 and 2 has been restricted since 18 August 2022 and the operation of ZNPP Units 3, 4, 5, and 6 has been restricted since 28 June 2023. In connection with illegal construction at the ZNPP DSFSF site, operation of the ZNPP DSFSF has been restricted since 28 October 2022.

Since 1 September 2022, representatives of the ISAMZ (IAEA Support and Assistance Mission to Zaporizhzhia) have been permanently working at the ZNPP site with periodic rotation of expert groups. The ISAMZ mission in 2023 was the only source of official information on the ZNPP safety under occupation, since the ZNPP legal operator was deprived of the possibility to perform the functions stipulated by the legislation and international obligations.

At other NPPs, in accordance with the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Convention on Nuclear Safety, the operating organization ensures plant stable and safe operation. Safety improvement measures at operating NPPs are implemented on a systematic basis in compliance with the requirements of national standards and rules on nuclear and radiation safety and IAEA recommendations, taking into account long-term operating experience and international practices.

SNRIU activities on safety regulation of nuclear facilities are intended to ensure nuclear and radiation safety at all their life stages and protect personnel, the public and the environment.

The main attention is focused on the compliance with nuclear and radiation safety requirements by the operating organization in the operation of NPP units, including maintenance and repair, and on safety improvement of operating Ukrainian NPPs.

Within the licensing of operating organizations at the life stages of nuclear facilities:

1) nine individual permits were issued by Energoatom for startup of power units after core refueling outages;

2) seven licenses of operating organizations were amended, namely:

– on 13 January 2023, amendments were made to License EO No. 001098 issued by the SNRIU to the SSE "Chornobyl NPP" on 12 January 2011

for personnel training related to nuclear facility operation. The amendments concerned the extension of the license until 12 January 2030.

– as for the occupied ZNPP: on 28 June 2023, amendments were made to four Energoatom licenses: No. EO 001062 for the operation of Unit 3, No. EO 001069 for the operation of Unit 4, No. EO 001090 for the operation of Unit 5 and No. EO 000196 for the operation of Unit 6 and DSFSF. The amendments restricted the operation of power units to the cold shutdown state.

– on 9 November 2023, amendments were made to Energoatom License No. EO 001019 for activities at the operational life stage of PNPP Unit 1. The amendments changed the plant name from the South Ukraine NPP to the Pivdennoukrainsk NPP and determined the date of the next periodic safety review: 2 November 2033.

– on 22 December 2023, amendments were made to License EO No. 00000051 issued to the Nuclear Research Institute, National Academy of Sciences of Ukraine, for the operation of the VVR-M nuclear facility. The amendments restricted the operation of the VVR-M nuclear research reactor to maintenance activities in shutdown state with nuclear fuel unloaded from the core until 31 December 2026.

Safety Improvement of Operating NPPs

NPP safety is improved through the implementation of 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 dated 7 December 2011.

In accordance with the above resolution, the operating organization develops annual schedules indicating the deadlines for the implementation of integrated safety improvement measures for power units and agrees them with the Ministry of Energy, SNRIU and SESU (in terms of fire prevention measures).

The C(I)SIP is financed from Energoatom funds and, since 2015, also from EBRD and Euratom loans (Resolution of the Cabinet of Ministers of Ukraine No. 356 dated 20 August 2014).

The military aggression by the russian federation directly affected the implementation of the C(I)SIP measures.

The force majeure circumstances related to the military aggression of the russian federation against Ukraine caused major damage to industrial enterprises and infrastructure, disruption of logistics, reduction in the number of personnel at design, construction, and pre-commissioning organizations because of mobilization and forced evacuation. This made it impossible to fulfill a number of obligations under contracts concluded for the supply of necessary equipment, materials, products and other goods, perform individual activities and provide services.

Under these circumstances, Resolution of the Cabinet of Ministers of Ukraine No. 479 dated 12 May 2023 extended the C(I)SIP implementation period until the end of 2025.

In total, 1295 measures were planned for implementation within the C(I)SIP, of which 1096 (~84.6 %) measures were completed and their reports were agreed by the SNRIU and SESU.

Periodic Safety Review of NPP Units

In accordance with Article 33 of the Law of Ukraine “On Nuclear Energy Use and Radiation Safety”, the operating organization (operator) is obliged to periodically, in compliance with NRS standard and rules, perform safety reviews of nuclear facilities and submit reports on their results to the state nuclear regulatory authority.

Requirements for periodic safety review of NPP units are set forth in the following regulatory documents:

– General Safety Provisions for Nuclear Power Plants;

– Requirements for Safety Assessment of Nuclear Power Plants;

– Requirements for Periodic Safety Review of Nuclear Power Plants.

The objective of periodic safety review is to determine:

– compliance of the safety level of an NPP unit with NRS standards and rules, design and operational documents, as well as the safety analysis report for the power unit;

– sufficiency and efficiency of the existing conditions to maintain the appropriate safety level of the NPP unit

until the next periodic safety review or until the expiration of its lifetime (if power unit operation is terminated before the next periodic safety review);

– list and timeframes of safety improvement measures for the power unit necessary to eliminate or mitigate shortcomings if they are identified upon safety analyses.

Periodic safety review is carried out for:

– systematic safety assessment of an NPP unit, which is performed every 10 years;

– making decisions on long-term operation of the NPP unit.

During the periodic safety review, 14 safety factors are subject to mandatory analysis, specifically:

– power unit design (SF-1);

– current technical condition of systems, structures and components (SF-2);

– equipment qualification (SF-3);

– ageing (SF-4);

– deterministic safety analysis (SF-5);

– probabilistic safety assessment (SF-6);

– analysis of internal and external events (SF-7);

– operational safety (SF-8);

– experience feedback from other plants and research findings (SF-9);

– organization, management system and safety culture (SF-10);

– operational records (SF-11);

– human factor (SF-12);

– emergency preparedness and planning (SF-13);

– radiation impact on the environment (SF-14).

In addition, an integral component of the Periodic Safety Review Report for an NPP unit is Comprehensive Safety Analysis. It is developed by the operating organization and should contain analysis of each safety factor and analysis of the relationships between the factors, assessment of the impact from identified deviations on safety, identification, categorization and prioritization of measures aimed at eliminating or compensating deviations and/or improving safety, brief results of forecasting changes for each safety factor until the next periodic review or until the expiration of the NPP unit lifetime (if power unit operation is terminated before the next periodic safety review), comprehensive safety improvement plan, as well as conclusions on the possibility of further NPP operational safety, including that in the long term.

Activities on the periodic safety review of Ukrainian NPP units are performed by the operating organization in accordance with the Summary Schedule for the Development of Periodic Safety Review Reports for Ukrainian NPP Units approved by the SNRIU. Taking into account the measures defined in the Summary Schedule, the SNRIU provided the following in 2023:

1. Completion of evaluations for materials within the Periodic Safety Review Report for PNPP Unit 1. The conclusions of the state expert review on nuclear and radiation safety with regard to materials of the Periodic Safety Review Report for PNPP Unit 1 were discussed at the meeting of the SNRIU Board and approved by Ordinance of the SNRIU Board No. 5 dated 2 November 2023.

2. State NRS review of the reports upon analysis of individual safety factors in the Periodic Safety Review Report for PNPP Unit 1 (SF-9, SF-10, SF-11, SF-12, SF-13, SF-14). Periodic safety review for PNPP Unit 1 is performed by the operating organization to justify safety of further unit operation at power levels after 31 December 2025. Submission of a complete package of materials within the Periodic Safety Review Report to the SNRIU is planned until 31 December 2024.

3. State NRS review with regard to specific safety factors of the Periodic Safety Review Report for KhNPP Unit 2 (SF-2, SF-3, SF-4). Periodic safety review of KhNPP Unit 2 is performed by the operating organization to justify further operational safety of the power unit within the design lifetime and should be completed by 7 September 2025. Submission of a complete package of materials within the Periodic Safety Review Report to the SNRIU is planned until 7 September 2024.

4. State NRS review of the reports upon analysis of individual safety factors in the Periodic Safety Review Report for RNPP Unit 4 (SF-3, SF-4). Periodic safety review of RNPP Unit 4 is performed by the operating organization to justify further operational safety of the power unit within the design lifetime and should be

completed by 7 June 2025. Submission of a complete package of materials within the Periodic Safety Review Report to the SNRIU is planned until 7 June 2024.

Extension of Long-Term Operation of Pivdennoukrainsk NPP Units 1 and 2

According to the review of justifications for further safe operation of PNPP Unit 1, including the Periodic Safety Review Report for the power unit submitted by operating organization Energoatom, conducted inspections and public discussions, the SNRIU decided to extend the long-term operation of PNPP Unit 1 at the power levels indicated in the design until 2 December 2033.

SNRIU Order No. 575 dated 9 November 2023 appropriately amended License No. EO 001019 for activities at the operational life stage of Pivdennoukrainsk NPP Unit 1.

According to License No. EO 001047 dated 9 December 2015, the lifetime of Pivdennoukrainsk NPP Unit 2 expires on 31 December 2025. Activities to justify further safe operation of the power unit are performed by the operating organization in accordance with the Program of Measures to Justify the Possibility of Further Long-Term Operation of PNPP Unit 2, agreed by the SNRIU in accordance with the established procedure.

Implementation of the National Action Plan upon Stress-Test Results

In June 2011, Ukraine joined the European initiative to conduct stress tests at NPPs in European Union member states and neighboring countries (Declaration on Stress Tests).

Stress tests for Ukrainian NPPs were carried out in accordance with the stress-test methodology for European NPPs agreed by the European Commission and ENSREG (13 May 2011, Declaration of ENSREG, Annex 1 “EU Stress Test Specifications”). The National Action Plans contain safety improvement measures identified upon the stress tests and schedules for their implementation at NPPs.

In 2023, the National Action Plan was updated (in accordance with the ENSREG requirements, the update is conducted every two years). The current status of safety improvement measures identified by the stress-test results and the deadlines for specific measures were updated. The number of planned measures and their scope did not change.

In 2023, a number of measures were implemented at Ukrainian NPP Units to develop necessary documents and perform equipment qualification, analyze in detail the need for VVER-1000 primary system makeup in the event of an accident involving a loss of power supply and/or ultimate heat sink, determine the possibility to implement in-vessel melt retention strategy at VVER-1000 units, ensure seismic resistance of equipment, systems and structures, develop seismic PSA, implement an external reactor pressure vessel cooling system at VVER-440 units etc.

Analysis of NPP Operational Events

The accounting and analysis of NPP operational events are an integral part of the operating experience feedback system, which in turn is an aspect of NPP operational safety. Maintaining an adequate level of NPP operational safety requires continuous comprehensive analysis of operating experience to assess the current state of power units, identify lessons learned, and develop corrective measures.

In order to unambiguously identify the categories of operational events at Ukrainian NPPs that were caused by military aggression of the russian federation and have consequences/features of operational event categories in accordance with the Provisions on the Procedure for Investigation and Accounting of NPP Operational Events (NP 306.2.235-2021) but were not accompanied by human errors, failures or other equipment malfunctions or organizational shortcomings, the operating organization made a decision to classify such events as operational events with category P23 “Any other events considered by the operating organization to be important to safety and require corrective actions” and agreed it with the SNRIU. In addition, if such events occurred at several power units of one NPP, they should be considered common-plant events. Otherwise (when events caused by military aggression were accompanied by an additional failure or human error, etc.), such events should be classified, according

to their consequences/features, as one of categories A01-P22 and investigated separately for each power unit.

In 2023, 26 information notices on operational events were reviewed and relevant reports on investigation of events that occurred at Ukrainian NPPs were considered.

On 9 November 2023, a meeting of the SNRIU Board was held to discuss the efficiency of operating experience feedback (investigation results for NPP operational events and calculation of safety performance indicators for 2022 and the first half of 2023). The results emphasized the need for the operating organization to implement a number of measures to:

– ensure proper supervision by the management over correctness of event classification and quality of operational event investigation;

– analyze lessons learned from operational events that were caused by the russian military aggression, as well as develop and implement measures for mitigating transients and increasing the robustness of power unit equipment during unstable grid operation and loss of external power;

– meet regulatory requirements in the classification of operational events and implementation of corrective measures;

– review the "List of Corrective Measures with the Implementation Period Exceeding Two Years from the Date of Their Identification, with Finally Determined Completion Dates".

Zaporizhzhia NPP under Occupation

Since 4 March 2022, the ZNPP has been under the russian occupation, which is a major breach of international law and neglect of IAEA safety standards and national NRS standards and rules.

Currently, the operation of ZNPP units is restricted to cold shutdown state, with relevant amendments introduced to the licenses for operation of the power units.

Despite this, the occupation administration repeatedly violated the license terms for the ZNPP units by transferring Units 4 and 6 to the hot shutdown state over the year.

Since 17 May 2023, the occupiers have blocked data transmission from the ZNPP data transmission system, including the automated radiation monitoring system, featuring early detection of changes in radiological situation for the purposes of emergency response and support of decision-making for the protection of the public and territories in automatic mode.

On 6 June 2023, russian terrorists destroyed the Kakhovka Reservoir (by blowing up the Kakhovka Dam), which served as a reliable water supply source for the ZNPP and as the ultimate heat sink for the cooling systems of six nuclear reactors and spent fuel pools.

The IAEA Director General proposed the following specific principles to contribute to ensuring nuclear safety and security at the ZNPP for preventing a nuclear accident:

1. There should be no attacks by or against the NPP, in particular against reactors, spent fuel storage facilities, other critical infrastructure or personnel;
2. The ZNPP should not be used as a storage or base for heavy weapons (i.e. multiple rocket launchers, artillery systems and ammunition, as well as tanks) or military personnel that could be used to attack from the NPP;
3. NPP power supply beyond its boundaries should not be jeopardized. For this purpose, every effort should be made to ensure the continued availability and safety of the external power supply;
4. All structures, systems and components necessary for safe and secure ZNPP operation should be protected against attacks or sabotage;
5. No action should be taken that undermines these principles.

In 2023, the IAEA permanent monitoring mission to the occupied Zaporizhzhia NPP (ISAMZ) that started in September 2022 continued its work. During 2023, 11 rotations of IAEA experts took place within the mission.

The permanent presence of the IAEA Mission at the Zaporizhzhia NPP is an extremely important factor for both IAEA member states and world community to receive realistic information on the nuclear safety and security at the ZNPP.

The main purpose of the permanent IAEA Mission at the Zaporizhzhia NPP is to prevent a nuclear accident. Support of the emergency preparedness and response capability remains a priority

Photo 1. View of the Zaporizhzhia NPP after the destruction of the Kakhovka Reservoir

task in war conditions and is an important element of national resilience. In 2023, daily information notices of the ISAMZ Mission on the ZNPP safety in accordance with seven safety pillars were analyzed and weekly meetings were held with the IAEA Incident and Emergency Center to exchange operating information on the situation at the temporarily occupied ZNPP and the safety at other NPPs, including ChNPP.

Unfortunately, the presence of the IAEA mission is not an obstacle for the russian occupiers to make unpredictable decisions and take irresponsible actions that undermine the nuclear safety and security of the ZNPP.

The russian occupiers use the ZNPP as a military base. The ISAMZ group has repeatedly recorded the facts of rocket and artillery fire from the territory around the ZNPP, violations of other safety principles by the occupation administration, etc.

The situation with regular maintenance at the ZNPP worsens day by day. There is no systematic approach or scheduled activities for maintenance of safety systems and systems important to safety. There has been no scheduled maintenance for a significant part of important equipment.

Since 1 February 2024, the ZNPP occupation management has prohibited access to the enterprise territory for employees who have not received a russian passport and have not signed a contract with rosatom. At the same time, rostechnadzor has illegally appropriated the rights of the regulatory authority, admits unqualified personnel to work, and issues fake 'permits' to unlicensed employees for the operation of ZNPP reactors.

In particular, the importance of the qualification and sufficient number of personnel for ZNPP safety was emphasized by IAEA Director General Rafael Grossi in his statement to the UN Security Council.

2. Safety Regulation of New Nuclear Facilities and Nuclear Fuel Management

Currently, the following nuclear facilities are at the stage of commissioning on the territory of Ukraine:

1) CSFSF: centralized dry long-term storage facility for spent nuclear fuel from operating NPPs;

2) Neutron Source: nuclear subcritical facility "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator".

In addition, there are arrangements in progress for:

– completion of KhNPP Units 3 and 4 and construction of Units 5 and 6;

– construction of a nuclear fuel fabrication plant;

– deployment of small modular reactors in Ukraine.

The safety of new nuclear facilities is regulated by the SNRIU through:

– review of draft ordinances/ resolutions of the Cabinet of Ministers

of Ukraine and laws of Ukraine related to the above issues and state NRS review of justification materials;

– state review and approval of technical specifications for systems and equipment important to safety of nuclear facilities, test programs for these systems and equipment;

– direct participation of SNRIU representatives in the testing of systems and equipment important to safety of nuclear facilities;

– state review and approval of design and operational documents for nuclear facilities.

Centralized Spent Fuel Storage Facility

CSFSF is designed for long-term (within 100 years) storage of spent fuel from the Rivne, Khmelnytsky and Pivdennoukrainsk NPPs.

The Holtec International (USA) technology is employed for spent fuel management.

The CSFSF is commissioned under Individual Permit No. EO 001060/1/15 for CSFSF commissioning issued within License No. EO 001060 for the construction and commissioning of the spent nuclear fuel storage facility, issued by the SNRIU on 29 June 2017.

During 2023, the SNRIU:

– exercised oversight of compliance with nuclear and radiation safety requirements at CSFSF and analyzed compliance with the terms of licenses;

– reviewed technical and operational documents to be agreed with the SNRIU in accordance with current legislation;

– provided regulatory support in the implementation of modification projects for Rivne, Khmelnytsky and Pivdennoukrainsk NPPs within their preparation for spent fuel unloading using equipment developed according to the Holtec International technology.

Neutron Source

The nuclear subcritical facility "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" (Neutron Source) was constructed on premises of the National Science Center "Kharkiv Institute of Physics and Technology" (KIPT) in accordance with the agreements reached at the Washington Summit, set forth in the Joint Statement of the Presidents of Ukraine and the United States in April 2010, and the "Memorandum of Understanding between the Governments of Ukraine and the United States of America on Nuclear Security Cooperation", signed on 26 September 2011. The project is being implemented under support of the U.S. Argonne National Laboratory.

The Neutron Sources is designed for scientific and applied research in nuclear physics, radiation materials science, biology, chemistry and production of medical radioisotopes.

The KIPT carries out its activities under Individual Permit No. EO 001018/2/15 for the initial startup of the Neutron Source dated 1 July 2020, issued in accordance with License EO No. 001018 dated 10 October 2013 for the construction and commissioning of the Neutron Source.

With the introduction of martial law, the Neutron Source was transferred to a deep subcritical state (no chain reaction) and remained in this state throughout 2023.

The institute territory where the Neutron Source is located was repeatedly shelled/bombed by russian troops. The institute infrastructure suffered catastrophic damage. The Neuron Source itself came under fire, and damage was inflicted to the off-site power supply system, air conditioning system, cooling system of the klystron gallery of the linear electron accelerator and buildings (with the nuclear facility, pumping units and cooling towers and isotope laboratory).

During 2023, the SNRIU:

– supervised compliance with nuclear and radiation safety at the Neutron Source;

– considered proposals of the NSC KIPT regarding approaches to the testing of all NPP systems for compliance with the design requirements upon remedial activities.

In addition, with involvement of the SSTC NRS and under support of the Norwegian Radiation and Nuclear Safety Authority (DSA), the SNRIU started developing an Action Plan in 2023, with the purpose of specifying the procedure to renew licensing of the facility in accordance with Ukrainian legislative and regulatory documents on NRS, taking into account the current state of the Neutron Source (remedial activities after shelling).

Photo 2. CSFSF site
(maintenance building, acceptance building)

Photo 3. Central hall of the CSFSF container acceptance building

Khmelnytsky NPP Units 3 and 4

The strategic initiatives of the Government and tasks outlined in the Energy Strategy of Ukraine until 2050, approved by Ordinance of the Cabinet of Ministers of Ukraine No. 373-r dated 21 April 2023, provide for the following:

– until 2025: preparatory activities and start of new construction at the Khmelnytsky NPP;

– until 2032: increase in nuclear power production (increase in NPP installed capacity factor and construction of new units at the Khmelnytsky NPP).

For the above purposes, Energoatom is working on the completion of KhNPP Units 3 and 4.

In 2023, the SNRIU reviewed:

– approaches proposed by Energoatom to resolve comments of state NRS reviews of reports prepared upon inspections and technical condition assessments of structures and buildings at KhNPP Unit 3 and 4;

– draft Law of Ukraine "On Siting, Design and Construction of Khmelnytsky NPP Units 3 and 4".

Khmelnytsky NPP Units 5 and 6

Ordinance of the Cabinet of Ministers of Ukraine "On Organizational Measures for the Construction of Khmelnytsky NPP Units" No. 52-r dated 20 January 2023 established that the AR1000 reactor performances would be used in the development of the feasibility study for nuclear facility construction and Energoatom would be the applicant for the construction of new Khmelnytsky NPP units.

During 2023, the SNRIU:

– considered Energoatom proposals to approve, at the national level, the application of the U.S. Nuclear Regulatory Commission's certificate issued to Westinghouse for the basic AR1000 reactor design in Ukraine and application of regulations, standards and rules;

– held consultations with the U.S. NRC on the granting of legal rights to Ukraine to use U.S. NRC certificates for the AR1000 and NuScale nuclear facility designs and receive reviews of the justifications submitted to obtain the certificates.

Nuclear Fuel Fabrication Plant

Decree of the President of Ukraine No. 104/2019 dated 4 April 2019 approved measures to support the development of nuclear energy and enhance safety in the use of nuclear energy, including the establishment of domestic nuclear fuel production.

Order of the Ministry of Energy of Ukraine No. 382 dated 11 November 2022 appointed Energoatom as the operating organization (operator) of a nuclear facility for the fabrication of fuel assemblies for nuclear reactors of nuclear power plants.

In 2023, SNRIU representatives became members of the coordination group for the project to initiate domestic fabrication of nuclear fuel in Ukraine.

The project to develop a production line for assembling VVER-1000 fuel in Ukraine is implemented by Energoatom in cooperation with Westinghouse. The technology provides for the construction of fuel assembles for VVER-1000 power units from ready-made Westinghouse components (except for fuel assembly bottom and top end pieces, to be produced by Atomenergomash) and does not involve uranium reconversion, production of uranium pellets or their loading into fuel rods. The completion and commissioning of the production facilities are scheduled for 2026.

In 2023, the SNRIU reviewed Energoatom's application to amend the laws of Ukraine and regulatory documents in nuclear energy use and radiation safety or to develop special terms ensuring that the requirements of the laws of Ukraine and regulatory documents related specifically to uranium reconversion, uranium pellet production and their loading into fuel rods do not apply to the production facilities for constructing fuel assemblies using the Westinghouse technology. The review indicated that there was no necessity for such action. It was proposed to follow the established legislative procedure for constructing a nuclear facility and licensing the operating organization's activities at individual life stages of the facility.

Westinghouse Nuclear Fuel

Until 2005, all nuclear fuel used at NPPs was exclusively of russian production.

In order to avoid dependence on a monopoly supplier and diversify nuclear fuel sources, Ukraine started licensing (qualification) of nuclear fuel produced by Westinghouse (FA-W, FA-WR).

With the beginning of russia's military aggression against Ukraine, Energoatom completely abandoned nuclear fuel produced by JSC TVEL and started activities to transfer all Ukrainian NPP units to nuclear fuel produced by Westinghouse.

Safety in the implementation of Westinghouse fuel is regulated through state NRS reviews and approval of the operating organization's safety justifications for the use of Westinghouse fuel and modification of other systems important to safety that are necessary for Westinghouse fuel management.

In 2023, the SNRIU reviewed a number of technical solutions with safety justification for implementing the first reload batch of VVER-440 fuel assemblies produced by Westinghouse for RNPP Unit 2.

As of 31 December 2023, the Westinghouse nuclear fuel is operated in the cores of eight Ukrainian NPP units: PNPP Unit 2, PNPP Unit 3, ZNPP Unit 1, ZNPP Unit 3, ZNPP Unit 4, ZNPP Unit 5 and RNPP Unit 3. Trial operation of nuclear fuel produced by Westinghouse was started at RNPP Unit 2 in 2023.

Implementation of Innovative Designs, Including SMRs

The grounds for implementing small modular reactors in Ukraine include:

– Energy Strategy of Ukraine until 2050 approved by Resolution of the Cabinet of Ministers of Ukraine No. 373-r dated 21 April 2023;

– Decree of the President of Ukraine No. 104/2019 dated 4 April 2019 "On Measures to Support the Development of Nuclear Energy and Enhance Safety in the Use of Nuclear Energy".

Energoatom and other organizations signed a number of memorandums with owners of SMR technologies for their deployment in Ukraine.

The SNRIU continued to study and analyze international experience, current trends and prospects for the introduction of small modular reactors, as well as challenges and tasks for regulatory authorities.

In addition, the Provisions for Pre-licensing Review of Nuclear Facility's Design were developed and approved by Ordinance of the SNRIU Board No. 04 dated 19 October 2023.

Results from Environmental Monitoring and Individual Dose Monitoring of Energoatom Personnel

According to the Annual Analytical Report on Radiation Safety and Radiation Protection at NPPs of JSC "National Atomic Energy Generating Company Energoatom" for 2023, the total collective exposure dose to Energoatom NPP personnel amounted to 5798.514 person-mSv. This is higher than in 2022 by 1488.964 person-mSv (4309.55 person-mSv without the ZNPP).

The majority of Energoatom NPP personnel received doses lower than 1 mSv. This group comprises 85 % of the total number of company personnel and personnel from third-party organizations.

The average individual annual dose to Energoatom NPP personnel for the reporting year increased compared to the previous year and amounted to 0.593 mSv/person per year (0.378 mSv/person in the previous year). The average collective dose to Energoatom NPP personnel for one power unit amounted to 0.73 man-Sv. This indicator is slightly higher than the industry long-term target level according to the WANO CRE indicator (collective radiation exposure for personnel), reaching 0.7 man-Sv per power unit, and is greater than the average level for foreign VVER NPPs, as presented in the 30th annual report of the ISOE program (three-year average collective dose for 2018–2020 is 0.45 man-Sv per power unit).

In 2023, the annual collective dose to NPP personnel referred to one power unit became higher for Energoatom as a whole because of:

1) significant increase of the indicator at KhNPP (1.09 person-Sv/unit in 2023 vs. 0.41 person-Sv/unit in 2022) due to refueling outage (medium) at Unit 1 and refueling outage (major) at Unit 2. A part of activities planned for the refueling outage of Units 1 and 2 in 2022 was postponed to 2023;

2) increase of the indicator at RNPP (0.36 person-Sv/unit in 2023 vs. 0.31 person-Sv/unit in 2022) due to

increase in the number of maintenance days for power units in 2023 by 40 % (326 days vs. 233 days in 2022).

The main portion of the collective dose is received by NPP personnel during scheduled and unscheduled maintenance. Quotas (budget) of collective doses were established both in general for each power unit and for the main divisions involved in maintenance. Preliminary forecasts of collective doses are developed upon analysis of the radiological condition of reactor equipment during previous maintenance, taking into account future labor costs for maintenance.

The contribution of maintenance for the main equipment groups to the total collective dose received by personnel during maintenance of NPP units in the 2023 refueling outage for Energoatom on average (without the ZNPP) was as follows: reactor ~35 %, reactor coolant piping ~ 6 %, reactor coolant pump ~ 8 %, steam generator ~ 18 %, pressurizer ~ 3 %, cooling systems ~ 15 %, reactor compartment auxiliary systems ~ 7 %, SWT-1,2 ~ 5 % and nuclear fuel (refueling) ~ 2 %.

Over the last five years, the reference levels of collective doses to the groups of personnel whose annual individual dose is higher than 6 mSv/year (RL6) were not exceeded for Energoatom. Over the last five years, the collective dose to personnel in this group did not exceed 56 % of the established reference level.

The basic limit of individual effective dose to personnel (20 mSv/year on average for any consecutive five years but not over the maximum individual dose limit of 50 mSv for a single year) was not exceeded at the Energoatom NPPs in the reporting year.

In the reporting year, the reference and permissible levels of gas releases into the environment for inert radioactive gases (IRG) were not exceeded at the Energoatom NPPs. In recent years, the levels of IRG airborne releases at all Energoatom NPPs have remained consistently low and virtually unchanged. Over the last five years, this indicator has remained virtually unchanged.

At RNPP, the total IRG release decreased in the reporting year compared to the previous year and reached 47.9 TBq against 61.8 TBq in 2022.

At PNPP, the total IRG release increased in the reporting year compared to the previous year and reached 17.7 TBq against 11.0 TBq in 2022.

At KhNPP, the total IRG release slightly decreased in the reporting year compared to the previous year and reached 10.4 TBq against 11.3 TBq in 2022.

At RNPP, the total LLN release in the reporting year slightly increased compared to 2022 and reached 105.7 MBq (85.5 MBq in 2022).

At PNPP, the total LLN release in the reporting year slightly decreased compared to 2022 and reached 65.0 MBq (78.8 MBq in 2022).

At KhNPP, the total LLN release in the reporting year remained at the previous level and reached 11.4 MBq (11.8 MBq in 2022).

At RNPP, the total release of iodine radionuclides in the reporting year compared to the previous year doubled and reached 59.3 MBq/year against 30.7 MBq/year in 2022. The increase in iodine radionuclide releases is associated with the presence of leaky fuel rods in the power unit cores.

At PNPP, the total release of iodine radionuclides in 2023 almost remained at the previous level and reached 30.8 MBq/year against 29.3 MBq/year in 2022.

At KhNPP, the total release of iodine radionuclides slightly decreased in the reporting year compared to the previous year and reached 13.1 MBq/year (15.9 Mbq/year in 2022).

In the reporting year, the permissible and reference levels of iodine radionuclide releases into the environment were not exceeded at the Energoatom NPPs.

The airborne releases from the Energoatom NPPs were at the level significantly below the release limits established for each NPP.

The permissible and reference levels for airborne releases and radioactive water discharges into the environment were not exceeded at the Energoatom NPPs in the reporting year.

Content of Radioactive Substances in the Environment

During the reporting year, Energoatom monitored the content of radioactive substances in the environment in the NPP location areas, including water in surface

water bodies, air and soils of nearby settlements. The monitoring scope and methods are determined by the Radiation Monitoring Procedures in force at the Energoatom NPPs, agreed with regulatory authorities.

The content of cesium and strontium radionuclides in the water of NPP surface water bodies compared to zero background demonstrates that these concentrations are values of the same order and may differ due to natural conditions: season, floods, drought, etc.

In the reporting year, tritium 3H content was monitored in the water of PNPP and KhNPP cooling ponds and in the Styr (RNPP), Pivdennyi Buh (PNPP) and Horyn (KhNPP) Rivers. The monitoring results indicate that the highest levels of this radionuclide in surface water bodies recorded this year are several orders of magnitude lower than the permissible concentration of tritium in drinking water established by the Radiation Safety Standards of Ukraine.

The content of cesium-137 and strontium-90 radionuclides analyzed during the year in the atmospheric air in settlements around the NPPs compared to zero background demonstrates that these concentrations are of the same order. The radiological condition of the atmospheric air in the NPP location areas remained at zero background, taking into account the impact of ChNPP accident consequences.

Analysis of radioactive substances in the surface soil layer at the radiation monitoring stations at a distance from the NPPs indicates that the levels of soil contamination density were within zero background in the reporting year.

Radiation parameters characterizing the operation of the Energoatom NPPs in the reporting year did not exceed the established values, and radiation protection of personnel and the public was ensured at an adequate level.

The operation of NPPs in the reporting year did not cause registered environmental changes that could indicate deterioration of the environment in the NPP location area compared to previous years. This characterizes the safety level of Ukrainian NPPs as the one in line with the requirements of national legislation and international recommendations.

3. Planning of Decommissioning for Operating Ukrainian NPPs, Spent Fuel Storage Facilities and Other Nuclear Facilities

In 2023, in accordance with the regulatory document “General Safety Provisions for Decommissioning of Nuclear Facilities" (NP 306.2.230-2020), the ChNPP, Energoatom and Nuclear Research Institute (National Academy of Sciences of Ukraine) implemented measures to bring their activities into compliance with the above regulatory document. Hence, relevant documents were developed and submitted to the SNRIU for review and approval.

Upon review, the SNRIU agreed the Decommissioning Strategies for ChNPP ISF-1 and ISF-2.

The following documents are at the stage of finalization:

– Decommissioning Concept for ChNPP ISF-1;

– Decommissioning Concept for ChNPP ISF-2;

– Decommissioning Strategy for VVR-M Nuclear Research Reactor;

– Requirements for the Content of the Decommissioning Strategy for Energoatom Nuclear Facilities;

– Requirements for the Content of the Decommissioning Concept for Energoatom Nuclear Facilities.

III. CHORNOBYL NPP DECOMMISSIONING AND CONFINEMENT-SHELTER OPERATION

1. Chornobyl NPP Decommissioning

Chornobyl NPP Units 1, 2 and 3 are being decommissioned by the SSE ChNPP operator under the license issued by the SNRIU on 22 March 2002 and reissued on 3 November 2020 and Individual Permit OD No. 000040/8 dated 31 March 2015 for the final closure and safe enclosure stage for ChNPP-1, 2 and 3 (FCSE).

The ChNPP implements the FCSE stage in accordance with the "Program for the Implementation of the Final Closure and Safe Enclosure Stage for Chornobyl NPP Units 1, 2 and 3" and Project "Final Closure and Safe Enclosure of Chornobyl NPP Units 1, 2 and 3". In accordance with these documents, the FCSE stage is to be completed in 2028.

The operating organization made efforts to ensure nuclear and radiation safety at the Chornobyl NPP site and to implement measures under the FCSE Program in difficult occupation conditions in February-March 2022 and in the period after the de-occupation.

According to the ChNPP Report on the Implementation of the FCSE Program for 2023, the armed aggression of the russian federation and the ChNPP funding situation made is impossible to fully implement the tasks and measures planned for 2023. Significant delays are observed in the implementation of the main startup stages (construction stages) of the FCSE Program, particularly the dismantling and processing of fuel channels and control rod channels from reactor facilities and the implementation of arrangements to prepare Units 1, 2 and 3 for final closure and safe enclosure.

The ChNPP is developing corrective measures as part of the planned activities, considering possible extension of the deadline for the FCSE stage.

In 2023, activities on the dismantling, fragmentation and marking of previously dismantled equipment and metal structures in the turbine hall of Chornobyl NPP Stage 1 were performed as part of other measures of the FCSE Program. 116 packages of radioactively contaminated equipment and materials with a total weight of 80,410 kg were produced. These materials were sorted, characterized and transferred to the existing sites (areas) for temporary storage.

Decommissioning of the Chornobyl NPP systems and equipment was ongoing as well.

According to the ChNPP, all process systems and systems important to safety were operated in regular mode as part of the ongoing activities in 2023. The process parameters of facilities at the ChNPP industrial site were within the safe operation limits. Regular measures were taken to ensure safety during activities at the Chornobyl NPP site.

The reference levels of surface radioactive contamination, radioactive releases and discharges into the environment or individual annual external and internal doses of personnel were not exceeded.

2. Radioactive Waste Management Facilities at Chornobyl NPP

Radioactive waste accumulated during Chornobyl NPP operation and mitigation of the 1986 accident consequences and waste generated during decommissioning of Units No. 1, 2 and 3 and Shelter transformation into an environmentally safe system is stored in radwaste storage facilities at the Chornobyl NPP site, such as solid radwaste storage facilities, liquid radwaste storage facilities and liquid and solid radwaste storage facilities, or is transferred for disposal.

A number of radwaste management facilities were constructed at the ChNPP site within international technical assistance projects. These facilities are currently in operation. They store and process radioactive waste to bring it to a condition acceptable for transfer for disposal in the engineered near-surface disposal facility

for radioactive waste (ENSDF) at the Vektor site in the exclusion zone.

Liquid Radioactive Waste Treatment Plant (LRTP)

Liquid radioactive waste is processed according to License No. OB 001092 for the Operation of the Liquid Radioactive Waste Treatment Plant (LRTP).

The LRTP technology envisages the processing of liquid radwaste in the form of evaporation bottoms, pulp of spent ion-exchange resins, perlite pulp and sludge.

According to the conditions of the above-mentioned license, the ChNPP only processes evaporation bottoms at the LRTP. After processing, packages with cemented liquid radwaste are transferred for disposal to ENSDF.

According to ChNPP report, 230.97 m^3 of evaporation bottoms were processed in 2023. As a result, 2500 packages with cemented radwaste were produced and sent to ENSDF for disposal.

An operational event occurred at the end of January 2023 (30 January 2023). It was caused by voltage drop at the Chornobyl NPP, specifically by LRTP blackout. Investigation revealed that power could not be supplied to the LRTP because the UPS-1 and UPS-E uninterruptible power supply sources were in inoperable condition.

In the above regard, the Nuclear and Radiation Safety Inspectorate in the Exclusion Zone issued Order No. R-2/31 on 14 April 2023 to terminate process operations related to radioactive waste processing at the LRTP until the defects in the specified UPS were eliminated and they were introduced into operation according to the standard procedure.

The ChNPP developed a technical decision "On the Renewal of Evaporation Bottoms Processing at the LRTP" to identify measures for the processing of evaporation bottoms until the uninterruptible power supply sources are restored to operable condition. The SNRIU agreed for the renewal of liquid radioactive waste processing at the LRTP upon state NRS review of the technical decision.

In 2023, the SNRIU made decisions to amend License No. OB 001092 upon review of the following ChNPP applications:

– in August 2023, to postpone the deadline to complete para. 3.4 of the license, namely complete "active" tests at the LRTP with spent ion-exchange resins and a mixture of ion-exchange resins and evaporation bottoms by 30 November 2024;

– in October 2023, to postpone the deadline to complete para. 3.3 of the license, namely implement the formulation for processing of evaporation bottoms with a salt content of at least 470 g/l and processing of evaporation bottoms with this salt content by 29 September 2026.

The main reasons to amend the license were the need for additional time to take measures to repair relevant LRTP equipment, lack of funds, as well as occupation of the Chornobyl NPP site by russian military in February-March 2022, which made it impossible to timely complete the planned activities.

Industrial Complex for Solid Radwaste Management (ICSRM)

ICSRM includes:

Lot 0 – Interim Storage Facility for group III waste (high-level waste) and low- and intermediate-level long-lived radwaste (ISF HLW and LIL-LLW);

Lot 1 – Solid Radwaste Retrieval Facility (SRRF);

Lot 2 – Solid Radwaste Treatment Plant (SRTP);

Lot 3 – Engineered Near-Surface Disposal Facility for solid radwaste (ENSDF) located on the Vektor site.

In 2023, the SNRIU reviewed and agreed "Emergency Plan for the Industrial Complex for Solid Radioactive Waste Management (ICSRM)" 1PL-VIP RM.

Operation of ISF HLW and LIL-LLW (Lot 0)

ISF HLW and LIL-LLW was designed for intermediate storage of solid radwaste preliminary sorted at the solid radioactive waste treatment plant (SRTP) that cannot be disposed in the engineered near-surface disposal facility (ENSDF) and high-level and intermediate-level radwaste generated during the activities to transform the Shelter into an environmentally safe system and ISF operation.

ISF HLW and LIL-LLW was put in operation in 2010 and SNRIU issued Individual Permit OD No. 000040/4 on 10 December 2010.

On 30 September 2021, the SNRIU issued License No. OB 001095 for the operation of ISF HLW and LIL-LLW.

Individual Permit OD No. 000040/4 dated 10 December 2010 was recognized invalid.

The ChNPP provides current operation of ISF HLW and LIL-LLW in accordance with the conditions of the above license.

Commissioning of SRRF and SRTP (Lots 1 and 2)

The SRRF is designed to retrieve solid radwaste from the solid radwaste storage facility, load it into containers and transfer for processing to the SRTP through the transport gallery.

The SRTP is designed for the processing of solid radwaste accumulated during ChNPP operation and radwaste generated during decommissioning of ChNPP Units 1, 2 and 3, ISF operation and Shelter transformation into an environmentally safe system.

The main solid radwaste processing operations include compaction, incineration and cementing.

According to the "ICSRM Commissioning Program" 57PR-TsPTRO, three stages of SRRF and SRTP commissioning are envisaged:

Stage 1 involves tests with homogeneous "sealed" solid radwaste with known characteristics (completed under Individual Permit No. 000040/3 dated 13 May 2010);

Stage 2 involves tests with homogeneous "unsealed" solid radwaste with known characteristics (completed under Individual Permit No. 000040/6 dated 23 May 2014);

Stage 3 involves tests with heterogeneous solid radwaste with unknown characteristics.

The ChNPP is implementing Stage 3 of SRRF and SRTP testing according to License No. OB 001096 for radwaste processing and storage, specifically for SRRF and SRTP commissioning.

During 2023, within Stage 3 of testing at the SRTP, 12 m^3 of salt–bitumen compound at the Rivne NPP (60 KRO-200 barrels) were processed (cemented). This resulted in the production of 12 KZ-3 packages with a total volume of 36 m^3, which were sent for disposal to the ENSDF.

3. Confinement-Shelter Operation

Confinement-Shelter (NSC-Shelter) is operated under License No. OB 001094 issued by the SNRIU on 12 August 2021 for the processing and storage of radioactive waste existing and generated during the Shelter transformation into an environmentally safe system within the Confinement-Shelter operation.

According to para. 3.18 of this license, the ChNPP was required to dismantle the Shelter unstable structures by 31 October 2023.

For a number of objective reasons (lack of full and stable funding for activities, Covid-19 spread, russian military aggression against Ukraine, including occupation of the Chornobyl NPP site), the ChNPP was unable to dismantle the unstable structures within the above deadline.

The ChNPP proposed postponing the deadline for these activities by six years, until 31 October 2029, including two years for the development of the working design and four years for dismantling.

As part of the measures for further dismantling of Shelter unstable structures, the ChNPP developed the "Decision on Safety Review of the Shelter Confining Structure to Justify the Extension of Its Operation after 31 October 2023 at the Safety Level Not Lower Than That Achieved after Completion of Immediate Stabilization" and agreed it with the SNRIU.

According to this decision and considering the results of previously completed activities, including additional Shelter surveys, the ChNPP developed the "Operational Safety Review Report for the Shelter Confining Structure to Justify the Extension of Its Operation after 31 October 2023 at the Safety Level Not Lower Than That Achieved after Completion of Immediate Stabilization" (SRR for the Shelter Confining Structure).

On 21 September 2023, the ChNPP submitted an application with a package of documents to the SNRIU to amend License No. OB 001094 to extend the deadline for dismantling the Shelter unstable structures by 31 October 2029.

On 19 October 2023, the state NRS review findings for the SRR for the Shelter Confining Structure were discussed at a meeting of the SNRIU Board.

The Board stated that the SRR for the Shelter Confining Structure had some drawbacks in the safety review and did not currently provide sufficient justification that the safety level of the Shelter Confining Structure remained not lower than the one achieved after the completion of emergency stabilization.

The decision of the Board established obligations for the ChNPP to:

– exercise enhanced control over the condition of the Shelter Confining Structure;

– perform additional surveys of the technical condition, systematic computer analysis of bearing capacity and position stability and systematic assessments of the failure probability for structures of nuclear and radiation safety categories I and II;

– complete the SRR for the Shelter Confining Structure taking into account additional surveys, computer analyses and other comments from the review of the SRR for the Shelter Confining Structure.

On 30 October 2023, amendments were made to License No. OB 001094, according to which the ChNPP:

– by 31 October 2025, shall design and approve the design for dismantling Shelter unstable structures;

– by 31 October 2025, within the design for the dismantling of Shelter unstable structures, shall develop detailed design and process decisions for additional stabilization of predetermined individual structures of the Shelter;

– by 31 October 2029, in compliance with the design approved according to the established procedure, shall dismantle Shelter unstable structures;

– if the design for dismantling unstable structures starts later than 31 October 2025, the ChNPP shall take measures for additional stabilization of individual predetermined unstable structures of the Shelter.

The SNRIU revised and agreed the following documents within the review for extension of the period for dismantling Shelter unstable structures:

– "Program for Inspecting the Condition of the Shelter Confining Structure";

– "Criteria Determining the Safety Level of the Shelter Confining Structure for the Period of Its Lifetime Extension";

– "Report on Analyzing the Condition of the Shelter Confining Structure Based on Monitoring Results";

– "Report on Reassessing the Resistance of the B1/B2 Beam System and Their Support Structures under the Safe Shutdown Earthquake";

– "Report with Data on the Technical Condition of the Shelter Confining Structure and Analysis of These Data".

In 2023, to establish systematized requirements and rules for nuclear and radiation safety on the Confinement-Shelter operation, the SNRIU with the involvement of the SSTC NRS completed the development of the regulation "Safety Requirements for the Confinement-Shelter System" (approved by SNRIU Order No. 15 dated 9 January 2024 and registered in the Ministry of Justice of Ukraine under No. 114/41459 on 23 January 2024).

Nuclear and radiation safety of the NSC–Shelter system is ensured by organizational and technical measures within the current NSC–Shelter operation and within the implementation of projects to transform the Shelter into an environmentally safe system. The activities are conducted with radiation and dose monitoring, including the recording of doses loads on ChNPP personnel and third-party organizations.

In 2023, the average individual dose of ChNPP personnel who worked on the NSC-Shelter site was 0.81 mSv, and the average individual dose of third-party personnel was 2.07 mSv.

The reference levels of individual annual exposure doses (13 mSv/year) of ChNPP personnel and third-party organizations were not exceeded.

Solid and liquid radioactive waste is generated during NSC–Shelter operations.

Liquid radwaste (radioactively contaminated water) is generated in the decontamination of rooms, equipment and tools, dust suppression and operation of changing rooms.

During 2023, 165 m^3 of radioactively contaminated water with the total activity of $4{,}136 \times 10^9$ Bq was collected and pumped from the Shelter rooms to prevent the ingress of radioactive substances into groundwater and to improve the radiological situation.

The primary solid radwaste in the NSC–Shelter system may result from decontamination, while the secondary radwaste may result from the use of individual protective means and from maintenance, repair and upgrade of the NSC and Shelter systems and equipment.

According to the ChNPP Report "On NSC-Shelter Safety for 2023", no solid radioactive waste was transferred for disposal in the reporting period.

IV. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

1. Radwaste Management at Operating NPPs

The generation of radioactive waste, differing by activity and aggregate state, is an integral factor in the electricity generation at NPPs. Radwaste originates both from the main technological process and routine and maintenance activities and operations.

According to the Strategy for Radioactive Waste Management in Ukraine, safe radwaste management is one of the most important aspects of sustainable development of the state's nuclear power. Improvement of NPP radioactive waste management systems is an urgent need and is aimed at radwaste processing to a state that will meet the acceptance criteria for centralized radioactive waste disposal facilities at the Vektor production site.

Measures for implementing the Energoatom technical policy in the area of radioactive waste management are identified by the Energoatom Comprehensive Radioactive Waste Management Program. According to this Comprehensive Program, the main functions of the Energoatom operating organization in the area of radwaste management are to:

– implement efficient and economically feasible technologies for solid and liquid radwaste processing;

– upgrade existing and create new facilities for solid and liquid radwaste processing;

– construct and commission integrated radioactive waste processing lines;

– ensure treatment and transfer of radwaste for long-term storage/disposal, including characterization of NPP radwaste;

– provide NPPs with containers for radwaste collection, transport, storage and disposal and improve the container fleet;

– implement a handling and transport scheme for NPP radwaste transfer to specialized radwaste management enterprises;

– establish areas for the release of radioactive materials from regulatory control at NPPs;

– manage high-level radwaste from NPP spent fuel processing;

– develop new and improve existing regulatory and methodological documents in the area of NPP radwaste management;

– further implement measures to minimize the generation of radioactive environments and radwaste.

Liquid and solid radioactive waste generated in the NPP operation is preliminarily processed at existing facilities and stored in special solid and liquid radwaste storage facilities (SRSF and LRSF) at NPP sites.

Liquid Radwaste Management

Liquid radioactive media and liquid radwaste are generated during NPP operation.

According to its properties, liquid radwaste is divided into:

– evaporation bottoms – highly concentrated salt solutions with potential sludge content;

– ion-exchange resins mixed with various sorbents and fine precipitates (heterogeneous systems) – spent filter materials (SFM);

– sludge, including dehydrated sludge from centrifugation installations);

– organic liquids (used oil).

Liquid radwaste storage at NPPs is ensured by LRSF systems.

Liquid radwaste is stored in sealed stainless steel containers equipped with an automatic system for determining the liquid radwaste level and generating alarms in case of leaks. To prevent liquid radwaste emergency leakage, all containers are placed in concrete premises lined with stainless steel sheets. Liquid radwaste storage designs provide for an empty spare tank to be used in the event of damage and need to repair other tanks.

To reduce volumes, the evaporation bottoms are additionally evaporated in

deep evaporation installations to obtain salt fusion cake (except for the PNPP), which is placed for storage in special stainless steel packages.

Spent filter materials and sludge are collected and stored under a water layer in tanks in the LRSF. Considering that the tanks available at NPPs have been significantly filled with the accumulated SFM, the priority task is to develop formulations for the immobilization of spent sorbents and sludge to ensure further processing of this liquid radwaste. Under of the Comprehensive Radioactive Waste Management Program, Energoatom develops formulations for the immobilization of NPP spent filter materials and sludge and performs immobilization of a pilot batch of NPP filter material and sludge. The immobilization of radioactive waste in a geopolymer or similar matrix using a mobile unit was chosen as the processing technique. This processing technique ensures the necessary characteristics of solidified radwaste acceptable for further safe storage and disposal.

The Zaporizhzhia NPP was chosen as the pilot plant, and the measures were planned to be completed in 2022. However, the activities were not completed because of the full-scale aggression of the russian federation against Ukraine and temporary occupation of the Zaporizhzhia NPP site.

Installations for the centrifugation and purification of drain waters to remove the solid fraction (sludge) are operated at the Rivne and Khmelnytsky NPPs. In addition to sludge dewatering, SFM can be processed at the centrifugation installation at KhNPP. The dewatered sludge or dewatered filter materials are temporarily stored in KT-0.2 containers in SRSFs. Spent radioactive oil is incinerated at ZNPP and KhNPP. It is not processed but accumulated at PNPP. RNPP introduced an oil purification installation designed to regenerate the accumulated spent oil from all RNPP units by removing mechanical impurities and dehydration.

In the framework of International European Commission Project U4.01/14A “Specification of Waste Forms Stored at Energy Enterprises of Ukraine to Allow Safe Storage and Disposal of Radioactive Waste”, carried out a physicochemical analysis and a radiochemical analysis of samples for selected streams of problematic radioactive waste, in particular, for salt fusion cake (ZNPP, RNPP, KhNPP), solid salt deposits (PNPP), SFM and sludge (all NPPs). In addition, justifications were prepared for the representativeness of the samples and radionuclide vectors for these radioactive waste streams were calculated. Energoatom will use the results obtained to select further techniques for liquid radwaste management at NPPs.

Photo 4. Installation for centrifugation and purification of radioactive oil at RNPP

Solid Radwaste Management

Sources of solid radwaste at NPPs include materials generated during repair and maintenance of process equipment, personal protective equipment for personnel, parts of equipment and piping, spent special ventilation filters, etc.

Solid radwaste is collected in situ, sorted into categories (according to the gamma dose rate) and transported to SRSF for temporary storage. SRSFs at NPP sites are reinforced concrete structures consisting of individual compartments for the placement of solid radwaste, depending on the activity category. The compartments are equipped with a fire alarm system, an automatic fire extinguishing system and exhaust ventilation with air purification. Individual SRSF compartments are additionally equipped with a moisture detection and removal system.

Solid radwaste management at NPPs involves the collection of waste into primary containers at the places of their generation; sorting by activity; transport to centralized collection or processing areas; radwaste processing; transport of solid radwaste containers to SRSFs using special vehicles; waste acceptance and unloading in storage facility sections; and reporting and radwaste accounting.

Radioactive waste treatment plants (RWTPs) are being constructed at all nuclear power plants in Ukraine to bring the radwaste management systems into compliance with current requirements. In 2019, radioactive waste treatment plants at ZNPP and RNPP were introduced into commercial operation. This enabled the successful start of radwaste processing and conditioning to reduce the volumes of radwaste accumulated in NPP storage facilities and prepare it for transfer to disposal. The activities are currently in progress to construct RWTPs at KhNPP and PNPP sites.

The treatment plant at the Zaporizhzhia NPP includes an incineration installation, release monitoring system, fragmentation installation, super-compaction facility, installation for retrieval of radioactive waste from the storage facilities and activity measurement facility. The treatment plant at the Rivne NPP includes a solid radwaste retrieval facility, sorting and fragmentation installation, super-compaction facility, activity measurement facility for characterization of radioactive waste packages, cementation facility, metal decontamination facility and oil purification facility.

RWTP commissioning allows processing of solid radwaste accumulated at NPP sites into the condition acceptable for disposal and for releasing the volume within the existing radwaste storage facilities at NPP sites, taking into account plans to extend the life of power units.

The RWTP facilities currently process most of the low-level radioactive waste (LLW) generated at RNPP. This results in a significant reduction in the amount of LLW entering the storage facilities. The implementation of RWTPs generally allowed a 50 % reduction in the volumes of radwaste sent to SRSF compartments.

According to the Energoatom Comprehensive Radioactive Waste

Photo 5. ZNPP RWTP building

Photo 6. RNPP RWTP building

Management Program, RWTP construction at KhNPP is planned by 2025 and at PNPP by 2029.

The construction of RWTPs at KhNPP and PNPP continued in the reporting period. Energoatom approved relevant RWTP construction projects and concluded and completed contracts for the supply of major equipment to the KhNPP RWTP. Construction and installation activities are under way at the KhNPP site.

As part of the RWTP construction, an activity measurement facility was supplied to PNPP and put into operation in 2019.

All plants will be equipped with radiation monitoring and characterization systems for radwaste packages. The radwaste packages will be sent for disposal to the Vektor disposal facilities.

Release of Radioactive Materials from Regulatory Control

In order to implement a series of measures to reduce the amounts of radioactive materials generated at NPP sites in the operation of power units, Standard "Radiation Safety. Release of Radioactive Materials from Regulatory Control at Energoatom" SOU NAEK 260:2022 (Enterprise Standard) was developed by Energoatom in 2023 and agreed by the SNRIU upon state NRS review.

The Enterprise Standard establishes release stages, requirements for the release area, procedure and criteria for the formation of streams and batches of radioactive materials, measurement of radioactive material batches at the installation for the release of radioactive materials from regulatory control and preparation of an application and justification documents for obtaining the SNRIU decision on the release of radioactive materials from regulatory control by termination.

In accordance with current nuclear and radiation safety standards and regulations, the release of radioactive materials from regulatory control may be unrestricted or restricted. The unrestricted release of radioactive materials from regulatory control allows the released materials to be used in economic activities without any restrictions. Restricted release envisages the use of materials provided that certain restrictions are met.

Photo 7. Pouring the foundation for KhNPP RWTP

Impact of Russian Military Aggression on NPP Radioactive Waste Management

As a consequence of the full-scale aggression of the russian federation against Ukraine, martial law implementation and temporary occupation of ZNPP, radioactive waste management activities can hardly be taken at the Zaporizhzhia NPP. The lack of unbiased data on the amount of radwaste generated and accumulated at ZNPP is currently one of the negative phenomena.

The full-scale aggression of russia against Ukraine has a very negative impact on the implementation of a significant part of measures planned under the Energoatom Comprehensive Radioactive Waste Management Program. In particular, the following became impossible:

– new construction of a light-type facility for temporary storage of conditioned radwaste in reinforced concrete containers at ZNPP;

– implementation of measures to develop the optimal formulation for the immobilization of filter materials and sludge, testing and processing of an experimental batch of filter materials and sludge at the Zaporizhzhia NPP (completion was scheduled for 2022);

– solid radwaste transfer from RNPP for processing to the incineration installation in the ZNPP RWTP;

– implementation of activities under the Comprehensive Program "Study of RNPP and ZNPP Solid Radioactive Waste Samples to Characterize Alpha-, Beta- and Gamma-Emitting Nuclides and Determine Radionuclide Vectors" to characterize packages of radwaste generated at NPPs for transfer to disposal.

The provision of NPPs with radioactive waste management packages and containers and other equipment is entrusted to Atomenergomash, whose main production facilities are located in the temporarily occupied city of Enerhodar. The uninterrupted operation of solid and liquid radwaste treatment facilities, particularly RWTPs, depends on stable supply of containers.

Atomenergomash produced the following types of containers for NPPs by the second half of 2022: KRO-200, KTRO-200, KTROf-0.2, KTROf-0.28, KT-0.2, UZZK, PU-0.17 primary package, etc.

In connection with the temporary occupation of Enerhodar in 2022-2023, the supply of containers and other equipment for radioactive waste management was not provided in full scope and had significant difficulties. Today, Energoatom is taking measures to solve this problem (Atomenergomash relocation, renewal of container production).

2. Radwaste Management at the RADON Association

Radioactive waste generated in the use of radiation sources in medicine, science and various industries, as well as disused radiation sources declared as radioactive waste, is collected and stored by the specialized radwaste management enterprise, RADON Association, which includes the Central Production Site (CPS), Dnipro Interregional Affiliate (DIA), Lviv Interregional Affiliate (LIA), Odesa Interregional Affiliate (OIA) and Kharkiv Interregional Affiliate (KhIA).

In accordance with the licenses issued by the SNRIU for radwaste processing and storage, the RADON Association provides:

– operation of facilities for container storage of radwaste and disused radiation sources (DRS);

- maintenance, control and monitoring of finally closed radwaste repositories, filled in the previous period (before 1996) using the disposal technology;

- collection, conditioning and transport of radwaste to storage facilities;

- transfer of radwaste in the form of DRS for long-term storage to the Centralized Facility for Long-Term Storage of Spent Radiation Sources (CLTSF) located in the Exclusion Zone;

- operation of decontamination areas for overalls, underwear and personal protective equipment;

- keeping of the State Register of Radioactive Waste and State Cadaster of Radioactive Waste Storage Facilities and Temporary Storage Sites;

- participation in the mitigation of radiation accidents.

Radwaste storage facilities operated by the RADON CPS, DIA, LIA, OIA, KhIA are hangar-type buildings for container storage of radwaste and spent radiation sources. These buildings were constructed on the RADON Association sites in the 1990s after the decision was made to transfer the state specialized enterprises for radwaste management to the radwaste storage technology.

Photo 8. Container storage of radwaste in hangar storage facilities

The finally closed radwaste repositories filled up to 1996 using the disposal technology represent a system of near-surface reinforced-concrete radwaste disposal facilities of a modular type with a capacity of 200 m^3 and 400 m^3, constructed according to standard designs in the 1960-1970s. The RADON Association provides maintenance, monitoring and reassessment of their safety to make decisions on the safety of each specific repository, periods during which these repositories can provide reliable isolation of radioactive waste, and technological solutions on the retrieval of radioactive waste and final closure of the repositories.

During 2023, the Central Production Site and RADON Interregional Affiliates, engineering and technical features of the RWDS facilities and physical protection systems were in normal and regular operation. Measures of radiation and environmental monitoring at the RADON facilities were taken with portable dosimetry devices.

The monitored radiation parameters in 2023 were within established limits. In particular, the equivalent dose rate (EDR) of gamma radiation in the strict access areas of radioactive waste disposal sites (RWDS) at the RADON Dnipro, Lviv, Odesa and Kharkiv Interregional Affiliates and Central Production Site ranged from 0.09 μSv/h to 42 μSv/h. The maximum EDR in the strict access area is attributed to the location of control measurement points within the radioactive waste disposal facilities.

The gamma EDR in the control areas of RWDS at the RADON Dnipro, Lviv, Odesa and Kharkiv Interregional Affiliates and Central Production Site ranged from 0.08 μSv/h to 0.20 μSv/h. The gamma EDR in the observation areas of RWDS at the RADON Dnipro, Lviv, Odesa and Kharkiv Interregional Affiliates and Central Production Site ranged from 0.07 μSv/h to 0.16 μSv/h.

In 2023, radiation monitoring at the RADON Interregional Affiliates and Central Production Site and their adjacent territories was conducted in full scope in accordance with the Radiation and Environmental Monitoring Programs at the RADON Interregional Affiliates and Central Production Site. There were no cases when reference levels were exceeded in the reporting period.

In the reporting period, there were no military operations near the RADON Central Production Site or Interregional Affiliates. There was no shelling or damage to safety important systems or power lines.

In 2023, under INSC UK/TS/58 Task H3 “Support of the Regulatory Activity for Radioactive Waste Management, Decommissioning and Remediation”, the SNRIU with the involvement of Ukrainian and international experts (SSTC NRS and IRSN) continued expert reviews and evaluations of the comprehensive safety assessments for the RADON Dnipro, Lviv, Odesa and Kharkiv Interregional Affiliates, developed under INSC U4.01/14C Industrial Project “Comprehensive Safety Assessment of Radioactive Waste Management Sites Operated by Radon Association and Project for Remediation of Specific Sites”.

Upon review of the application package submitted by the RADON Association, the SNRIU extended the validity period of licenses for the processing and storage of radioactive waste at the Odesa, Kharkiv and Dnipro Interregional Affiliates of the RADON Association.

In 2023, the SNRIU reviewed technical decisions submitted by the RADON Association on the transport and acceptance of radwaste batches as disused radiation sources, transferred by entities for disposal to RWDS of the RADON CPS and Interregional Affiliates. In total, the SNRIU agreed 30 technical decisions prepared by the RADON Association based on the review findings.

In 2023, based on the review findings, the SNRIU agreed Amendment No. 1:2023 to Technical Specifications TU U 34.2-03062071-012:2012 “IP-2 Packaging for the Transport and Temporary Storage of Low- and Intermediate-Level Solid Radioactive Waste KTTZ-NS-1-02.00.00 TU” (Technical Specifications) submitted by the RADON Association.

The RADON Association is also involved in urgent actions of competent authorities to mitigate emergencies related to the detection of orphan radiation sources or radiation sources in illicit trafficking. All these radiation

sources are transferred to the RADON disposal facilities to ensure their safe and controlled storage and confinement to prevent their release to the environment and places accessible to the public (*more details on the detection of radioactive materials in illicit trafficking are given in Section IX*).

Chornobyl Decontamination Waste

On the territory of the Kyiv, Zhytomyr and Chernihiv regions beyond the exclusion zone, there are a number of facilities where radioactive waste resulting from ChNPP accident mitigation is located, namely, decontamination waste storage sites and decontamination treatment sites. This radioactive waste is mostly of very low level.

From February to April 2022, parts of the Kyiv, Zhytomyr and Chernihiv regions was under military occupation. After the liberation of the Kyiv, Zhytomyr and Chernihiv regions, explosive technicians (mine clearance experts) are surveying individual territories for the purpose of demining (if necessary).

Routine inspections and maintenance of the decontamination treatment sites and decontamination waste storage sites will be renewed after the surveys of these territories for the absence of explosive devices have been completed.

3. Radioactive Waste Management in the Exclusion Zone (Radwaste Long-Term Storage and Disposal)

The main activities for radwaste management in the exclusion zone (except the ChNPP site) are carried out by the Centralized Radwaste Management Enterprise, which is the operating organization at all life stages of radwaste disposal facilities and also undertakes radwaste processing and long-term storage.

On the Exclusion Zone territory, the CRME deals with:

– operation of two parallel modules of the Engineered Near-Surface Disposal Facility for Low- and Intermediate-Level Short-Lived Waste (ENSDF) constructed on the Vektor site;

– operation of the Centralized Long-Term Storage Facility for Disused Radiation Sources (CLTSF) on the Vektor Site (concerning comprehensive (hot) tests);

– operation of radioactive waste disposal facility No. 21A at the Buryakivka RWDS;

– measures to maintain the existing facilities for management of Chornobyl radwaste generated in the first years of the Chornobyl accident mitigation in proper condition, such as Buryakivka RWDS, Pidlisnyi RWDS, ChNPP Stage III RWDS (including their monitoring, reconstruction, stabilization, safety improvement, inspection, safety review, remediation), as well as maintenance, inspection, monitoring and removal of trenches and piles on the radioactive waste interim confinement sites (RICS) in the Exclusion Zone;

– commissioning of near-surface disposal facilities for low- and intermediate-level short-lived radwaste resulting from the Chornobyl catastrophe of two types: SRW-1 facility for radwaste disposal in reinforced concrete containers and SRW-2 modular-type facility for disposal of unpackaged and large-sized waste;

– prospecting and research activities on siting for a geological repository for long-lived and high-level waste.

Centralized Long-Term Storage Facility for Disused Radiation Sources (CLTSF) on the Vektor Site

The CLTSF is an important component in the management system for radwaste in the form of DRS in Ukraine. The CLTSF is intended for centralized placement of radwaste as DRS.

CLTSF operations include acceptance, processing (conditioning) and long-term storage (50 years) of radwaste in the form of DRS of various types and designs, accumulated at the sites of RADON specialized radioactive waste management enterprises, as well as radiation sources that are used in medicine and industry after completion of their operation and transfer to the radwaste category.

The total expected number of DRS for which the CLTSF is designed is approximately 174,000. The total DRS activity expected to be transferred to the CLTSF is approximately 1.15E+15Bq. The total activity of 15 RITEGs to be stored without processing is approximately 3E+16Bq.

The CLTSF envisages the management of five DRS streams:

– stream 1 – RITEG DRS (radioisotope thermoelectronic generators);
– stream 2 – DRS of BGV and E types;
– stream 3 – neutron DRS;
– stream 4 – gamma DRS, intensive beta and alpha+gamma DRS;
– stream 5 – alpha DRS, low-intensity alpha+gamma, beta and gamma DRS.

In compliance with the CLTSF Hot Test Program agreed by the SNRIU, the DRS in streams 2–5 are managed.

The procedure for hot tests within the management of DRS in the form of RITEGs for stream 1 was not determined in the Test Program. The CRME developed an Amendment to the Hot Test Program of the Centralized Long-Term Storage Facility for Disused Radiation Sources at the Vektor Site. Process Stream 1".

The document was agreed with the SNRIU based on NRS review findings.

In 2023, the CRME continued comprehensive (hot) tests at the CLTSF using DRS streams 2-5. In particular, to ensure the transfer of IBN-7 and IBN-9 disused fast neutron sources from Energoatom to CLTSF, hot tests of process equipment using DRS of these types were successfully performed in May 2023.

In 2023, 448 DRS with an activity of 6.68E+13 Bq were transferred to the CLTSF for long-term storage, including those from:

– RADON Lviv Interregional Affiliate – 37 DRS;
– RADON Odesa Interregional Affiliate – 129 DRS;
– RADON Kharkiv Interregional Affiliate – 25 DRS;
– RADON Central Production Site – 36 DRS;
– RADON Dnipro Interregional Affiliate – 196 DRS;
– Khmelnytsky NPP – 25 DRS.

Since the start of operation, 22,299 DRS were accepted for storage at the CLTSF with a total activity of 2.078E+14 Bq.

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

The ENSDF was constructed on the Vektor site in 2009 within the design of the ChNPP Industrial Complex for Solid Radioactive Waste Management (ICSRM) for the disposal of radwaste packages from the ChNPP Liquid Radioactive Waste Treatment Plant and Solid Radioactive Waste Treatment Plant.

Photo 9. Hot tests of CLTSF process equipment using IBN-7 and IBN-9 DRS

The disposal facility consists of two parallel sections, each having 11 reinforced concrete compartments (modules), equipped with a central drainage gallery and two mobile frame structures with overhead cranes. The disposal facility can accommodate 50210 m^3 of radioactive waste packages.

In 2023, according to the license to operate the radioactive waste disposal facility, the CRME continued filling two symmetrical ENSDF modules A1 and D1. Since the start of operation, the ENSDF has accepted 13,442 radwaste packages for disposal, with a total volume of 3139.48 m^3 and a total activity of 2.42E+13 Bq.

In 2023, to transfer NPP radwaste for disposal to Vektor facilities, 12 KZ-3 packages with salt–bitumen compound from the Rivne NPP with a total volume of 36 m^3 were disposed in the ENSDF.

Within disposal facility operations, the operator also takes measures to monitor the condition of civil structures of the disposal facility modules and the central drainage gallery under the disposal facility and implements up-to-date methodologies for ENSDF safety assessment.

Radwaste Disposal Facilities: SRW-1 and SRW-2 at the Vektor Site

There are two near-surface solid radwaste disposal facilities with a total capacity of 19,200 m^3 at the final stage of construction on the Vektor site:

– SRW-1 is a near-surface facility for radwaste disposal in reinforced concrete packages (9800 m^3);

– SRW-2 is a module-type facility for disposal of large-sized, bulk radwaste, radwaste in drums, kraft bags and cage-type containers (9400 m^3).

In 2023, the CRME continued revising documents on the safety analysis of SRW-1 and SRW-2 disposal facilities to incorporate comments of the state NRS review. In the reporting year, the CRME performed activities to inspect the condition of buildings and equipment and conducted their maintenance.

Buryakivka Radioactive Waste Disposal Site (Buryakivka RWDS)

There are 30 near-surface disposal facilities (trenches) for radwaste disposal at the Buryakivka RWDS. All 30 trenches have been fully filled and closed. The total volume of radwaste in 30 trenches of the Buryakivka RWDS is 709.43 thousand m^3 with a total activity of 2.54 E + 15 Bq.

In order to expand the production capacities of the RWDS Buryakivka, an additional disposal facility (trench No. 21A) was constructed in 2018. In 2023, within the license to operate radwaste disposal facilities, the CRME continued operation of radioactive waste disposal facility 21A at the Buryakivka RWDS and maintained and supported the finally closed 30 radwaste disposal facilities in a safe condition.

Trench No. 21A at the Buryakivka RWDS accepted for disposal 28.20 thousand m^3 of radioactive waste with a total activity of 2.25E+12 Bq as of late 2023. According to the reporting information from the CRME, disposal facility No. 21 A at the RWDS Buryakivka is full, and preparatory activities are in progress for its closure. Thus, the production capacities of the RWDS Buryakivka have been exhausted. In accordance with plans of the operating organization, measures are taken to develop a project for the construction of an additional disposal facility at the RWDS Buryakivka site.

Photo 10. ENSDF

Photo 11. Completion of the fifth layer in ENSDF module D1

To expand the capacities of the RWDS Buryakivka, RWDS Buryakivka Reconstruction Project was agreed in 2019, to provides for the construction of six additional inter-trench disposal facilities for radwaste placement in the space between the existing closed disposal facilities. However, measures to implement this project did not start due to lack of funding.

Pidlisnyi and ChNPP Stage III Radioactive Waste Disposal Sites

These disposal sites were constructed and filled with accident-origin waste in 1986-1988 within the priority measures to mitigate the Chornobyl accident.

During 2023, the CRME carried out routine activities to ensure safety of the Pidlisnyi and ChNPP Stage III RWDS.

Radwaste Interim Confinement Sites (RICS)

RICS are territories adjacent to the ChNPP, with a total area of about 10 hectares, where trenches and piles were constructed to confine radwaste within the priority measures for mitigation of the Chornobyl accident. For the most part, this radwaste represented civil structures, household items, topsoil, etc. contaminated in the accident release. Nine RICS are located in the Exclusion Zone: Yaniv Station, Naftobaza, Pishchane Plato, Rudyi Lis, Stara Budbaza, Nova Budbaza, Pripyat, Kopachi and Chystohalivka. These estimated number of trenches and piles of these RICS ranges from 800 to 1000.

The CRME surveys RICS, taking into account the degree of hazardous environmental impact, to close the most dangerous trenches and piles.

In 2023, the CRME carried out activities in accordance with the technical decision agreed by the SNRIU for the retrieval and redisposal of bulk radwaste from the Nova Budbaza RICS to fill voids formed after filling disposal facility No. 21A at the Buryakivka RWDS. The retrieved radwaste was used to fill the voids and form a leveling soil layer in trench No. 21 at the Buryakivka RWDS for its further closure.

The CRME conducts routine operations to ensure safety in accordance with the Technical Specifications for Safe Operation of RICS.

Construction of Geological Repository for Radwaste Disposal

Measures for the construction of a geological repository for radioactive waste disposal are defined in the Strategy for Radioactive Waste Management in Ukraine and the National Target Environmental Program for Radioactive Waste Management.

Photo 12. Buryakivka RWDS

Photo 13. Pidlisnyi RWDS

Photo 14. ChNPP Stage III RWDS

The CRME was appointed as the operating organization (operator) of the disposal facility for high-level and intermediate-level waste in stable geological formations in 2018.

A series of exploration, assessment, scientific, methodological, research and design activities to select sites potentially suitable for an intermediate-depth disposal facility and geological repository for radioactive waste, as well as research work to select an optimum system of engineering barriers for such radioactive waste disposal facilities, are envisaged under the Concept of the National Target Environmental Program for Radioactive Waste Management, approved by Resolution of the Cabinet of Ministers of Ukraine No. 992-r dated 4 November 2022.

The first-priority measures envisage:

– organizational, licensing and legislative support for siting, design and construction of a geological repository;

– basic scientific methodological and scientific technical activities, personnel training to assess the safety of a geological repository;

– exploration activities in promising territories, including ground-based remote, geological, geophysical and indicator survey, drilling of boreholes and wells for comprehensive research;

– development, support and continuous updating of databases in the system for storing information on geological exploration, design and assessment activities under the geological repository program;

– work with the public and public hearings on the placement of a geological repository;

– development and implementation of the programs for scientific and research and development support for geological repository construction in Ukraine.

Project P4.01/14B " Development of a National Plan for Geological Disposal of Radioactive Waste in Ukraine and Its Implementation Schedule" was implemented to perform these tasks under international technical assistance to Ukraine from September 2018 to March 2021. As a result of the project implementation, recommendations were provided for the development of the Draft National Action Plan for the Construction, Operation and Closure of a Geological Repository for Radioactive Waste in Ukraine based on the best international experience.

Radiation and Dose Monitoring, Environmental Monitoring and Individual Dose Monitoring of CRME Personnel

The reference levels for external and internal individual doses of CRME personnel were not exceeded in 2023. The maximum personnel external exposure dose for 12 months of 2023 was 2.11 mSv, the minimum dose was 0.05 mSv and the average dose was 0.91 mSv.

Radiation monitoring in or near places where radioactive waste management activities are performed, as well as on the Exclusion Zone territory, was conducted by the State Specialized Enterprise "Ecocenter" in accordance with the "SSE Ecocenter Operating Procedures on Radiation Environmental Monitoring and Dose Control on the Exclusion Zone Territory" and with the "Scope of CRME Radiation and Dose Monitoring for 2023".

The monitored radiation parameters in 2023 were within the established limits. There were no cases when reference levels were exceeded.

To upgrade the dose monitoring system in the Exclusion Zone and environmental radiation monitoring, INSC U4.01/18B industrial project "Modernization of the Dosimetric Control Systems in the Exclusion Zone and Environmental (Radiation) Monitoring at the Vektor Site and the Buryakivka Disposal Facility" was implemented under financial support of the European Commission within the Instrument for Nuclear Safety Cooperation.

Under this project, in particular, the environmental radiation monitoring system at the Vector and Buryakivka RWDS is to be improved by establishing a new automated system using modern technical features and equipment.

The SNRIU reviewed and agreed relevant design documents and technical specifications for equipment.

V. SAFETY OF URANIUM SITES

Uranium ores are minerals that contain all elements of the uranium-238 and uranium-235 decay chain in radioactive equilibrium. The radiation background from uranium ore directly depends on the uranium content and is insignificant for Ukrainian uranium ores since the concentration of uranium-238 is relatively low, averaging 1.5 kg per ton of ore. Nevertheless, Ukraine has ore deposits with a fairly high uranium content.

Ukraine's uranium industry began to develop in the late 1940s. The nuclear fuel cycle begins with the extraction of uranium ore, the basic raw material for nuclear fuel production. Uranium ore is extracted at uranium mining plants and processed at uranium processing plants.

Uranium sites (uranium mining and processing plants) consist of major industrial plants and auxiliary facilities that support the uranium ore mining and processing cycle to yield the final product: natural uranium concentrate.

In Ukraine, the State Enterprise "Skhidny Mining and Processing Plant" (SkhidGZK) is the only enterprise that provides a full process cycle, from mining to the production of natural uranium concentrate. SkhidGZK is among the ten largest uranium producers (2 % of global production). SkhidGZK deals with the extraction and processing of uranium ores under a license issued by the SNRIU. SkhidGZK includes three mines: Smolinska, Novokostiantynivska and Inhulska mines.

Since 1969, the Inhulska mine has been developing the Michurinske and Tsentralne deposits. Since 1972, the Smolinska mine has been developing the Vatutinske deposit. Since 2011, the Novokostiantynivska mine has been conducting pilot development of the Novokostiantynivske deposit.

As of late 2023, underground and surface process systems, located at the industrial sites of the Novokostiantynivska and Inhulska mines, are used for the extraction of uranium ore from deposits.

The uranium ore reserves in the Vatutinske deposit are almost depleted. According to the Concept of the State Target Environmental Program for Decommissioning of Uranium Plants for 2023-2027, approved by Cabinet Resolution No. 4-r dated 6 January 2023, arrangements for decommissioning of the Smolinska mine are under way.

1. Operation of Uranium Mining Plants

The **Inhulska mine** was established in February 1967. The first ore batch was mined and sent to the hydrometallurgical plant in 1971. The enterprise's key production activities include uranium ore underground mining by rock blasting, ore crushing and transport to the surface facilities, sorting at the ore processing facility, loading into railway cars and transport for subsequent processing to the hydrometallurgical plant, which is part of SkhidGZK. Waste rock and off-balance ores are dumped in piles on the territory of the mine industrial site.

The **Novokostiantynivska mine** develops the Novokostiantynivske uranium deposit established in 1975. According to SkhidGZK, the deposit is the most powerful in Europe in terms of uranium ore reserves and is one of the ten largest deposits in the world.

The pilot industrial mining of uranium ore was started in July 2011. Ore deposits are mined at depths from 180 to 300 meters. Uranium ore is extracted at the mine by underground blasting and transporting the rock to the surface facilities. Uranium ore is transported for subsequent processing to the hydrometallurgical plant, part of SkhidGZK. The Investment Project "Novokostiantynivska Mine. Development of Production Capacities" was started in 2018.

Waste rock and off-balance ores are dumped in piles on the territory of the industrial site.

2. Operation of Uranium Processing Plants

The SkhidGZK Hydrometallurgical Plant (HMP) is the only uranium processing plant currently in operation, which was commissioned in 1959. Measures were taken to upgrade the HMP in operation for both improving its safety and increasing its capacity.

The HMP deals with the processing of uranium ores mined at the Inhulska and Novokostiantynivska mines, chemical concentrates from bulk leaching and sludge from mine water treatment installations to yield finished products in the form of natural uranium concentrates.

Waste from uranium ore processing is placed in the Balka Shcherbakivska tailing pit.

3. Decommissioning of Uranium Plants Decommissioning of Uranium Mining Plants

The specifics peculiar to the termination of uranium plants in Ukraine are determined by the Law of Ukraine "On the Mining and Processing of Uranium Ores".

As a result of operations at the Smolinska mine, 89.05 hectares of land were contaminated with naturally occurring radionuclides and require remediation measures. Water is pumped out and the mine water treatment facility is operated to maintain safety at the Smolinska mine.

The issues related to the termination of uranium plants are conceptually planned to be resolved in two stages to deal with technological, environmental and social problems related to Smolinska mine decommissioning and to prevent contamination of the populated areas and atmospheric air with naturally occurring radionuclides.

The first stage provides for Smolinska mine decommissioning through its closure, remediation of disturbed lands and treatment of mine waters before their discharge into water bodies in accordance with established standards for boundary permissible discharges of hazardous substances using the operating mine water drainage system – stationary pumping stations located at horizons of –640 and –460 meters – and promoting conditions for the development of this area.

The second stage envisages mine water treatment before discharge into water bodies using a well specially constructed for planned flooding of mine openings to reach the natural level of groundwater, observed prior to the development of the deposit, including horizons where stationary pumping stations of the mine drainage system are located, as well as radiation environmental monitoring. This approach will enable implementing a series of measures to protect the environment and public against radiation exposure and ensure economic development of the area.

In accordance with the Law of Ukraine "On the Mining and Processing of Uranium Ores" and the regulatory framework that governs safety in the closure of uranium plants, these activities are performed under projects approved under the procedure established by Ukrainian legislation.

The project for the closure of uranium plants should include a socio-economic feasibility study, proposals on the potential use of mine openings and structures, measures to prevent hazardous impacts of production activities on the public and the environment, radiation monitoring, storage of generated waste, construction of waste disposal and decontamination and land remediation facilities.

Upon state NRS review, the SNRIU agreed the Feasibility Study "Decommissioning of the SkhidGZK Smolinska Mine". The next step is to develop and implement measures under the State Target Environmental Program for Decommissioning of Uranium Plants for 2023-2027, approved by Cabinet Resolution No. 4-r dated 6 January 2023, for safe decommissioning of the Smolinska mine through its closure, assurance of radiological and environmental safety and reduction in contamination with naturally occurring radionuclides to a level that does not affect human health and the environment.

The uranium mine in Smoline has been in dry closure state since March 2023.

Decommissioning of Uranium Processing Plants

From the 1940s to 1991, the Production Association "Prydniprovsk Chemical Plant" (PCP) processed uranium-containing blast furnace slag, uranium concentrates and uranium ore from different deposits of the Soviet Union and Eastern Europe.

The processing of uranium ores and the production of uranium concentrate were terminated in 1991.

USSR legacy in Ukraine is the PCP territory, which contains several tailing pits (facilities for the temporary storage of uranium ore processing waste) that have accumulated approximately 42 million tons of uranium ore processing waste with a total activity of $3{,}17 \times 10^{15}$ Bq (Note: based on the research findings of the Ukrainian Research Design Institute for Industrial Technology, Zhovti Vody) and a significant number of radioactively contaminated buildings and structures that belonged to the main industrial production sites and auxiliary facilities of the uranium processing facility.

The decommissioning of this uranium processing plant (UPP) did not follow the legislation and regulations establishing safety requirements for the decommissioning and oversight of disposal facilities for uranium ores processing waste if placed at the site.

The State Enterprise "Barrier" (SE Barrier) was established in 2000 to decommission the UPP and bring the territory of the former PCP into a radiologically safe condition.

The SE Barrier operates under the SNRIU's license.

Resolution No. 756 dated 21 August 2019 approved the "State Target Environmental Program of Priority Measures for Bringing the Facilities and Site of the Former Uranium Production Facility of the Prydniprovsk Chemical Plant into a Safe Condition for 2019-2023" to determine measures aimed at proper UPP decommissioning and bringing the site into a safe condition.

Unfortunately, funding of the measures under the Program was suspended as a result of the ongoing armed aggression of the russian federation against Ukraine since 24 February 2022.

At the same time, individual activities are currently determined by the Program and regulatory requirements, specifically: monitoring and regular activities for technical oversight and maintenance of the former PCP facilities to ensure radiation safety are carried out by the SE Barrier with financial support of the European Commission (EC).

The international technical assistance projects "Implementation of Urgent Measures to Eliminate the Emergency State of the Prydniprovsk Chemical Plant in Kamianske (former Dniprodzerzhynsk) in Ukraine", funded by the European Commission, and "Risk Reduction, Control of Radioactive Contamination and Improvement of Environment Monitoring System at the Prydniprovsk Chemical Plant in Ukraine", funded by the Government of Norway, are ongoing on the territory of the former Prydniprovsk Chemical Plant.

Under the EC technical assistance project "Remediation of the Former Prydniprovsk Chemical Plant (PCP) Production Association in Ukraine" in 2023, the following was performed:

– development of design documents for the construction of a new waste disposal facility;

– inspection of radioactively contaminated territories and buildings at the industrial site, sampling and characterization, determination of waste volumes to be placed in the disposal facility, commissioning of the ventilation system in the SE Barrier measurement laboratory and fencing of the radiation hazardous area in the northern part of the industrial site at the former PCP;

– certification of compliance and calibration of a gamma radiation energy spectrometer based on a high-purity germanium detector; radiation survey in the area where the UPP is placed.

The goal of these activities is to exclude or reduce the impact of radiation from uranium ore processing waste on the environment and to protect workers and personnel at the site of the former Prydniprovsk Chemical Plant and the public living in the impact zone in the adjacent territories against harmful radiation effects.

4. Radiation Safety and Radiation Protection at Uranium Plants

Radiation safety at uranium plants in operation and decommissioning is considered to be ensured in the following cases:

– use of progressive, safe and harmless methods for the preparation and development of uranium ore deposits;

– identification of measures for safe mining operations;

– permanent maintenance of operating mine openings, extraction and transportation of minerals in the condition determined by technical operation and safety rules;
– compliance with boundary permissible values for radioactive releases and discharges into the environment;
– compliance with reference exposure levels of personnel and workers at uranium plants;
– radiation and environmental safety during mining operations;
– bringing land plots released after the closure or safe enclosure of uranium plants to a condition suitable for their intended use in accordance with the Land Code of Ukraine;
– minimizing the generation of waste to be disposed;
– minimizing the area of the territory subject to administrative (institutional) control.

Radiation Monitoring and Radiation Safety and Protection at SkhidGZK

The SkhidGZK Central Research Laboratory performs research and development, trial and commercial activities and physicochemical, chemical and radiochemical analyses of solid, liquid and gaseous samples. The laboratory perform activities to monitor the working conditions of enterprise personnel, production releases and environmental objects, namely:
– monitoring of working conditions according to radiological and other hazardous factors at workplaces and in underground mine openings;
– monitoring of stationary sources of industrial releases;
– radiological and environmental monitoring;
– radiation monitoring of pulp samples discharged into the tailing pits;
– radiation monitoring of structural and raw materials and industrial waste, including scrap metal;
– radiation monitoring of finished products.

Environmental monitoring is carried out at the industrial sites also by physicochemical laboratories of the mines, in control areas and observation areas. Atmospheric air, soil, plants, snow cover, waters from mine wells, river waters and bottom sediments are subject to monitoring.

No cases of exceeded reference levels of monitored parameters were recorded in SkhidGZK departments in 2023.

Radiation safety and environmental protection groups were established within SkhidGZK departments. Their main task is to ensure an effective system for radiation safety management and environmental protection at the enterprise and improve activities for each department in this area. Compliance with radiation safety standards and rules within departments is controlled by radiation safety engineers.

The production environment is monitored according to the following radiation hazardous factors:
– external dose rate;
– content of ore dust and uranium in the air of the working area;
– total alpha activity of uranium nuclides in the air of the working area;
– specific activity concentration of radioactive gases and aerosols of daughter products;
– radioactive contamination level of equipment surfaces and overalls.

No cases of exceeded reference levels of radiation hazardous factors were recorded in SkhidGZK departments in 2023.

Radiation Monitoring and Radiation Safety and Protection at State Enterprise "Barrier"

Radiation monitoring in the area of uranium plants, radioactivity measurements in the environment, radiation monitoring and surveys (measurement laboratory for radiation control and monitoring studies) were conducted by personnel of the SE Barrier measurement laboratory in accordance with the SE Barrier Radiation Monitoring Program for Uranium Plants for 2022-2023 and the Dose Monitoring Program.

Supervision over the technical condition of the uranium plants was carried out. If defects are detected at these plants after intense or prolonged precipitations, snow melting and transition to work in new seasonal conditions, an extraordinary inspection of the plants is conducted, and drainage trays and headers are cleaned, grass is mowed and bushes are cut.

The SE Barrier conducts dose control and radiation monitoring to ensure radiation safety and assess the impact of

radiation hazardous facilities (tailing pits, radioactively contaminated buildings, structures and equipment, etc.) on personnel, the environment and the public.

Surface gamma radiation is an integral indicator of radiation safety regarding the impact on personnel, the public and the environment and a qualitative (indirect) indicator of the integrity and adequacy of the protective covering on storage facilities for uranium ore processing waste and uranium raw materials.

Analysis of the results in comparison with those for the previous periods indicates that radiological conditions in the studied territories are stable and there are no significant changes in the nature of contamination.

No cases of exceeded reference levels of radiation hazardous factors were recorded in SkhidGZK departments in 2023.

No radiation accidents occurred at the SE Barrier and SkhidGZK.

Measures were also added to the SkhidGZK and SE Barrier emergency plans to respond to potential radiation accidents taking into account the growing risks of external hazards and threats (rocket attacks, military actions) as a result of the ongoing military armed aggression of the russian federation against Ukraine.

VI. SAFETY IN USE AND PRODUCTION OF RADIATION SOURCES

In 2023, measures to ensure the safety of personnel and the public in the use and production of radiation sources remained priority areas in the state regulation of nuclear and radiation safety under martial law. Activities with radiation sources may be allowed only after the entity confirms its ability to comply with the requirements of radiation safety standards and rules and provides safety justifications for using the radiation sources.

As of 31 December 2023, **26 921** radiation sources were used in Ukraine, which are not released from regulatory control and are registered in the State Register of Radiation Sources and Individual Doses: **8 248** sealed radiation sources (including **874** sources of category 1; **170** sources of category 2**; 1 526** sources of category 3) and **18 673** non-radionuclide radiation sources.

Data on the number of radiation sources by regions are presented in Table 2.

The SNRIU constantly monitors the mandatory state registration of radiation sources in order to properly control their location and transfer on the territory of Ukraine, which is especially important under martial law.

Reliable information on the condition of radiation sources on the occupied territories is missing.

In 2023, access to the premises within the Lyptsiv base of the Institute of Metrology was restored in the de-occupied territory of Kharkiv region after demining the territory. Employees of the institute conducted an initial survey of the base premises in order to assess the damage caused and determine possible losses of radiation sources. The issue of physical inventory of radiation sources and transport of radiation sources to a safe place for temporary storage is being resolved. This issue is under the SNRIU's control.

In 2023, in Ukraine, **4 830** nuclear entities used radiation sources, including **2 893** entities with radiation sources subject to licensing.

The number of nuclear entities using radiation sources that are not released from regulatory control by regions of Ukraine at the end of 2023 is presented in Table 3.

The number of licensees by industries using radiation sources for each territorial inspectorate for nuclear and radiation safety in 2023 is presented in Table 4.

In 2023, **1,693 radiation sources were registered** in the State Register of Radiation Sources and Doses, including **124** radionuclide sources and **1,569** non-radionuclide sources generating radiation.

In 2023, **885** sources, including **253** radionuclide sources and **632** non-radionuclide installations, were **deregistered** from the State Register of Radiation Sources and Doses (the total number of deregistered sources includes: radionuclide sources that were transferred to specialized radwaste management enterprises; exported and lost radionuclide radiation sources; non-radionuclide installations due to their deactivation without the possibility to restore their operation).

In 2023, **19** radionuclide sources were **exported** from Ukraine in accordance with 8 permits (12 spent medical radiation sources and 6 radiation sources used in geophysical research).

At the same time, **92** radionuclide sources (including one set consisting of six sources and two radionuclide solutions) were **imported** to Ukraine in 2023.

Radiation sources were imported to Ukraine by USIE Izotop and LLC ShimUkraine.

Information on the total number of radiation sources imported to Ukraine in 2023 by individual radionuclides and unsealed radiation sources is presented in Table 5 and Table 6, respectively.

In addition, during 2023, **621** non-radionuclide radiation sources were **imported** to Ukraine, these are mainly medical linear accelerators, mobile surgical systems, X-ray surgical angiographic systems, computed tomography scanners, densitometers, mammographs, dental machines, and X-ray installations for various purposes for industry and luggage screeners.

The main suppliers of non-radionuclide sources are listed in Table 7.

In 2023, the positive trend of re-equipping medical institutions with up-to-date high-tech equipment for diagnostic and therapeutic purposes continued. These include new computer tomography scanners, accelerators and diagnostic X-ray systems with digital image processing.

In order to optimize the licensing procedure for individual activities such as the use of medical radiation sources for state and communal health care institutions and business entities that are procurement customers and belong to the management sphere of the Ministry of Health for the period of martial law in 2022, in accordance with Resolution of the Cabinet of Ministers of Ukraine No. 1404 dated 20 December 2022 "On Amending Annex 2 to Resolution of the Cabinet of Ministers of Ukraine on Some Issues of Implementing Economic Activities under Martial Law" No. 314 dated 18 March 2022", the right was introduced to conduct activities such as the receipt (purchase), transfer (sale) and storage of X-ray diagnostic generating radiation sources under a declaration on using radiation sources.

During 2023, **581** declarations on receipt (purchase), transfer (sale) and storage of X-ray generating radiation sources were **registered** by the SNRIU..

Production of Radiation Sources in Ukraine

In 2023, 14 entities had licenses for the production of radiation sources.

In the reporting year, Elvatech LLC produced **468** SER-01 (ElvaX JL series) and SER-02 (ElvaX series) X-ray energy spectrometers. Of these, **432 items** were exported from Ukraine. Deliveries were made to more than 15 countries, including India, Brazil, USA, Israel and others.

Unsealed radiation sources were produced mainly for their own purposes by the Feofania Clinical Hospital of the State Administration of Affairs and the Kyiv City Oncology Center.

A list of radiation source manufacturers in Ukraine in 2023 is presented in Table 8.

Although the license of **LLC Teleoptik** to manufacture radiation sources was cancelled in May 2022, in 2023 this company illegally produced 11 KRDTs-04-Alpha digital X-ray diagnostic systems, which were supplied to health care institutions of Ukraine in violation of legislation in nuclear energy.

The SNRIU took appropriate response measures.

Other manufacturers terminated their economic activities in connection with the introduction of martial law in Ukraine.

Medical Applications of Radiation Sources

The most widespread industry for the use of radiation sources remains medicine, where radiation sources are used for both diagnostics and treatment.

Of 2,893 licensees using radiation sources in their activities, 2,082 licensees are health care institutions that deal with medical applications of radiation sources.

In 2023, the SNRIU, with the involvement of the SSTC NRS, performed 141 nuclear and radiation safety reviews for the designs of premises where it is planned to place medical radiation sources.

The Central Laboratory for Radiation Safety and Medical Dose Monitoring (CLRS MDM), which is operated by the Grigoriev Institute for Medical Radiology and Oncology of the National Academy of Medical Sciences of Ukraine since 1979, provides centralized individual dose monitoring for employees of Ukrainian health care institutions.

The main tasks of the CLRS MDM include:

– quarterly monitoring of individual doses to different categories of medical personnel during the main activities

with radiation sources: remote radiation therapy using gamma therapy devices and linear accelerators; brachytherapy using intracavitary gamma therapy devices and contact gamma therapy by manual method; X-ray therapy; nuclear medicine (radionuclide diagnostics and therapy using unsealed radiation sources), X-ray diagnostics, interventional radiology, radon therapy, dosimetry, and radiometry;

– collection, generalization and multidimensional radiation and health analysis of the information on the IDM of occupational medical exposure, assessment of collective and average annual personnel doses by different occupational groups; identification of groups with the highest individual and average annual doses;

– analysis of cases when medical personnel receive doses exceeding the reference levels of quarterly or annual doses established for IDM purposes, 5 mSv and 10 mSv, respectively, or the limit of annual effective dose for Category A personnel of 20 mSv/year in accordance with the Radiation Safety Standards of Ukraine (NRBU-97);

– assessing the risks of remote somatic and stochastic effects due to occupational exposure for different professional groups of medical workers;

– justification of measures aimed at improving radiation protection of medical personnel during the work with radiation sources, especially in high-risk groups.

For the IDM, the CLRS MDM applies thermoluminescent dosimetry using DTG-4 TL detectors *(LiF:Mg, Ti)* and DTU-01, DVG-02TM thermoluminescent dosimetry units.

The information database already contains the information on annual and accumulated doses for **20,230** employees of Ukrainian health care institutions who were or are undergoing centralized IDM at the CLRS MDM.

Analysis of centralized IDM for 2023 showed that 5,120 persons of category A personnel from 543 health care institutions/institutions of Ukraine in 23 regions (except for the city of Kyiv and Kyiv region, Autonomous Republic of Crimea and occupied territories of Luhansk and Donetsk regions) were subjected to the centralized IDM in the CLRS MDM, of which:

– 4,106 persons worked with X-ray sources (non-radionuclide) for diagnostic and therapeutic purposes;

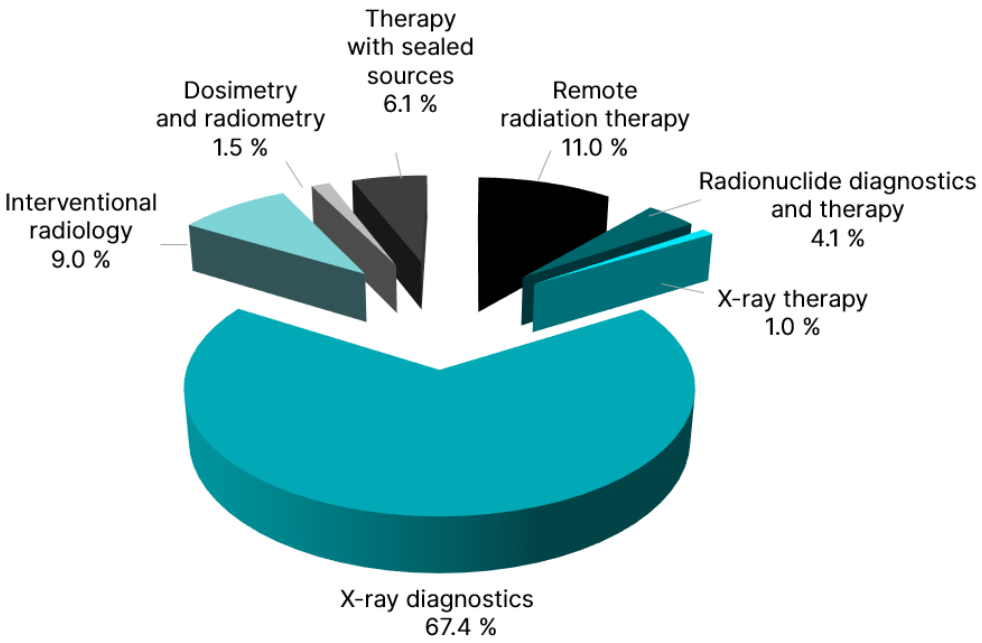


Figure 1. Distribution of medical personnel subjected to centralized IDM by medical applications of radiation sources

– 1,014 persons worked with gamma radiation sources (radionuclide).

In connection with martial law in Ukraine since February 2022 and occupation of territories in the Luhansk, Donetsk, Kherson and Zaporizhzhia regions, the number of health care institutions and medical workers who were subjected to the centralized IDM in 2023 decreased by 160 institutions and 938 persons compared to 2021.

The largest number of category A personnel (67.4 %) is employed in radiodiagnostics; personnel of radiotherapy and radiology departments performing remote radiation therapy and sealed source therapy (contact radiation therapy) account to 11.1 %; nuclear medicine (radionuclide therapy and unsealed source diagnostics) employs 4.1 % of personnel; and interventional radiology employs 9.0 %

Analysis carried out by the CLRS MDM showed that the total collective dose to employees of all monitored health care institutions in Ukraine amounted to **2,944.5 person-mSv,** in particular: the collective dose to medical personnel working with X-ray sources was **2,287.3 person-mSv** and that to personnel working with gamma and inhibitory photon radiation sources was **657.2 person-mSv**.

IDM analysis indicates that the contribution of the collective effective dose received by medical personnel of X-ray diagnostic departments/rooms to the total collective dose of medical personnel in Ukraine is the highest and amounts to 67.0 %; the contribution of the collective dose received by personnel of radiation therapy/radiology departments (remote and contact radiation therapy) is 11.0 %; and for personnel of nuclear medicine departments (radionuclide therapy and diagnostics with unsealed radiation sources) is 3.9 %.

The contribution of the collective effective dose received by medical personnel of interventional radiology departments (medical interventions under X-ray procedures) to the total collective dose caused by medical personnel exposure amounted to 11.4 %.

The average annual doses for individual health care institutions/establishments ranged as follows:

– 0,40–1,54 mSv for personnel of radiation therapy/radiology departments working with gamma radiation sources;

– 0,40–2,5 mSv for personnel of X-ray diagnostic departments.

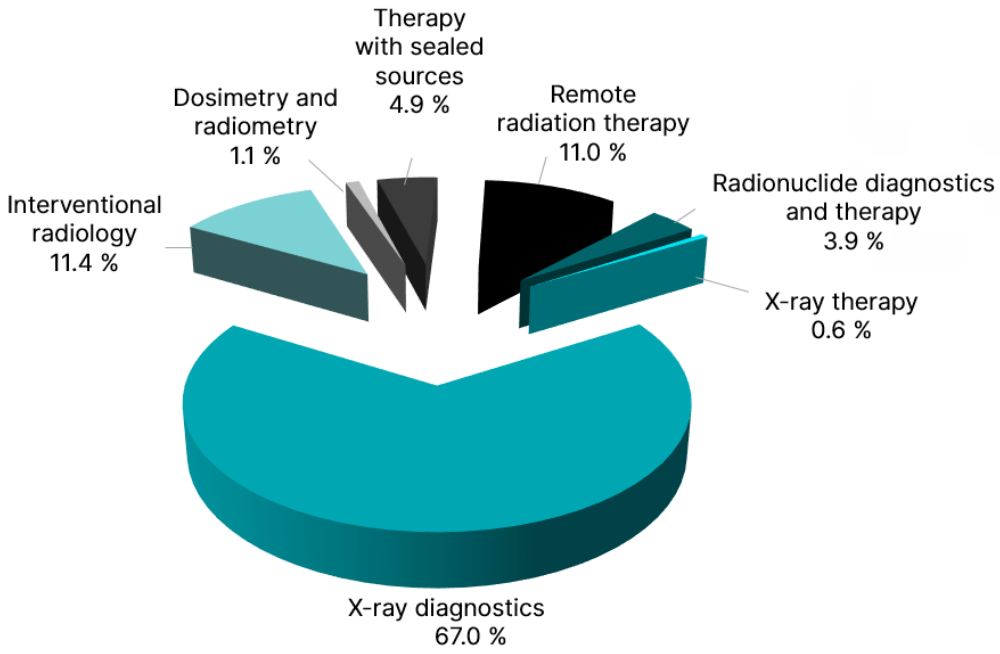


Figure 2. Distribution of the collective dose to medical personnel by medical applications of radiation sources

Maximum values of average annual doses were recorded in the following health care institutions:

– 1.54 mSv for category A personnel of radionuclide diagnostics and therapy department at the I. Mechnikov Dnipropetrovsk Regional Clinical Hospital in work with unsealed gamma radiation sources;

– 2.5 mSv for category A personnel of the X-ray surgery department at the Zaporizhzhia Regional Center for Cardiovascular Diseases of the Zaporizhzhia Regional Council.

The generalized average annual dose to medical personnel in all medical institutions of Ukraine in the work with gamma radiation sources amounted to **0.54 mSv** and in the work with X-ray sources to **0.45 mSv.**

Thus, for the majority of occupational groups of medical employees performing radiation therapy and radiation diagnostics using radionuclide sources, the average annual doses did not exceed 1.0 mSv.

The highest average annual doses were recorded for:

– – holders of radioactive substances of sealed radiation source units (contact gamma therapy) – 2.65 mSv;

– group of radiomanipulation nurses of sealed radiation source units – 1.60 mSv;

– group of nurses involved in packing and administration/dispensing of radiopharmaceuticals (unsealed radiation sources) for therapeutic or diagnostic purposes in nuclear medicine departments – 1.51 mSv.

Among medical personnel working with generating radiation sources, the highest average annual doses were observed for specialists engaged in complex interventions under X-ray procedures (angiography, coronarography, endoscopy, lithotripsy, etc.):

– surgeons, cardiac surgeons and anesthesiologists – 0.98 mSv;

– anesthesia nurses, operating room nurses – 0.91 mSv.

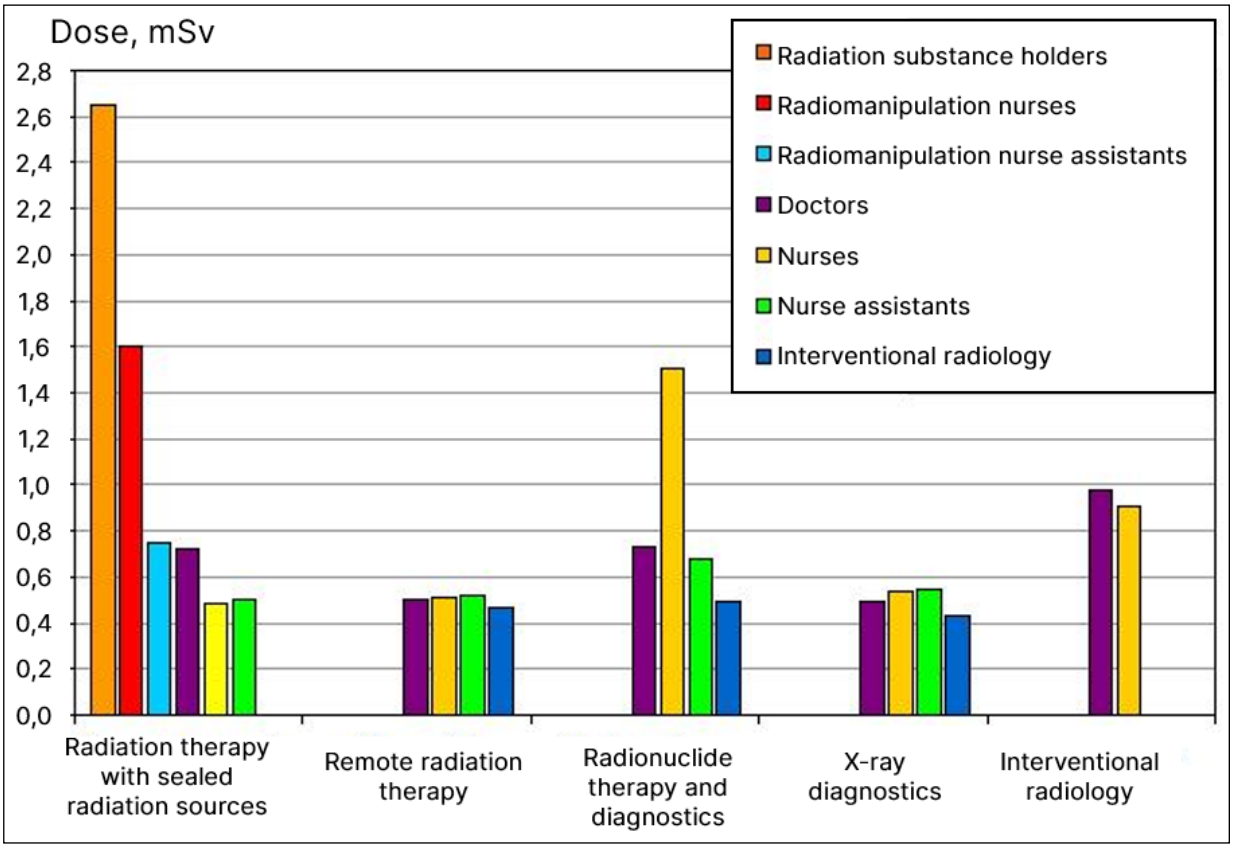


Figure 3. Distribution of average annual doses for selected occupational groups of medical personnel in Ukraine by applications of radiation sources

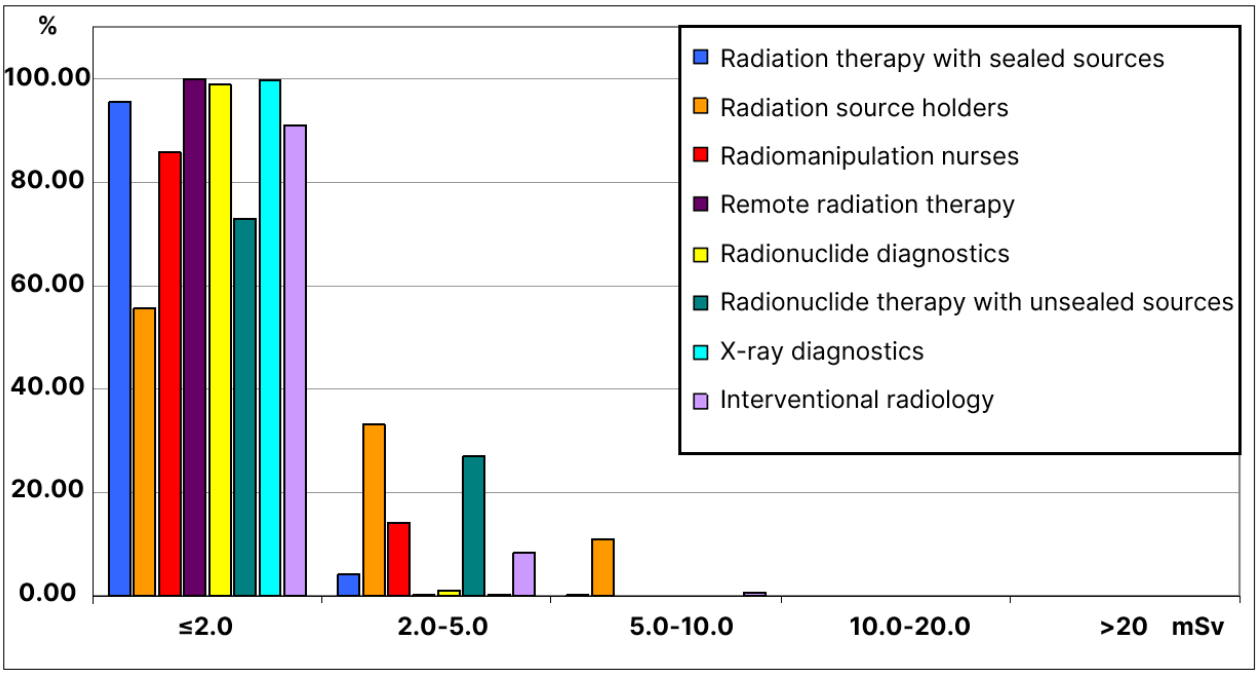


Figure 4. Distribution of individual annual doses for medical personnel by applications in radiation therapy and radiation diagnostics, including those for holders of radioactive substances and radiomanipulation nurses in contact gamma therapy

For the majority of occupational groups of medical personnel working with radiation sources, individual annual doses do not exceed 2.0 mSv (0.1 DL_A). Hence, the number of persons with doses up to 2 mSv amounted to 96.2 % or medical personnel group "Therapy with sealed sources", to 99.0 % for group "Remote gamma therapy" and to 97.9 %, 92.6 % and 98.9 % for groups "Radionuclide diagnostics", "Therapy with unsealed radiation sources" and "X-ray diagnostics", respectively.

For medical personnel from sealed radiation source units of radiology departments performing contact gamma therapy, the number of persons with doses up to 2.0 mSv amounted to: 83.3 % for radiation source holders and 88.5 % for radiomanipulation nurses. For these personnel groups, the largest number of personnel with individual doses ranging from 2.0 to 5.0 mSv was observed: 16.7 % for radiation source holders and 11.5 % for radiomanipulation nurses.

For medical personnel involved in interventional radiology, doses lower than 2.0 mSv were received by 92.6 %, while the number of personnel with doses ranging from 2.0 to 5.0 mSv amounted to 5.8 %.

The following occupational groups received doses higher than 5.0 mSv:

– personnel engaged in dosimetry – 2.8 %;

– personnel of interventional radiology departments – 1.4 %.

In the reporting year, centralized IDM revealed four cases of annual individual doses amounting to or exceeding 10 mSv. These cases were recorded for medical personnel involved in interventional X-ray procedures.

The dynamics of average annual doses for medical personnel by applications of radiation sources for 2019-2023 is presented in Table 9.

In addition, in some occupational groups of medical staff, the average annual doses are not sufficiently stable. Hence, for radiation source holders and radiomanipulation nurses dealing with sealed contact gamma therapy sources, individual doses in the period 2019-2023 varied between 1.25 – 2.65 mSv and 0.76 – 1.60 mSv, respectively. This was associated with the number of personnel and the scope of contact gamma therapy treatment procedures conducted manually.

As of 1 January 2024, most of the oncological institutions in in Ukraine perform contact gamma therapy exclusively using AGAT-V, AGAT-VU, MultiSourse and other brachytherapy devices, which significantly improves the radiation safety of medical personnel. Only four medical institutions of Ukraine with sealed source units in radiology departments perform contact gamma therapy manually: Kramatorsk Regional Territorial Medical Association, Poltava Regional Clinical Oncologic Dispensary, Sumy Regional Clinical Oncologic Dispensary, and Cherkasy Regional Oncologic Dispensary. Individual doses to medical personnel of sealed radiation source units at these oncologic institutions lead to an increased level of average annual doses for the groups of radiation source holders and radiomanipulation nurses.

For medical personnel of nuclear medicine departments (radionuclide therapy and radionuclide diagnostics), the highest doses were observed in the group of manipulation nurses. For the period 2019-2023, the average annual doses in this group ranged from 1.13 to 1.51 mSv.

For surgeons, cardiologists, urologists, anesthesiologists and other specialists engaged in interventional radiology procedures, the average annual doses for the period 2019-2023 varied insignificantly: from 0.82 to 1.08 mSv.

The dynamics of collective doses for medical personnel by applications of radiation sources for 2019-2023 is presented in Table 10.

According to centralized IDM in 2023, most groups of medical personnel working with radiation sources had radiation protection systems that complied with radiation safety requirements since the annual doses do not exceed 0.1 DL_A for category A personnel according to NRBU-97, i.e. 2.0 mSv/year.

Meanwhile, the number of personnel involved in interventional radiology procedures is constantly growing. Given the level of potential individual doses during interventions under X-ray procedures, personnel of these departments may be referred to the high-risk group.

At the same time, the number of radiology departments that manually deal with sealed contact gamma therapy units is decreasing (today manual radiation therapy is used only in four medical oncological institutions of Ukraine).

Therefore, further improvement of radiation protection in medicine in operations with radiation sources should be aimed at the optimization of doses to personnel from:

– interventional radiology departments who are engaged in complex interventions under X-ray procedures (surgeons, cardiac surgeons and other specialists);

– sealed radiation source units of radiology/radiation therapy departments, specifically: radiation source holders and radiomanipulation nurses involved in manual contact gamma therapy;

– nuclear medicine departments in radionuclide therapy and radionuclide diagnostics with unsealed radiation sources (manipulation nurses).

VII. SAFETY OF RADIOACTIVE MATERIAL TRANSPORT

The safe transport of radioactive materials is a priority area of nuclear and radiation safety in the use of nuclear energy.

Radioactive material transport is a complex process that consists of preparation, loading, carriage and shipment of radioactive material cargoes and packages, including their in-transit storage, unloading and receipt at the final destination. Radioactive materials are under continuous regulatory control when moved outside their facilities/sites.

Radioactive materials are transported by various types of transport (road, rail, air and water) using public roads. For this reason, the safety of radioactive material transport is of paramount importance. Since the onset of the full-scale invasion and insidious aggression of the russian federation, civilian air and water transport in Ukraine has been virtually stopped, resulting in increased burdens on road and rail transport systems.

Ukraine has established and operates a legislative framework for regulating the transport of radioactive materials. This framework consists of laws and regulations on nuclear and radiation safety, which are specifically aimed at ensuring the safe transport of radioactive materials. These regulations determine the functions and responsibilities of radioactive material transport entities, state regulatory authorities and management bodies and identify relations between them.

In accordance with the Ukrainian legislation, safety in the transport of nuclear materials is regulated through:

– issue of authorizations (licenses for the transport of radioactive materials, permits for international shipments of radioactive materials, certificates of approval for the transport of radioactive materials);

– state oversight measures to verify compliance with nuclear and radiation safety requirements;

– legislative initiatives and development of regulations.

In order to improve regulatory requirements for the safety of radioactive material transport, the SNRIU, with involvement of the SSTC NRS and financial and expert support from DSA, developed a number of regulatory documents:

– Requirements for Management System for the Safe Transport of Radioactive Materials (SNRIU Order No. 564 dated 31 October 2023, registered in the Ministry of Justice of Ukraine No. 2256/41312 dated 27 December 2023);

– Requirements for the Structure and Content of Safety Analysis Reports on Packaging Design (SNRIU Order No. 587 dated 14 November 2023, registered in the Ministry of Justice of Ukraine No. 49/41394 dated 9 January 2024);

– Program for Ensuring Compliance with the Rules for the Safe Transport of Radioactive Materials (the document is recommendatory and is applied within SNRIU activities).

Measures to improve the regulatory framework are ongoing. Therefore, the SNRIU, jointly with the SSTC NRS, prepared a proposal for the CONVEYANCE project and submitted it to the DSA in 2023. The proposal provides for systematic support to the SNRIU in regulating the safety of activities related to the transport of radioactive materials, including radiation sources, when they are removed from facilities with high radiation risks caused by potential effects of military operations.

The following documents are proposed for development: Recommended Approach to State Regulation of Activities on Transport of Radioactive Materials, Including Radiation Sources, under War Risks and Recommended Procedure for Activities on Transport of Radioactive Materials, Including Radiation Sources, under War Risks.

These documents should establish the necessary framework for regulating the transport safety of radioactive materials, including radiation sources, in the context of military risks in Ukraine.

Under the martial law in Ukraine, starting from 24 February 2022, the radioactive material transport became much more complicated, necessitating the revision of conventional transportation routes. New logistical chains were established to ensure the continuous operation of nuclear power plants, healthcare facilities and other critical enterprises.

During 2023, within regulation of safety in the transport of radioactive materials, the SNRIU issued/amended 36 permits for international shipments of radioactive materials; issued 13 certificates of approval for the transport of radioactive materials, including eight certificates of approval for special conditions of radioactive material transport and five certificates of approval for packaging design for radioactive material transport; issued two licenses for the transport of radioactive materials and extended one license; other enterprises used the right to automatically extend their permits under martial law in accordance with Cabinet Resolution No. 314 "Certain Issues of Conducting Activities under Martial Law" dated 18 March 2022.

The SNRIU chose the justification principle for each specific shipment as the key priority in the state regulation of safety in radioactive material transport under such challenging conditions. This approach complies with the Basic Health and Radiation Safety Rules of Ukraine (OSPU-2005), considering the actual risks and implementing appropriate measures to ensure radiation safety in specific transport conditions.

VIII. SUPPORT OF EMERGENCY PREPAREDNESS AND RESPONSE IN UKRAINE

Emergency preparedness and response is one of the IAEA's ten fundamental principles of nuclear and radiation safety. The SNRIU, as the competent authority for emergency notification, performs the following functions in accordance with the Convention on Early Notification of a Nuclear Accident:

– maintains its own response capabilities related to notification;

– supervises emergency preparedness of entities dealing with the use of nuclear energy in compliance with the requirements of standards and rules on nuclear and radiation safety and conditions of authorizations;

– arranges and participates in exercises, training and workshops, including international ones, with the use of simulators and up-to-date techniques for assessment and forecast of situations;

– analyzes information and promotes the dissemination of knowledge and skills on emergency preparedness and response among its own staff, licensees and counterparts of authorities and organizations that have responsibilities for responding to nuclear and radiation emergencies.

In 2023, the functional subsystem of nuclear and radiation safety within the Unified State Civil Protection System was in the state of full readiness for actions in accordance with Resolution of the Cabinet of Ministers of Ukraine No. 179-r dated 24 February 2022 "On the Performance of the Unified State Civil Protection System under Martial Law" and performed relevant tasks under martial law in compliance with the regulations and recommendations of the State Emergency Service of Ukraine (SESU), as the central executive authority that provides for the state policy in civil protection.

The SNRIU, as the central executive authority that establishes and implements state policy in the use of nuclear energy and functions as a unified national point of contact according to the Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and Convention on the Physical Protection of Nuclear Material and Nuclear Facilities, ensures 24-hour duty at the Information and Emergency Center and constant communication with the facilities dealing with nuclear energy use in Ukraine (nuclear facilities, radioactive waste management facilities, uranium facilities and other radiation sources), the SESU operational duty service, other authorities, IAEA Incident and Emergency Center (IAEA IEC) and competent authorities of other countries within international agreements.

Under martial law, since the morning of 24 February 2022, constant daily communication with the IAEA IEC has been ensured. SNRIU Order No. 192 dated 4 March 2022 activated the Information and Emergency Center to carry out a 24-hour analysis of nuclear and radiation safety and perform forecasting calculations of potential emergency consequences using the European JRODOS decision support system in cooperation with the SSTC NRS, Ukrainian Hydrometeorological Center (UkrHMC), SESU, Energoatom, NPPs and other licensees dealing with the use of nuclear energy.

Events that may affect nuclear and radiation safety are reported to the IAEA Incident and Emergency Center and other member states through the USIE[1] secure website. In 2023, the SNRIU published 20 messages in the USIE system.

Messages on NPP operational events are analyzed, daily information reports on the state of NPP units are developed and

1 USIE is a unified system for information exchange in incidents and emergencies, allowing IAEA member states to exchange urgent notifications and follow-up information during an emergency in a continuous manner, around the clock. USIE is the primary channel for member states to transmit information on security and nuclear or radiological safety, incidents or emergencies related to nuclear safety and physical and radiological protection. Competent authorities of IAEA member states and international organizations have access to the system.

monthly statistical reports on operational events are sent to the Cabinet of Ministers of Ukraine. In 2023, there were 27 NPP operational events (nine at ZNPP, six at PNPP, seven at KhNPP, four at RNPP and one at ChNPP, 25 of which were classified according to the International Nuclear and Radiological Event Scale (INES) as below scale/level 0 – no safety significance, and two of level 1 – anomaly). There were 54 events in 2022.

Communication with the competent authorities and/or contact points is tested periodically under bilateral agreements with Austria, Bulgaria, Latvia, Germany, Norway, Poland, Romania, Slovakia, Turkey, Hungary, Finland and Sweden.

Information on radiological situation in places where high-level radiation sources are used and on their security is sent online to the SNRIU IEC within the Centralized System for Monitoring of Radiation Sources at Medical Institutions and Radioactive Waste Management Enterprises and within state oversight measures implemented by territorial nuclear and radiation safety inspectorates.

The restoration of radiation monitoring and control over nuclear and radiation safety at the facilities that were occupied or affected by the military aggression of the russian federation (particularly, at the ChNPP site and other nuclear and radiation facilities in the Exclusion zone) and the state of accounting, control and security of nuclear materials in Kharkiv, Kherson, etc.) remain issues of pressing concern.

In response to the risks to nuclear and radiation safety arising from the destruction of the Kakhovka Hydroelectric Power Plant, operational coordination between SNRIU experts and personnel of the UkrHMC and Central Geophysical Observatory was established to facilitate the exchange of information and the acquisition of accurate, operator-independent radiation monitoring data in a continuously evolving situation. This included setting up alternative radiation monitoring stations in the ZNPP location area and launching additional control points to monitor changes in radiological conditions.

In 2023, in the framework of cooperation and enhancement of coordination, notification and data exchange with the U.S. Department of Energy/National Nuclear Security Administration (DOE/NNSA) in the area of emergency preparedness and response:

– communications with the U.S. Joint Special Operations Command (JSOC) was periodically tested;

– training exercises were conducted with the DOE/NNSA National Atmospheric Release Advisory Center (NARAC) to share best practices in modeling and data analysis: with UkrHMC, SSTC NRS and Energoatom to compare modeling results for a conditional nuclear detonation scenario (18 January 2023 and 20-21 December 2023); with the Ministry of Energy, Energoatom, Rivne NPP, SESU and UkrHMC to test the algorithm of actions to model and predict the progression of a conditional emergency at the ZNPP using different assessment tools and compare the results (1 February 2023); and EOC-to-EOC training to verify interaction with the DOE/NNSA and SNRIU (22 February 2023, online) within plant response exercises with participation of DOE/NNSA, UKrHMC, Rivne NPP and SSTC NRS;

– a workshop on modeling the consequences of emergencies was held in Kyiv (24-25 April 2023) with the participation of experts from organizations involved in emergency preparedness and response;

– advisory support was provided to DOE/NNSA experts in assessing and forecasting the progression of potential scenarios.

During 2023, staff of the SNRIU Information and Emergency Center took part in international IAEA exercises and organized special training in the framework of bilateral agreements on prompt notification and information exchange in the event of a radiation accident:

– ConvEx-1a (28 March 2023) to test that the national communication points are continuously available and the national competent bodies are capable of receiving notifications;

– ConvEx-1b (15 August 2023) to test that the national communication points are continuously available and the national competent bodies are capable of responding to the notifications in a prompt manner;

– ConvEx-2a (14 June 2023) to test the capabilities and skills of the competent bodies and national INES coordinators in filling out standard forms in accordance with the development of a conditional emergency; During the exercises, the

ability to upload radiation monitoring data to the International Radiation Monitoring Information System (IRMIS) was tested. This process involved responsible providers who handle the monitoring of radiation parameters, working in cooperation with SESU and UkrHMC experts;

– ConvEx-2c (3 October 2023) to test the mechanisms of response to a transnational or radiological emergency.

According to SNRIU Order No. 585 of 13 November 2023, personnel of the SNRIU Information and Emergency participated in the joint plant-wide emergency exercises at RNPP (15-16 November 2023) on the scenario "General Accident at NPP" with full activation of the SNRIU Information and Emergency Center.

Inspectors from the Nuclear Safety Inspectorate at KhNPP participated in the plant-wide emergency exercise on the scenario "General Accident Caused by a Military Emergency Leading to Loss of In-House Power Supply at Unit 1, Leak from the Pressure Relief Tank, and Primary-to-Secondary Coolant Leak with the Atmospheric Steam Dump Valve of a Defective Steam Generator Stuck in the Open Position". Nuclear Safety Inspectorates at NPPs performed general regulatory assessments of plant-wide, unit-level and workshop-level exercises conducted by the licensee.

During the year, procedures for interaction with other central executive authorities and departments dealing with emergency response to nuclear and radiological incidents according to their duties, powers and instructions (agreements) on interaction with the SNRIU, particularly the SESU, SSU, UkrHMC and Ministry of Health, were tested and trained at the state and regional levels through the participation in command post exercises:

– on actions in case of a radiological accident at ZNPP (29 June 2023);

– on response to the potential use of nuclear weapons on the territory of Ukraine (31 October – 03 November 2023). In 2023, the draft Plan of Response to Nuclear and Radiation Accidents was under approval and revision to incorporate comments from its review by interested central executive bodies and other agencies, considering amendments to the Law of Ukraine "On Human Protection against Ionizing Radiation".

In the framework of European Commission project U4.01/19B "Support for the Creation of an Integrated Automatic Radiation Monitoring System Covering the Whole Territory of Ukraine", SNRIU/SSTC NRS experts took part in a series of working meetings and a workshop on the conceptual approaches and main measures to develop an integrated automated radiation monitoring system on the entire territory of Ukraine.

To ensure the state of emergency preparedness and response at ZNPP, Energoatom, in agreement with the SNRIU, developed the "Temporary Notification and Response Procedure in the Event of a Nuclear Accident or Other Radiological Situation at ZNPP under Occupation Conditions".

SNRIU representatives participated in a meeting with the heads of civil protection departments (employees) from central executive authorities and other state bodies to discuss the arrangement and implementation of civil protection measures. At SESU request, information was provided to support the development of the draft White Book on Civil Protection in Ukraine.

SNRIU and SSTC NRS experts participated in four online HERCA meetings (information meetings of ECURIE, HERCA and WENRA competent authorities) within the Working Group for Ukraine Modelling and Response (25 January, 27 June, 19 July and 23 November). At these meetings, key issues related to NPP safety were presented and calculations regarding the radiological consequences of a hypothetical accident at ZNPP were compared.

In 2023, regulatory decisions were reviewed and prepared for the following documents:

– Emergency Action Plan for Use of Radiation Sources in the Production Enterprise, provided by the State Enterprise "USIE IZOTOP";

– Emergency Action Plan for the VVR-M Nuclear Research Reactor at the Nuclear Research Institute of the National Academy of Sciences of Ukraine, AP.04/02-05/23;

– Emergency Action Plan for Radioactive Waste Processing and Storage at the RADON Lviv Interregional Affiliate;

– Emergency Action Plan for Radioactive Waste Processing and Storage at the RADON Kharkiv Interregional Affiliate;

– Emergency Action Plan for Radioactive Waste Processing and Storage at the RADON Dnipro Interregional Affiliate;

– Chornobyl NPP Plan of Response to Accidents and Emergencies.

IX. PHYSICAL PROTECTION OF NUCLEAR FACILITIES, NUCLEAR MATERIAL, RADIOACTIVE WASTE AND OTHER RADIATION SOURCES

Measures for Improving the Effectiveness of the State Physical Protection System

Physical protection of nuclear facilities and radioactive materials is an important area in the use of nuclear energy in Ukraine, a country with a highly developed nuclear energy infrastructure.

The priority tasks of state policy in the use of nuclear energy with respect to security are aimed at fulfilling Ukraine's international obligations to achieve the main goals of physical protection. They are intended to minimize the risks of sabotage, theft or any other illicit trafficking of radioactive materials and strengthen the nuclear non-proliferation regime.

Within international activities, the Department experts participated in the following events:

– 23rd and 24th Meetings of the Nuclear Security Guidance Committee (Nuclear Security Series) and the IAEA Technical Meeting of the Points of Contact for Integrated Nuclear Security Sustainability Plan (INSSP);

– workshop on the management of radiation sources in high-risk conflict areas with the support of the Office of Radiological Security of the National Nuclear Security Administration of the U.S. Department of Energy (Bratislava, Slovakia);

– workshop on the trafficking of radioactive materials in the Black Sea region (Tbilisi, Georgia);

– regular meeting of GEIGER Project Working Groups of the Black Sea region and Caucasus;

– regional staff exercises (Tbilisi, Georgia);

– working meeting to discuss past and future events within the framework of the Contact–Black Sea Project.

In addition, the representative of the Nuclear Security and Safeguards Department participated in the communication with IAEA on the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities and Amendments to it.

In order to fulfill tasks defined by Resolution of the Cabinet of Ministers of Ukraine No. 956 of 27 August 2022, the SNRIU established an Interdepartmental Working Group to Define Design-Basis Threat for Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Radiation Sources in Ukraine. Upon efforts of the Interdepartmental Working Group, a draft document "Design-Basis Threat for Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Radiation Sources in Ukraine" was developed and agreed with the state central authorities. The draft document addressed the potential occurrence of a special period (Act on Activities of the Interdepartmental Working Group for the Design-Basis Threat Definition No. 13-22/46 DSK of 5 June 2023). Pursuant to Orders of Denys Shmyhal, the Prime Minister of Ukraine, No. 352/3/1-23-DSK of 10 April 2023 and No. 1621 of 19 July 2023, the SNRIU developed the draft Law of Ukraine "On Amendment of the Law of Ukraine on Physical Protection of Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Radiation Sources regarding the Powers of the State Nuclear Regulatory Authority". The draft law has been submitted to the Cabinet of Ministers of Ukraine. The adoption of this law will positively influence Ukraine's national security and preparedness to respond and counter potential threats of sabotage against nuclear facilities and radioactive materials and unacceptable radiological consequences.

According to Article 25 of the Law of Ukraine "On Mobilization Training and Mobilization" and subpara. 4 of para. 2 in the Procedure and Criteria for Determining Enterprises, Institutions and Organizations Critically Important to the Economy and Public Wellbeing in Special Period, approved by Resolution of the Cabinet of Ministers of Ukraine No. 76 of 27 January 2023, SNRIU Order No. 225 of 1 May 2023 approved criteria for determining enterprises, institutions and organizations that are critically important for the national economy in the safe use of nuclear energy. The order was registered in the Ministry of Justice of Ukraine on 15 May 2023 under No. 810/39866.

SNRIU Order No. 420 dated 14 August 2023 designated the Engineering and Technical Center "Atomenergotrening" subsidiary as critically important to the economy and public wellbeing during the special period.

SNRIU physical protection specialists reviewed 22 Acts for determining the physical protection level and 102 Lists of positions that require permits to perform special activities in order to prevent the threats of sabotage, theft and other illegal actions by internal offenders. 50 SNRIU inspectors and 9 managers of privately owned enterprises using radiation sources were granted permits to perform special activities.

Within authorizing activities, four permits were issued for the use of land and water reservoirs located in the control areas of nuclear facilities, radioactive waste management facilities and uranium plants.

Two state inspections (ChNPP and CRME) were conducted to check physical protection systems of nuclear facilities, nuclear materials, radioactive waste and other radiation sources and interaction plans in case of sabotage.

Project to Improve the Security of Radiation Sources

In 2023, the following activities were performed within the project "Improving Security of Radiation Sources Used in Ukraine" as part of the Global Threat Reduction Initiative, implemented under the general coordination of the Office of Radiological Security of the U.S. Department of Energy:

– physical protection systems at oncology centers in Ukraine, facilities using high-level radiation sources, and RWDS of the RADON Association were upgraded;

– deficiencies in the performance of communication systems (data transmission lines) were eliminated and operated in test mode;

– a team of SNRIU duty officers ensured continuous operation of the Central Monitoring Station, to which 32 facilities were connected

– five facilities were connected to the monitoring station installed at the CRME Vektor site, Chornobyl, Kyiv region;

– monitoring systems for engineered features of the physical protection systems located in the combat zone (Vector site, Chernihiv and Kharkiv oncology centers, RWDS of the RADON KhIA) were updated.

The following measures were implemented upon the results of the meetings with project donors:

– installation of the optical fiber communication line from Ivankiv to Chornobyl and further between Pidlisnyi RWDS, Buryakivka RWDS, ChNPP Stage III RWDS and their connection with the Central Monitoring Station of the Vektor site continued.For this purpose, the donor decided on the purchase of 120 km of an optical fiber cable, and a part of activities on laying the line from Ivankiv to Dytiatky checkpoint was completed;

– four Renault Duster cars were purchased and delivered for the immediate response team at CRME;

– a roadmap was developed for taking surveys of facilities for the further implementation of the design and development of terms of reference for the creation of working designs on PPS modernization with the definition of the most threatening areas with the participation of representatives of the recipients and the contractor, namely: SNRIU, SAUEZM, CRME, USIE IZOTOP, RADON Association, Atomenergotrening;

– measures were taken on the development and production of containers for RM transport, which will significantly improve nuclear security, nuclear safety and expand the enterprise's production capabilities;

– further steps to ensure safe transport of RITEGs from OIA RWDS to CLTSF, in particular:

1) the need for forklifts, specialized trucks, trucks with manipulators,

transport containers and containers for long-term storage of RITEGs were determined;

2) the measures to improve engineering and technical means of RITEG storage area at CLTSF were agreed in order to increase the efficiency of the defined level of physical protection and safety of production personnel;

3) the tabletop training on the transport of RITEGs from RADON OIA RWDS to Vektor CLTSF was conducted with the involvement of representatives of all shipment participants (SNRIU, SAUEZM, RADON Association, CRME, National Police of Ukraine, Security Service of Ukraine);

4) the needs for cars for the response groups of the RADON Association were determined;

5) the additional need for protection means for physical protection units (helmets, body armor, etc.) were identified;

– the possibility of creating a Central Monitoring Station for PPS of RADON Association sites was confirmed;

– the relevant tasks and needs of Atomenergotrening on further implementation of the project of organizing a reliable connection with Exclusion Zone enterprises through laying an optic fiber line were specified;

– technical condition assessments of engineered features within PPS of the RADON Association RWDS sites by representatives of ORS Program in Ukraine and SNRIU through survey of RWDS of the RADON Kharkiv and Lviv Interregional Affiliates were planned.

Within the Project with the Ministry of Internal Affairs (MIA) on Radiation Awareness and Response, teachers of the higher educational establishments of the MIA of Ukraine were involved as observers to participate in the development of a pilot training course on response to nuclear security events. A training session was conducted. Based on the above results, the conclusions were made as related to the implementation of the course, which is integrated into training programs and training processes in MIA institutions to ensure training of the employees of the National Police of Ukraine involved into response measures related to radiation source nuclear security in Ukraine. In addition, the issue of possible assistance in arranging classrooms for relocated higher educational establishments of MIA of Ukraine was considered.

The main results of the Project are as follows:

1. The theoretical materials of the training course on radiation awareness and primary response of security police units to criminal actions related to the illegal acquisition of radiation sources were finalized.

2. A group of trainers from educational establishments of MIA (29 people) completed a full training course and received certificates. The received certificates confirm the readiness and ability of Ukrainian trainers to teach the course, which consists of the theoretical part and the tabletop training and is developed for five training days.

3. The course was implemented and its teaching started in six educational establishments of MIA.

4. The donor supplied equipment and equipped 11 classrooms in higher educational establishments of MIA, including furniture, computer equipment, software, etc.

In addition, the U.S. Department of Energy, in case of receiving an application from MIA of Ukraine, is ready to consider the possibility of organizing and holding additional training courses for teachers of advanced training centers of the National Police of Ukraine.

The results were achieved with the help of holding and participation in five international working meetings of the Project participants.

Detection of Radioactive Materials in Illicit Trafficking

In 2023, five notifications on the detection of radioactive materials in illicit trafficking in Ukraine were sent as part of data exchange with the IAEA Incident and Trafficking Database (ITDB).

Thus, on 16 June 2023, a 15x15x15 round metal item with an increased level of gamma radiation was detected in a forest belt (territory of the Novooleksandrivka rural territorial community of the Dniprovsky district of the Dnipropetrovsk region). Experts of RADON DIA conducted a survey that revealed an increased level of gamma radiation at a distance of 0.1 m

from the surface – 4.5 μSv/h. U-238 radionuclide was identified. No radiation contamination was recorded in the adjacent area. Radioactive material was retrieved from the place of detection and transferred for storage to RADON DIA RWDS.

On 20 June 2023, three metal items with an increased level of gamma radiation were detected in Kamianske:

– a spherical item with a diameter of about 20 cm;

– a round lid with a diameter of about 10 cm;

– a round stand with a diameter of about 10 cm (see photos).

Experts of RADON DIA conducted a survey that revealed an increased level of gamma radiation at a distance of 0.1 m from the surface – 4.85 μSv/h. U-238 radionuclide was identified. No radiation contamination was recorded in the adjacent area. Radioactive material was retrieved from the place of detection and transferred for storage to RADON DIA RWDS.

Besides, a metal container was detected in Kamianske. Experts of RADON DIA conducted a survey that revealed an increased level of gamma radiation at a distance of 0.1 m from the surface – 5.5 μSv/h. U^{238} radionuclide was identified. The investigated item was in a barrel similar to a protective container in an abandoned state. Radioactive material was retrieved from the place of detection and transferred for temporary storage to RADON DIA RWDS.

On 2 October 2023, a suspicious item with an increased level of gamma radiation was detected in a postal shipment on the territory of the Directorate of Mail Processing and Transportation of JSC Ukrposhta in Kyiv. According to Resolution of the Cabinet of Ministers of Ukraine No. 813 dated 2 June 2003 "On Approval of the Procedure for Interaction of Executive Authorities and Legal Entities Dealing with the Use of Nuclear Energy in Case of Detecting Radioactive Materials in Illicit Trafficking", the commission conducted a radiation survey and found the item: DP-63 dosimeter. The survey detected an increased level of gamma radiation on the surface of the item – 25.3 μSv/h.

Radioactive material was retrieved from the place of detection and transferred for storage to RADON CPS RWDS.

Photo 15. Radioactive material with U-238 radionuclide revealed in a forest belt of the Novooleksandrivka rural territorial community of the Dniprovsky district in the Dnipropetrovsk region

Photo 16. Metal items with an increased level of gamma radiation revealed in Kamianske

Photo 17. Metal container revealed in Kamianske

On 9 October 2023, an item with a radiation hazard sign installed on its surface was detected in the Pokotylivka village of the Kharkiv region. The radiation survey revealed a RID-1 fire detector produced in 1979 and identified an increased level of gamma radiation on the surface of the item of 1.5 μSv/h (with a probable content of Pu^{239} radionuclide). The radioactive material was retrieved from the place of detection and transferred for storage to RADON KhIA RWDS.

Information on the detection of illicit trafficking of radioactive materials was entered to the IAEA Incident and Trafficking Database (ITDB).

Within improvement of the international cooperation, experts of the Nuclear Security and Safeguards Department actively participate in the events held with the support of international organizations.

Thus, with the support of the Interpol General Secretariat, the working meeting on the GEIGER Project was held from 14 to 16 June 2023 in Bucharest (Romania) together with the representatives from the Administration of the State Border Guard Service of Ukraine and the National Police.

The participants shared their histories of success, received knowledge and the difficulties they faced during the detection of illicit trafficking of radioactive materials. The participants were involved into discussions, got acquainted with the positive experience of countering and sharing information at the stages of detection and response and participated in the discussions of ways to improve regional cooperation in countering illicit trafficking of radioactive materials.

The workshop participants listened to the presentations of various experts from different organizations, who presented real cases of illicit trafficking of radioactive materials in their countries and shared experience in detection and response by different authorities and services, as well as interaction between them.

The workshop was held to see how interaction with different organizations is performed inside these countries in case of detection and response to such events, as well as interaction with other countries and planning of joint antiterrorist operations.

Photo 18. DP-63 dosimeter revealed on the territory of the JSC Ukrposhta Mail Processing and Transportation Directorate

Photo 19. RID-1 of 1979 detected on the territory of the Pokotylivka village in the Kharkiv region

The event was arranged by the United Nations Interregional Crime and Justice Research Institute (UNICRI) and the Government of Georgia. About 20 representatives of border guard authorities (border guards and customs officers), agencies of internal affairs, security services, prosecutor's and investigation offices, regulatory authorities for nuclear and radiation safety from three countries (Georgia, Moldova and Ukraine), as well as a number of experts from UNICRI participated in the trainings.

The events consisted of discussions based on the scenario and interactive events where the presentations were made by the participants. A group discussion of issues discovered during the implementation of practical tasks was conducted. The possibilities for mutual information exchange, investigations, planning and conducting of undercover operations were considered.

As a result, the preparedness of the participating countries for detection and response to incidents related to radioactive material safety in the region was assessed, the methods and techniques for investigation and silent operations were improved, the interdepartmental coordination between the interested executive authorities and regional cooperation between the participating countries in the safety of radioactive materials were promoted in the First Regional Staff Training.

Photo 20. Working meeting within the GEIGER Project

Photos 21, 22. Participation in staff exercises with the scenario of prevention, detection and response to illicit trafficking of radioactive materials within the CONTACT – Black Sea Project

X. NUCLEAR WEAPON NON-PROLIFERATION SAFEGUARDS

IAEA Inspection Activities in Ukraine

In accordance with the Agreement between Ukraine and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, the IAEA conducts inspections on the territory of Ukraine.

The IAEA conducted routine and unannounced inspections at nuclear facilities and enterprises of Ukraine to confirm the declared inventory of nuclear materials in 2023.

In total, the IAEA conducted 70 inspections and 14 technical visits and received five complementary accesses for IAEA inspectors.

The IAEA conducted inspection to ensure that there are no undeclared nuclear materials or undeclared nuclear activities through additional accesses to enterprises and nuclear facilities of Ukraine.

In 2023, IAEA inspectors received five complementary accesses, covering:

1) Rivne NPP,
2) Proton-21 LLC, Kyiv,
3) SE Mykolaiv Shipyard, Naval Park LLC and DDP Private Company, Mykolaiv,
4) Kharkiv Institute of Physics and Technology,
5) Zaporizhzhia NPP.

IAEA Missions in Ukraine

In 2023, the IAEA permanent monitoring mission at the occupied Zaporizhzhia NPP, started in September 2022 and governed by an individual terms of reference, continued its work. In 2023, 11 rotations of IAEA experts took place within the mission at ZNPP.

In September 2023, IAEA inspectors performed annual physical inventory in all nuclear material balance areas at the Zaporizhzhia NPP.

In addition, since January 2023, IAEA permanent missions were introduced at all Ukrainian NPPs at the request of Ukraine in order to monitor safety at all NPPs in conditions of russia's military aggression. They started their work in January 2023 at ChNPP, KhNPP, RNPP and PNPP.

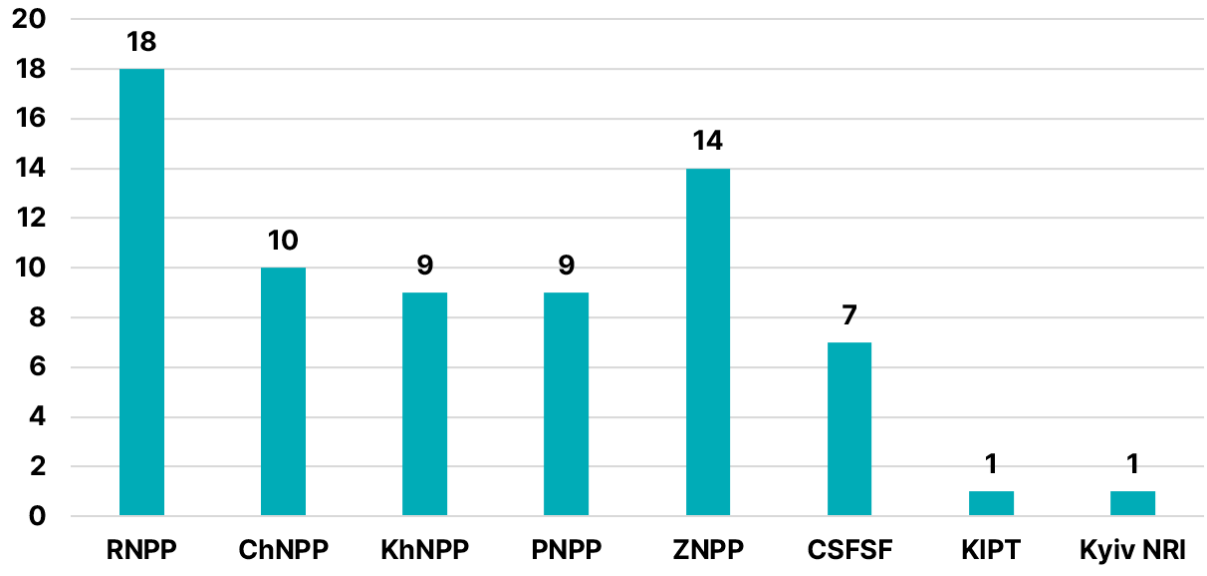


Figure 5. IAEA inspections at nuclear facilities in Ukraine

In 2023, there were 17 rotations of IAEA experts as part of IAEA permanent monitoring missions at PNPP, RNPP, KhNPP and 19 rotations at ChNPP.

In addition, there were two IAEA medical missions:

– to assess critical needs for medical support to operating personnel of Ukrainian NPPs;

– to assess the need and priorities for medical support to ChNPP.

Photo 23. IAEA experts in permanent monitoring missions

State Accounting and Control of Nuclear Materials

The SNRIU keeps the state information data bank of nuclear materials, containing information on the quantity and composition of nuclear materials in any balance area or individual enterprise. 192 reports on nuclear materials were sent to the IAEA from the data bank in the reporting period.

During the year, the IAEA was regularly provided with information under the Agreement (information on the design of nuclear facilities, immediate and long-term planning of IAEA inspections, radiation doses of IAEA inspectors, etc.).

Implementation of the Additional Protocol to the Safeguards Agreement

The Additional Protocol to the Safeguards Agreement applies to all nuclear activities of the country and provides extended powers to the IAEA in the field of non-proliferation control over the use of nuclear materials for peaceful purposes, as well as over the peaceful nuclear activities of countries.

In 2023, 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 and the information was annually updated in accordance with the Additional Protocol to the Agreement (32 declarations).

Meeting of the Joint Ukraine-IAEA Safeguards Implementation Review Group

The Safeguards Implementation Review Group (SIRG) was established to facilitate the implementation of the Safeguards Agreement and the Additional Protocol to this Agreement. Every year, SIRG holds a meeting to consider practical issues related to compliance of Ukraine with its international obligations in the field of nuclear non-proliferation safeguards.

On 25 August 2023, a regular annual meeting of SIRG was held in SNRIU office. Representatives from the SNRIU, IAEA, Ministry of Energy of Ukraine, Ministry of Foreign Affairs of Ukraine, Energoatom, Atomremontservis, ChNPP and Kharkiv Institute of Physics and Technology participated in the meeting.

At the meeting, the participants discussed current issues of applying IAEA safeguards in Ukraine and measures need to improve efficiency of implemented IAEA safeguards.

According to SIRG, an updated action plan was developed to ensure efficient application of safeguards in Ukraine and

Photo 24. Meeting of the Ukraine –
IAEA Safeguards Implementation Review Group (SIRG) in Ukraine

terms for the implementation of approved measures were identified.

Implementation of Bilateral International Agreements on Cooperation in Peaceful Use of Nuclear Energy

During the year, the SNRIU exchanges information on international transfer of nuclear materials according to bilateral international agreements with:

– European Atomic Energy Community,
– Atomic Energy Control Board of Canada and
– Australian Safeguards and Non-Proliferation Office.

Support of Efficiency of the Safeguards Infrastructure in Ukraine

Traditionally, great attention is paid in Ukraine to training and advanced training of experts of the SNRIU and Ukrainian NPPs, enterprises and organizations involved into the implementation of safeguards in Ukraine.

In 2023, training events for experts in safeguards took place in Ukraine. Besides, Ukrainian experts participated in training courses outside Ukraine arranged with the participation of the IAEA, U.S. Department of Energy, State Office for Nuclear Safety (SUJB) of the Czech Republic, Institute for Radiation Protection and Nuclear Safety (IRSN) of France and Nuclear Regulatory Authority (NDK) of Turkey. The participants deepened their knowledge in the application of IAEA safeguards within the global non-proliferation regime and learned how IAEA safeguards are applied around the world.

Photos 25, 26. Participation in safeguards raining courses for Ukrainian experts

XI. INTERNATIONAL COOPERATION AND EUROPEAN INTEGRATION

1. International Cooperation, Including European Integration Processes

The year 2023 was rich in international events and activities, taking place both online and onsite. New areas of cooperation were established and new projects were launched.

In 2023, the SNRIU continued active interaction with European and world institutions and associations aimed at the implementation of cooperation projects and fulfillment of Ukraine's obligations in the context of strengthening the regulation of nuclear and radiation safety and operational safety of NPPs.

International Agreements

The SNRIU Chairman Oleh Korikov signed three international agreements in 2023, specifically:

– Arrangement between the State Nuclear Regulatory Inspectorate of Ukraine and the United States Nuclear Regulatory Commission for the Exchange of Technical Information and Cooperation in Nuclear Safety Matters (signed on 1 August 2023);

– Memorandum of Understanding between the State Nuclear Regulatory Inspectorate of Ukraine and the Canadian Nuclear Safety Commission for the Cooperation and Exchange of Information on Nuclear Regulatory Matters (signed in Kyiv on 15 August 2023);

– Arrangement between the State Nuclear Regulatory Inspectorate of Ukraine and the United Kingdom's Office for Nuclear Regulation for the Exchange of Information and Cooperation on Safe Regulation of Peaceful Use of Nuclear Energy (signed in Vienna on 28 September 2023).

In accordance with Article 62 of the Vienna Convention on the Law of Treaties, part three of Article 24 of the Law of Ukraine "On International Treaties of Ukraine", para. 12 of the Regulation on the Procedure for Conclusion, Implementation and Denunciation of International Interagency Treaties of Ukraine, approved by Cabinet Resolution No. 422 dated 17 June 1994 and Order of the Vice Prime Minister for European and Euro-Atlantic Integration of Ukraine No. 13444/1/1-23 dated 3 May 2023 and in connection with the military aggression of the russian federation against Ukraine and the participation of the Republic of Belarus in it, the Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and the Ministry of Emergencies of the Republic of Belarus on Cooperation in Nuclear and Radiation Safety concluded in Kyiv on 5 September 2013 was terminated on 14 August 2023.

Cooperation with the European Commission, Groups and Associations

Under the Instrument for Nuclear Safety Cooperation (INSC), the SNRIU and the European Commission successfully completed the Project "Strengthening of State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) Capabilities Relevant for the Regulation of Nuclear Activities and in Licensing and Severe Accident Management of Nuclear Installations" (U3.01/14-15, U3.01/18 (UK/TS/51-58)).

This year, the European Commission launched new INSC project: U3.01/21 "Continued Alignment of the Ukrainian Regulatory Regime with the EU Acquis" (UK/TS/59). The project includes six tasks: Support to SNRIU in Activities Implemented in the Framework of the ENSREG Topical Peer Reviews on Ageing Management and Fire Protection; Introduction of Graded and Integrated Approaches in Safe Management of Radioactive Waste and Radioactive Material; Providing Methodological Harmonisation in Radiation Monitoring through Development of Guidance on Radiation Monitoring in Planned, Emergency and Existing Exposure

Situations; Strengthening of SNRIU Regulatory Capabilities in Licensing of Load Following Modes for NPP Units; Support to Ukraine in the Development and Implementation of a National Strategy for the Alignment of Nuclear Regulatory Framework with EURATOM Directives; and Strengthening Regulatory Capabilities in the Field of Severe Accident Management to Review the Possibility of Implementing In-Vessel Melt Retention for Ukrainian NPPs (WWER-440 and WWER-1000).

In connection with the granting of an observer status to Ukraine in the European Nuclear Safety Regulators Group (ENSREG), the SNRIU representatives participated in plenary sessions and monitored the main trends of the European Union's policy on enhancing the operational safety of NPPs, managing radioactive waste, updating relevant EU regulations, developing proposals to strengthen cooperation with non-EU countries, etc.

SNRIU Acting Chairman – Chief State Inspector for Nuclear and Radiation Safety of Ukraine – Oleh Korikov informed European experts about the situation in the area of nuclear and radiation safety in Ukraine and in his speeches called on European partners to international isolation of the russian federation as a country that shamefully violates international standards, principles of nuclear safety and fell back on criminal nuclear blackmail of the world community.

In the framework of participation in the activities of the Western European Nuclear Regulators Association (WENRA), SNRIU Acting Chairman – Chief State Inspector for Nuclear and Radiation Safety of Ukraine – Oleh Korikov and SNRIU experts participated in WENRA regular plenary meetings. During the meetings, a separate session was devoted to the current situation in Ukraine due to the military aggression of the russian federation against our country. During this session, the SNRIU delegation presented reports on the current state of nuclear and radiation safety at the Zaporizhzhia NPP, as well as on Ukraine's progress in rejecting russian nuclear fuel for VVER-1000 and VVER-440 reactors.

During the year, SNRIU experts participated in the meetings of three WENRA working groups: Working Group on Research Reactors (WGRR), Reactor Harmonization Working Group (RHWG) and Working Group on Waste and Decommissioning (WGWD).

Cooperation with the IAEA

The Joint Eighth and Ninth Review Meeting on the implementation of obligations under the Convention on Nuclear Safety (CNS) was held in Vienna, Austria, from 20 to 31 March 2023.

The delegation of Ukraine presented the National Report on the fulfillment of obligations under the Convention.

Upon the review of the National Report at the Joint Eighth and Ninth Review Meeting under the Convention on Nuclear Safety, four challenges were identified for Ukraine:

– reorganize the State Nuclear Regulatory Inspectorate of Ukraine into the Commission;

– implement C(I)SIP measures;

– implement EU Directives and WENRA reference levels into national legislation;

– fully implement the provisions of Articles 9-10 and 16 at the temporarily occupied ZNPP site in the light of the current invasion of Ukraine by the russian federation.

In addition, two proposals were identified: conduct an IRRS mission and implement VVER-440 containment venting taking into account the experience of countries operating such reactors.

Three areas of Ukraine's successful activities were noted:

– a training center was established in 2018, with full-scale equipment and systems for personnel training;

– in accordance with Article 5 of the Convention on Nuclear Safety and provisions in INFCIRC 572, rev. 6, Ukraine has demonstrated transparency in its international relations over the past year in discussing comprehensive information on the current safety status of its nuclear facilities under unprecedented circumstances;

– in accordance with Article 19 of the Convention on Nuclear Safety, Ukraine has demonstrated high efficiency in developing procedures to respond to anticipated operational events, such as an accident resulting from the loss of external power supply during unprecedented circumstances over the past year.

Permanent IAEA Missions at Ukrainian NPPs

At request of the President of Ukraine Volodymyr Zelenskyy, IAEA Director General Rafael Mariano Grossi, in addition to the permanent mission at ZNPP, deployed permanent missions to all Ukrainian NPPs, including the Chornobyl NPP.

Mission location	Mission beginning	Number of rotations
ZNPP mission	29 August 2022	15
ChNPP mission	18 January 2023	20
KhNPP mission	23 January 2023	18
RNPP mission	17 January 2023	17
PNPP mission	16 January 2023	16

In the framework of the IAEA Technical Cooperation Program, equipment was supplied and Ukrainian experts passed training/internship under the following IAEA national projects for 2022-2023:

– Support for decommissioning and radioactive waste management and other complex long-term issues of Chornobyl and Exclusion Zone;

– Strengthening radiation therapy and medical imaging in Ukraine;

– Enhancing cancer diagnostics and treatment.

Moreover, Ukrainian experts participated in the implementation of 14 IAEA regional projects.

From 25 to 29 September 2023, the regular 67th session of the IAEA General Conference was held in Vienna. During the plenary week, the key issues of the organization's activities were discussed, in particular: approval of the Agency's budget for 2024, identification of priorities according to programs of activities for ensuring nuclear and radiation safety, safety of radioactive waste management and nuclear security. Results from the verification carried out in 2023 were discussed and areas for improving the existing safeguards system, areas for developing contemporary science and technology, planning of the technical cooperation program, etc. were agreed.

During the 67th session of the IAEA General Conference, Resolution GC(67)/RES/16 "Nuclear Safety, Security and Safeguards in Ukraine" was adopted. The Resolution includes the following key provisions under which the member states:

– support the permanent and enhanced presence of the IAEA support and assistance monitoring mission at the Zaporizhzhia NPP;

– emphasize the need to provide IAEA experts with unrestricted and timely access to all relevant locations at ZNPP and around it;

– request the IAEA Director General to continue to report regularly on the nuclear safety and protection situation at ZNPP;

– call for the urgent withdrawal of all unauthorized military and other unauthorized personnel from the Zaporizhzhia NPP and immediate return of the NPP to the full control of the competent Ukrainian authorities under the current license issued by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) to ensure its safe and secure operation;

– fully support the continued provision of IAEA technical support and assistance to Ukraine for ensuring safe operation of nuclear facilities and activities with radioactive sources, including the permanent presence of IAEA experts at all Ukrainian NPPs.

On 28 September 2023, at the 67th session of the IAEA General Conference, Ukraine was elected as a member of the Agency's Board of Governors. The decision on Ukraine's membership in the IAEA's governing body was adopted by 79 votes. According to the IAEA official website, the newly elected member states of the Agency's Board of Governors are also the following: Algeria, Armenia, Bangladesh, Burkina Faso, Ecuador, Indonesia, Republic of Korea, Netherlands, Paraguay and Spain.

For the period 2023-2024, new membership of the IAEA Board of Governors including 35 member states will be as follows: Algeria, Argentina, Armenia, Australia, Bangladesh, Brazil, Bulgaria, Burkina Faso, Canada, China, Costa Rica, Denmark, Ecuador, Finland, France, Germany, India, Indonesia, Japan, Kenya, Republic of Korea, Namibia, the Netherlands, Paraguay, Qatar,

Russia, Saudi Arabia, Singapore, South Africa, Spain, Turkey, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay and Ukraine.

The Board of Governors is one of the IAEA's two governing bodies, alongside the General Conference of the IAEA Member States. The powers of the IAEA Board of Governors include considering IAEA financial information, programs, budgets and making recommendations thereon to the General Conference. The Board of Governors reviews applications from applicant countries for membership in the Agency, approves safeguards agreements and publishes IAEA safety standards. It also appoints the IAEA Director General, to be approved by the General Conference.

On the margins of the 67th session of the IAEA General Conference, Oleh Korikov, SNRIU Acting Chairman – Chief State Inspector for Nuclear and Radiation Safety of Ukraine – held a number of bilateral meetings with heads of nuclear regulatory authorities.

In particular, a working meeting of Oleh Korikov and Petteri Tiippana, Chairman of the Radiation and Nuclear Safety Authority of the Republic of Finland (STUK) was held.

First of all, the meeting participants discussed the situation at the occupied Zaporizhzhia NPP. Oleh Korikov noted that the state of nuclear and radiation safety significantly degraded. He pointed out the following key factors that led to this degradation: illegitimate, unpredictable personnel brought by the russian occupants are present at ZNPP; ZNPP has been turned into a military base (military equipment, explosives, weapons are stored, various parts of the industrial site are mined); decisions of the Ukrainian regulatory body are not implemented; occupants have made illegal, unlawful modifications in the design of nuclear facilities; emergency preparedness and response system is degrading; there is no proper reliable connection to the energy system; there is no proper routine maintenance of equipment important to safety; reliable water supply source for the Zaporizhzhia NPP – Kakhovka Reservoir – has been lost; automated radiation monitoring system has been blocked by the invaders.

The meeting participants also discussed the prospects for cooperation between STUK, SNRIU and SSTC NRS within the FURN project aimed at strengthening the supervisory, monitoring and regulatory capabilities of Ukraine in order to overcome the negative consequences of russian military aggression for the Ukrainian nuclear industry.

Oleh Korikov also informed his colleague about the start of trial operation of new Westinghouse nuclear fuel for VVER-440 reactors.

At the meeting with Rumina Velshi, President of the Canadian Nuclear Safety Commission, it was agreed to start cooperation in accordance with the Memorandum of Cooperation between the two nuclear regulatory authorities signed in Kyiv in August 2023. The key areas for cooperation are pre-licensing reviews of nuclear facilities, restoring safe operation of nuclear facilities, remediation of former uranium mining sites and geological disposal of radioactive waste.

Oleh Korikov discussed the Norwegian Nansen Support Program for Ukraine with Per Strand, Director General of the Norwegian Radiation and Nuclear Safety Authority, in terms of assistance to the regulatory authority and implementation of existing bilateral projects.

On 28 September 2023, the State Nuclear Regulatory Inspectorate of Ukraine and the Office for Nuclear Regulation of the United Kingdom of Great Britain and Northern Ireland signed an Arrangement for the Exchange of Information and Cooperation on Safe Regulation of Peaceful Use of Nuclear Energy. According to the arrangement, the parties will cooperate through mutual assistance in the training of scientific and technical personnel; personnel exchange (for information exchange or training on technical regulation issues); establishment of joint working groups to implement specific nuclear safety cooperation measures and related studies; and information exchange. The parties may determine other terms of cooperation by mutual agreement.

In addition, Oleh Korikov met with IAEA Deputy Directors General Lydie Evrard and Massimo Aparo. At the meetings, they discussed the issues of permanent missions to Ukrainian NPPs, ZNPP safety and IAEA safeguards in Ukraine.

On the margins of the General Conference, the SNRIU organized the Side Event "Nuclear Safety, Security and Safeguards in Ukraine: Nuclear and Radiological Risks and Threats, Regulatory Challenges and Lessons Learned and the implementation of the Safeguard Agreement between Ukraine and the IAEA.

Presentations at the event were made by SNRIU Acting Chairman Oleh Korikov, President of Energoatom Petro Kotin, member of the Ukrainian delegation Natalia Rybalka, Director for Nuclear Energy in the Directorate General for Energy of the European Commission Jan Panek, and representative of the IAEA Department of Nuclear Safety and Security Juraj Rovny.

The event organized by the Ukrainian delegation was joined by Jan Panek, Director for Nuclear Energy in the Directorate General for Energy of the European Commission, Rumina Velshi, President of the Canadian Nuclear Safety Commission (CNSC), Mark Foy, Chair of the Office for Nuclear Regulation (ONR) and Chief Nuclear Inspector of Great Britain, Christopher T. Henson, Chairman of the United States Nuclear Regulatory Commission (US NRC), Per Strand, Director General of the Norwegian Radiation and Nuclear Safety Authority (DSA), and Juraj Rovny, representative of the IAEA Department of Nuclear Safety and Security.

Oleh Korikov emphasized that nuclear and radiation safety at ZNPP had seriously degraded under the occupation: Europe's largest nuclear power plant turned from the electricity producer into a consumer; the NPP has lost its reliable water supply source – Kakhovka Reservoir (destroyed as a result of blowing up the Kakhovka HPP dam by the russian military); destruction of physical barriers on the path of radiation spread into the environment is continued (due to the lack of proper and professional equipment maintenance); the NPP is militarized, mined, military equipment and weapons are stored; the invaders have stopped transmitting data from the automated radiation monitoring system at ZNPP (which complicates responding to a possible radiation accident at ZNPP and deprives Ukraine of the opportunity to meet the conditions of the International Convention on Early Notification of a Nuclear Accident).

He also recalled that during the full-scale invasion by the russian federation, a number of other Ukrainian enterprises suffered hazardous effects of war (shelling): RADON Association, KIPT Neutron Source, seizure of the Lyptsi premises of the Institute of Metrology and others. Russian cruise missiles were repeatedly observed at a hazardous distance from nuclear power plants located on the territory controlled by the Ukrainian government, high-voltage power lines connecting the Zaporizhzhia NPP with the Ukrainian energy system were repeatedly damaged as a result of shelling, energy infrastructure facilities were also damaged, which affected the operation of Ukrainian NPPs.

Natalia Rybalka, Director of the SNRIU Radiation Technology and Radioactive Waste Management Safety Directorate – Deputy Chief State Inspector for Nuclear and Radiation Safety of Ukraine – informed international colleagues about the consequences of Chornobyl Exclusion Zone occupation by the russian troops (end of February-March 2022).

In addition, the SNRIU Acting Chairman took part in closed meetings of the International Nuclear Regulators Association (INRA) and the Western European Nuclear Regulators Association (WENRA).

On 25 August 2023, a meeting of the Safeguards Implementation Review Group (SIRG) was held at the SNRIU premises. This year, the IAEA delegation was headed by Deputy Director General and Head of the Department of Safeguards Mr. Massimo Aparo, and the meeting was also attended by inspectors from the Division of Operations C of the IAEA Department of Safeguards.

Ukraine's working group was headed by the Acting Chairman, Chief State Inspector for Nuclear and Radiation Safety of Ukraine, Oleh Korikov. Representatives of the SNRIU, Ministry of Energy, Ministry of Foreign Affairs, Energoatom, Chornobyl NPP, Atomremontservis, and KIPT also participated.

Organization for Economic Cooperation and Development / Nuclear Energy Agency (OECD/NEA)

In 2023, the SNRIU started active cooperation with the Organization for Economic Cooperation and Development/

Nuclear Energy Agency (OECD/NEA). The cooperation was arranged through the Cabinet of Ministers of Ukraine as an official contact center, and in pursuance of the following regulatory documents:

– Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Draft Letter of the Government of Ukraine to the Nuclear Energy Agency of the Organization for Economic Cooperation and Development on the Participation in the Agency's Bodies as an Invited Party";

– Memorandum of Understanding between the Government of Ukraine and the Organization for Economic Cooperation and Development on Deepening Cooperation and Programs of the Organization for Economic Cooperation and Development for Ukrainian Cabinet of Ministers;

– Resolution of the Cabinet of Ministers of Ukraine "Some Issues of Cooperation between the Cabinet of Ministers of Ukraine and the Organization for Economic Cooperation and Development in the Context of the Dialogue on Entering the Organization".

Експерти Держатомрегулювання брали SNRIU experts participated in online meetings of NEA committees and working groups as reviewers, since Ukraine is not a member of the NEA, but only an invited party.

Two SNRIU experts arrived to Boulogne-Billancourt (Republic of France) for a six-month professional training for Ukrainian experts in the area of nuclear safety at the headquarters of the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD).

European Integration

Pursuant to the instruction of Vice Prime Minister for European and Euro-Atlantic Integration O. Stefanyshyna No. 7639/0/1/1-23 dated 14 March 2023 and in accordance with Resolution of the Cabinet of Ministers of Ukraine No. 189 "On Approval of the Procedure for Initial Assessment of the Implementation Status for the EU Acquis" dated 28 February 2023, the SNRIU made a comprehensive comparative analysis between the Ukrainian legislation and EU acquis, namely the EU provisions in Section 15 "Energy", and provided proposals for the comparative analysis report.

Bilateral Cooperation

In the framework of cooperation with the U.S. Nuclear Regulatory Commission, project "International Regulatory Training and Support" was implemented in 2023 and preparation of a new bilateral project on technical support to the SNRIU was started.

To intensify cooperation, Oleh Korikov, SNRIU Acting Chairman, Chief State Inspector for Nuclear and Radiation Safety of Ukraine, and Christopher T. Henson, Chairman of the United States Nuclear Regulatory Commission (US NRC), signed a Memorandum of Cooperation in the Area of Nuclear and Radiation Safety.

The Memorandum provides for the continuation and deepening of cooperation, experience exchange and interaction between the regulatory authorities of Ukraine and the United States on the issues of regulation and oversight over safety and security of nuclear facilities and radioactive materials, application of safeguards, and environmental impact of nuclear facilities and radioactive materials.

The Memorandum plans projects of joint programs on a number of important areas with regard to nuclear and radiation safety. In particular, it deals with:

– studying the US practice on safety assessment for NPP sites, in particular deployment of small modular reactors, in order to review and update the relevant regulatory requirements of Ukraine;

– studying the safety of US reactors using advanced technologies that could potentially be applied in Ukraine;

– developing safety assessment guidelines for dismantling of Shelter structures under the New Safe Confinement;

– developing a safety assessment methodology for packaging used to transport radioactive materials;

– supporting SNRIU activities in terms of strengthening preparedness and response to emergencies;

– strengthening the SNRIU infrastructure to ensure the performance of regulatory functions under martial law;

– modernizing the accounting system for radiation sources;

– studying the experience of US NRC regulatory activities in decommissioning of uranium mining and processing plants.

In March, at the invitation of the US NRC, the SNRIU delegation participated in the regular annual Information Conference.

The cooperation project with the U.S. Department of Energy «to improve the security of radiation sources used in Ukraine and cooperation with the U.S. National Nuclear Security Administration (DOE/NNSA) continued. In the framework of the project, communication and channels for requesting assistance in case of an accident at a nuclear power plant or nuclear detonation were tested, results from atmospheric transfer modeling and forecast assessments performed for conditional events using JRODOS in Ukraine, NARAC tools in the USA (in January, February, November jointly with Ukrainian Hydrometeorological Center, SSTC NRS, and Energoatom) and the IXP information exchange platform were compared; humanitarian assistance was received (backup satellite communication systems, computer equipment for the IEC, backup power supply sources for the SSTC NRS and SNRIU); working meetings were held, etc.

About 30 bilateral cooperation projects were implemented in collaboration with the Norwegian Radiation and Nuclear Safety Authority (DSA).

The SNRIU delegation took part in international workshop "Radiological Protection during Armed Conflict: Strengthening the Capability of the Regulatory Body and Operators", which was organized by the Norwegian Radiation and Nuclear Safety Authority (DSA) and Nuclear Energy Agency (NEA) in Oslo (Kingdom of Norway).

During the workshop, Oleh Korikov, Head of the SNRIU delegation, SNRIU Acting Chairman, Chief State Inspector for Nuclear and Radiation Safety of Ukraine, informed about the state of nuclear and radiation safety and security in Ukraine and fulfillment of nonproliferation guarantees by Ukraine under martial law.

He told in detail about the violation of safety principles and requirements at the Zaporizhzhia NPP occupied by russia, main risks and threats to nuclear and radiation safety at the ZNPP and at other nuclear installations and facilities for nuclear energy use in Ukraine located in the de-occupied territories and in the territories temporarily beyond the control of Ukraine.

In 2023, the State Nuclear Regulatory Inspectorate carried out bilateral cooperation with the Radiation and Nuclear Safety Authority of Finland (STUK). During the year, pursuant to the Memorandum of Understanding between the State Nuclear Regulatory Inspectorate of Ukraine and the Radiation and Nuclear Safety Authority of Finland (STUK) for Cooperation and Information Exchange in the Field of Nuclear and Radiation Safety, experts of the regulatory bodies agreed the provisions of the FURN project to prepare it for signing and further implementation.

Traditionally, the Swedish Radiation Safety Authority (SSM) remains a reliable partner for the SNRIU. Cooperation is implemented under the Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and the Swedish Radiation Safety Authority on Nuclear and Radiation Safety Cooperation.

The following areas were implemented:

– information support of the SNRIU, development and filling of the independent web resource on nuclear safety, radiation protection and non-proliferation of nuclear weapons – www.Uatom.org;

– technical support of the SNRIU for keeping the nuclear material accounting database (STAR).

Antivirus software was purchased for 2024-2025 under the support of the Swedish Radiation Safety Authority.

In 2023, the SNRIU started cooperation with the Canadian Nuclear Safety Commission. The official start of such cooperation was the visit of President of the Canadian Nuclear Safety Commission Rumina Velshi to Ukraine.

The main purpose of the visit was to show support for Ukraine and to sign a Memorandum of Understanding for Cooperation and Information Exchange on Nuclear Regulation between the State Nuclear Regulatory Inspectorate of Ukraine and the Canadian Nuclear Safety Commission.

During the working meeting held after signing the Memorandum, the parties discussed a number of promising areas for cooperation in which the Canadian regulator has considerable experience.

Cooperation in the area of pre-licensing safety review of new nuclear facility designs (small modular reactors) is among the priorities. The second important area will be the issue of regulatory activities on decommissioning of uranium plants.

In addition, Ukrainian and Canadian regulators will cooperate on the issues of restoring safe operation of the temporarily occupied Zaporizhzhia NPP and other nuclear and radiological hazardous facilities affected by the war, as well as on improving regulatory activities on radioactive waste management.

In the framework of cooperation with the National Atomic Energy Agency of the Republic of Poland, regular meetings were held between the heads of agencies, both face-to-face and in online format.

Coordination of Assistance to Ukraine through RANET

Протягом 2023 продовжувалась poln 2023, cooperation continued to follow the agreements reached during the meeting of IAEA Director General Rafael Mariano Grossi with heads of the SNRIU, Ministry of Energy of Ukraine and Energoatom in March 2022 and set forth in joint document "Assistance to Ukraine on Nuclear and Radiation Safety, Nuclear Security and Safeguards" and develop a list of technical assistance needs in the form of equipment, missions and expert support, including those directly at sites and facilities, provision of equipment and spare parts for nuclear facilities, radioactive waste management facilities and facilities using radiation sources, with the purpose of their control, inspection and restoration of safe operation.

Requests for international assistance in accordance with the IAEA Statute and Article 2 of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency were prepared and sent from Ukraine to the IAEA using the IAEA Response and Assistance Network (RANET). This is mainly equipment for the safety needs of nuclear facilities, radioactive waste management facilities, uranium plants, other radiation sources, as well as radiation monitoring devices and protective equipment to protect first responders in case of emergencies. This list was supplemented periodically in accordance with updates of the needs and official requests from SESU, Ministry of Health, SESU UkrHMC, Chornobyl NPP, SAUEZM, RADON Association, USIE IZOTOP, Energoatom and its separate entities.

At the initiative of IAEA Director General Rafael Mariano Grossi, expressed during a conversation with President of Ukraine Volodymyr Zelenskyy on 26 April 2023, a new IAEA program on medical support for Ukrainian NPP personnel was launched.

In June and November, experts of the IAEA Medical Assistance and Coordinator NS Missions visited Ukraine. The needs in medicines and medical equipment for medical institutions of Energoatom separate subdivisions, Chornobyl NPP and NPP satellite towns were summarized.

From 25 to 31 July 2023, the IAEA Support and Assistance Mission on the Safety and Security of Radioactive Sources in Ukraine (ISAMRAD) was held in Ukraine for the first time. It was attended by representatives of the SNRIU, IAEA and enterprises whose activities are related to the use of radiation sources and management of radioactive waste in the form of spent radiation sources.

During the week, IAEA experts visited a number of Ukrainian enterprises, in particular, the RADON Association, National Cancer Institute, USIE Izotop, and Institute of Metrology, talked to the management and personnel of the enterprises and had an opportunity to make sure that all the mentioned enterprises were affected by the war: from the risks and threats of shelling by the occupants to the disruption of logistics chains.

Upon the mission, IAEA experts identified technical assistance for each of the enterprises visited.

In 2023, humanitarian assistance was received from the USA, Canada and other countries.

The SNRIU continues to conduct organizational and advisory activities on the provision of humanitarian assistance to Ukraine in accordance with the changing needs, to ensure communication with the IAEA coordinator, responsible experts of the State Emergency Service, UkrHMC, Ministry of Health, SAUEZM and other organizations.

Detailed information on humanitarian assistance provided to the SNRIU is presented in Table 11.

Photos 27, 28. Participants of the final meeting on the IAEA mission (ISAMRAD)

XII. COMMUNICATION AND INTERACTION WITH MASS MEDIA

In 2023, a number of important issues related to nuclear and radiation safety in Ukraine were presented to the public through electronic consultations.

In particular:

– draft regulation "On Amendment of Certain Regulations on Radioactive Waste Management";

– draft regulation "Requirements for the Structure and Content of Safety Analysis Reports on Packaging Design";

– draft regulation "Procedure for Issuing Certificates for the Safe Transport of Radioactive Materials";

– draft regulation "Requirements for Management System for the Safe Transport of Radioactive Materials";

– draft Cabinet Resolution "On Amendment of the Cabinet Resolutions No. 440 dated 6 May 2001 and No. 591 dated 1 June 2011";

– draft Cabinet Resolution "On Amendment of the Cabinet Resolution No. 1382 dated 5 December 2007".

In 2023, the SNRIU Board convened six meetings. The SNRIU Board discussed the following topics:

– effectiveness of operating experience feedback (results from investigations of NPP operational events and calculation of safety performance indicators for 2022 and the first half of 2023);

– status of justifications for further operation of Pivdennoukrainsk NPP Unit 1 in the long-term operation period;

– Provisions for Pre-licensing Review of Nuclear Facility's Design;

– findings from state nuclear and radiation safety review of the Report on Safety Review of the Shelter Confining Structure with justification of its further operation until 31 October 2029 at the level of safety not lower than that achieved after the completion of emergency stabilization measures;

– implementation of the financial plan of the State Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety" based on the results of activities in 2022;

– results of activities on regulation of nuclear and radiation safety in 2022 and priority areas for 2023;

– status of justification for further operation of the Nuclear Research Institute, National Academy of Sciences of Ukraine, in the long-term operation period; status of physical protection systems in the Exclusion Zone.

Interaction with Mass Media

Active interaction with the mass media on relevant issues of nuclear and radiation safety in Ukraine was ensured in 2023.

Photos 29, 30. SNRIU Board Meeting

Oleh Korikov, SNRIU Chairman – Chief State Inspector for Nuclear and Radiation Safety of Ukraine – participated in more than 30 live broadcasts of TV channels: My-Ukraina, Rada, Suspilne, Freedom, ICTV, Espreso.tv, Kyiv-24, Inter, ČT24 (Czech Republic).

Interviews and comments were provided for Radio Svoboda, Radio NV, YouTube Project Pryazovia News, Internet publication of TSN.ua, LIGA.net, AFP (Poland), Der Spiegel (Germany), Diplomatic Courier (USA), The I (Great Britain), AZ.TV (Azerbaijan).

An interview of more than an hour was made for the project of a documentary created by Ukrainian documentalists together with the German-French ARTE media group. The documentary aims at familiarization of the European audience with the facts of nuclear terrorism of russia in Ukraine.

Both in 2022 and 2023, the main interest of the mass media concerned the situation at Zaporizhzhia NPP occupied by russia and those threats that arise to nuclear and radiation safety as a result of the occupation. The peak of media interest was in June, as well as the most requests for comments and interviews. This was caused by the russian occupiers blowing up the Kakhovka HPP, which led to the destruction of the Kakhovka water reservoir as a reliable source of water supply to Zaporizhzhia NPP.

Google trends confirm such conclusions.

The priority issues for the mass media in 2023 were as follows:

– nuclear and radiation safety at the Zaporizhzhia NPP occupied by russian invaders;

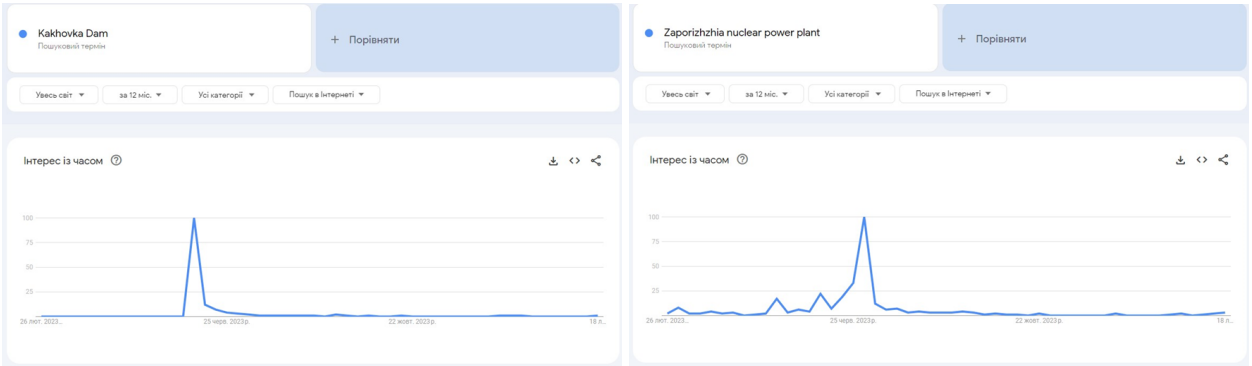
Photo 31. Participation of the Chairman in the United News telethon

Photo 32. Participation in interview

– cooperation with the IAEA and IAEA permanent missions at Ukrainian NPPs;

– restoration of regulatory oversight of facilities in the Chornobyl Exclusion Zone for management of radioactive waste, radiation sources and spent nuclear fuel;

– regulatory, oversight, authorizing activities of the SNRIU.



Figures 6, 7. Demonstration of search statistics

Photo 33. Participation of Oleh Korikov in a press briefing at the Ukraine-Ukrinform Media Center

Seven press briefings were held in the Media Center Ukraine-Ukrinform for proper informing of the media and society about the state of nuclear and radiation safety in Ukraine.

Important and relevant information on the state of nuclear and radiation safety in Ukraine was published on the official website of the SNRIU (https://snriu.gov.ua/) and on Facebook and Telegram social media pages. More than 750 news were published in total.

ANNEXES

Table 1

Number of SNRIU Authorizing Procedures in 2023

Type of authorizing document / activity	Number
Licenses for activities with the use of radiation sources (territorial bodies)	103
Declarations registered for activities with the use of radiation sources, namely: receipt (purchase), transfer (sale), storage of X-ray diagnostic sources	581
Licenses for activities on radioactive material transport	2
Licenses for NPP personnel for direct NPP reactor control	16
Licenses for officials of the operating organization whose duties include organizational and administrative functions related to nuclear and radiation safety	9
Individual permits for the operating organization to perform activities or operations at specific life stages of a nuclear facility	28
Individual permits for the operating organization for the startup of a nuclear facility after scheduled refueling outage	9
Permits for international shipment of radioactive materials (issued and amended)	36
Permits for land and water use in the control areas of nuclear facilities, radioactive waste management facilities, uranium plants	4
Certificates of approval for special conditions of radioactive material transport	8
Certificates of approval for packaging design for radioactive material transport	5
Total licenses issued	130
Amendments made to valid licenses	1176
Licenses cancelled	110

Table 2

Number of Radiation Sources Used in Regions Controlled by Territorial Nuclear and Radiation Safety Inspectorates

Inspectorate	Total number of registered sources	Including	
		Sealed radionuclide sources	Non-radionuclide sources
Northern	6976	1760	5216
Central	2961	1077	1884
South-Eastern	4530	1501	3029
Eastern	4217	1483	2734
North-Western	2055	456	1599
Southern	3466	1631	1835
Western	2716	340	2376
Total	**26921**	**8248**	**18673**

Table 3

Number of Licensees by Applications of Radiation Sources for Each Territorial Nuclear and Radiation Safety Inspectorate in 2023

Inspectorate	Total number			Number of licensees in medicine	Number of licensees in industry	Licensees performing maintenance
	number of entities	number of licensees	number of procedures in 2023			
Central	476	247	129	197	50	19
North-Western	540	259	154	222	19	18
South-Eastern	863	461	54	322	139	22
Eastern	661	409	155	301	108	39
Northern	1087	699	407	369	330	163
Southern	457	344	101	289	55	16
Western	679	407	242	326	50	27
Chornobyl Exclusion Zone Inspectorate	67	67	34	56	11	8
Total	**4830**	**2893**	**1247**	**2082**	**751**	**304**

Table 4

Number of Nuclear Entities Using Radiation Sources Not Released from Regulatory Control by Regions of Ukraine at the end of 2023

Part, region	Total number of radiation source owners	Number of radionuclide source owners	Number of non-radionuclide source owners	Number of owners with both radionuclide and non-radionuclide sources
Northern part of Ukraine				
Kyiv	462	42	445	25
Kyiv region	212	35	188	11
Vinnytsia region	160	5	157	2
Zhytomyr region	125	16	113	4
Chernihiv region	80	5	78	3
Cherkasy region	115	6	113	4
Total	**1154**	**109**	**1094**	**49**
Eastern part of Ukraine				
Kharkiv region	328	59	310	41
Poltava region	148	22	137	11
Sumy region	196	12	191	7
Total	**661**	**93**	**627**	**59**
Central part of Ukraine				
Dnipropetrovsk region	402	50	368	24
Kirovohrad region	75	6	73	4
Total	**476**	**56**	**448**	**28**
South-eastern part of Ukraine				
Donetsk region	458	54	425	21
Zaporizhzhia region	195	16	189	10
Luhansk region	210	24	196	10
Total	**863**	**94**	**810**	**41**
North-western part of Ukraine				
Volyn region	111	9	104	2
Rivne region	142	6	139	3
Ternopil region	127	3	126	2
Khmelnytsky region	160	9	154	3
Total	**540**	**27**	**523**	**10**

Continuation of Table 4

Part, region	Total number of radiation source owners	Number of radionuclide source owners	Number of non-radionuclide source owners	Number of owners with both radionuclide and non-radionuclide sources
Western part of Ukraine				
Zakarpattia region	99	4	99	4
Ivano-Frankivsk region	214	14	204	4
Lviv region	274	22	265	13
Chernivtsi region	72	6	71	5
Total	**679**	**46**	**659**	**26**
Southern part of Ukraine				
Odesa region	252	36	233	17
Mykolaiv region	95	8	92	5
Kherson region	108	5	106	3
Total	**457**	**49**	**431**	**23**
TOTAL	**4830**	**474**	**4592**	**236**

Note: *the number of owners in a specific part of Ukraine may not coincide with the total number of owners in this region since the same owner may possess radiation sources in different regions of Ukraine*

Table 5

Total Number of Imported Radiation Sources by Individual Radionuclides

No.	Radionuclide	Purpose	Number of radiation sources
1	Ir-192	Gamma therapy	16
2	Na-22	Reference and calibration sources for health care institutions	7
3	Ge-68	Reference and calibration sources for health care institutions	4
	Total	For health care institutions	27
4	Am-241	Radioisotope devices for process control in industry, customs control, etc.	14
5	Co-60	Radioisotope devices for process control	7
6	Cs-137	Radioisotope devices for process control	19
7	Ir-192	For gamma-ray flaw detection at NPPs, ship-building and ship repair facilities, construction, oil and gas production and other enterprises	14
8	Sr-90	For process control	1
9	Pm-147	For process control	1
10	Kr-85	For process control	2
11	Ni-63	For process control	3
12	H-3	Neutron generators	2
13	Radioactive sample solutions	For process control	2
	Total	For industry, customs control, etc.	65

Table 6

Total Number of Unsealed Radiation Sources (Radionuclide Generators and Radiopharmaceuticals) Imported in 2023

No.	Period	Radionuclide	Number	Activity, MBq
1	Quarter I	I-131	383	1 273 820,00
		Sr-89	24	3 600,00
		MIBG		
2	Quarter II	I-131	781	2 781020,00
		Sr-89	43	6 450,00
		MIBG (preparation set)	1	3 700,00
3	Quarter III	I-131	598	2 141540,00
		Sr-89	31	4 650,00
		MIBG (preparation set)	1	3 700,00
4	Quarter IV	I-131	789	2755600
		Sr-89	24	3600
		MIBG (preparation set)	1	3700
TOTAL			**2676**	8 981380,00

Table 7

Major Suppliers of Radiation Sources

No.	Supplier company	Non-radionuclide facilities by purpose	Number
1	Kharvind LLC	X-ray diagnostic systems, C-arm X-ray machines, mammography systems, computer tomography systems	28
2	ALKONT-SERVIS LLC	X-ray diagnostic systems, X-ray diagnostic C-arm systems, computed tomography scanners, mammography systems	9
3	ALSI-CHROM LLC	X-ray diagnostic systems	1
4	ARTEK MEDICAL GROUP LLC	X-ray diagnostic systems, computed tomography scanners, angiography systems, C-arm X-ray systems	66
5	ASKO PHARM LLC	X-ray diagnostic systems	1
6	Astrium LLC	Interventional angiography systems, computed tomography scanners	18
7	BLANKOM LLC	Radiographic and fluoroscopic systems	2
8	WATEK IMPLEMENTATION AND PRODUCTION LLC (WATEK I&P LLC)	Rapiscan X-ray television introscopes	2
9	Geosantris LLC	X-ray emitter units for X-ray therapy units, X-ray therapy and X-ray diagnostic machines	3
10	Griner LLC	X-ray diagnostic systems, fluoroscopy machines	3
11	DELTA-STAR LLC	Computed tomography scanner, X-ray diagnostic systems, digital mammography system, X-ray radiographic system	4
12	Diagnostychni Prylady Scien-tific and Production Company	Industrial X-ray machines, portable X-ray machines	21
13	Ekna Ukraine LLC	X-ray diagnostic system, digital mammography system	2
14	Ekopel Engineering LLC	X-ray diagnostic systems	2
15	Ilatanmed LLC	X-ray diagnostic systems, computed tomography scanners, X-ray diagnostic C-arm systems, panoramic X-ray systems with tomography function	22
16	Inmed Ukraine LLC	Computed tomography scanners, X-ray tubes	12

Continuation of Table 7

No.	Supplier company	Non-radionuclide facilities by purpose	Number
17	Commercial Department of IPST LLC	Dental X-ray machines, X-ray machines	14
18	Ksenko LLC	Mobile X-ray machine, mobile X-ray system, mobile C-arm fluoroscopic system, radiographic system	11
19	Livin LLC	Mobile X-ray machine	1
20	Medgarant LLC	X-ray diagnostic and fluorographic systems, mammography systems, computed tomography scanners, X-ray densitometers	94
21	Medradiophysics Plus LLC	X-ray diagnostic C-arm system, X-ray diagnostic and fluoroscopic system, computed tomography scanner, digital mammography system, linear medical electron accelerators	8
22	Med Solutions LLC	X-ray diagnostic systems, X-ray diagnostic C-arm systems	3
23	Medigran LLC	X-MIND PRIME 3D X-ray system with orthopantomography function, mobile fluoroscopy/radiography system, radiography system	9
24	Mediprime LLC	Mammography systems, X-ray diagnostic systems	17
25	New Medical Group LLC	Mobile radiography and fluoroscopy machine	1
26	PRANTEX LLC	X-ray diagnostic systems, X-ray diagnostic C-arm systems	41
27	Protech Solutions Ukraine LLC	Computed tomography scanners, linear accelerators, X-ray diagnostic systems	46
28	Salius LLC 30176442	X-ray diagnostic systems	3
29	Scan Systems LLC	Rapiscan	9
30	SOYUZ MED Expert LLC	X-ray diagnostic system, computed tomography scanner	2
31	SOYUZ MEDTEH LLC	X-ray diagnostic systems, computed tomography scanners	6
32	Siemens Healthineers LLC	Computed tomography scanners, X-ray diagnostic systems, mammography systems	51
33	TOMOTEK LLC	Computed tomography scanners	1
34	Trading House Elite Advice LLC	X-ray diagnostic systems, mammography systems	11
35	UKRMEDEXPERT LLC	X-ray systems, angiography systems, mammography systems	8

Continuation of Table 7

No.	Supplier company	Non-radionuclide facilities by purpose	Number
36	UKR MEDSERVIS LLC	Mobile X-ray systems, computed tomography scanners	4
37	Folgat LLC	ThreatScan LS-1	1
38	Volkhin Roman Hennadiiovych Individual Enterpreneur	X-ray diagnostic system	2
39	Kyseliov Yurii Vasiliovych Individual Enterpreneur	X-ray pantomographic systems with 3D tomography	2
40	FORAMED LLC	Mobile digital radiographic systems, computed tomography scanners	13
41	Zimmer MedizinSysteme Ukraine LLC	X-ray diagnostic systems, mammography systems	5
42	Ivodent LLC	Dental X-ray machines	10
45	Received directly from producer	Mobile digital radiographic systems, computed tomography scanners, dental X-ray machines, etc.	52

Table 8

Producers of Radiation Sources in Ukraine in 2023

Producer	Type of non-radionuclide facilities	Produced (pcs.)	Including:	
			for Ukraine	exported abroad
Kvant X-Ray Equipment Factory LLC	INDIagraf-02, KRD50 X-ray diagnostic systems in modification of INDIascor-01, INDIascan KRD50	10	10	-
Elvatekh LLC	SER-01 (ElvaX JL series) and SER-02 (ElvaX series) X-ray energy spectrometers	468	36	432
Institute of Analytical Monitoring Methods LLC	EXPERT 4L	5	5	-
Teleoptic LLC	KRDTs-04-Alfa	11	11	-
KRAS Scientific and Production Company LLC	ASPEKT	1	1	
Total		495	63	432

Table 9

Dynamics in Average Annual Doses for Medical Personnel by Applications of Radiation Sources for 2019-2023

Medical applications of radiation sources and individual occupational groups	Average doses, mSv				
	2019	2020	2021	2022	2023
Contact therapy with sealed sources *(group as a whole)*	0,59	0,56	0,62	0,58	0,91
- holders of radioactive substances	***1,25***	***2,35***	***1,80***	***1,84***	***2,65***
- radiomanipulation nurses	***1,13***	***1,14***	***1,16***	***0,76***	***1,60***
Remote radiation therapy	0,47	0,52	0,52	0,50	0,50
Radionuclide therapy and diagnostics (department of nuclear medicine)	0,67	0,75	0,67	0,64	0,73
- nurses involved in packing of radiopharmaceuticals	***1,29***	***1,35***	***1,13***	***1,18***	***1,51***
X-ray diagnostics	0,48	0,48	0,49	0,46	0,51
Interventional radiology	1,00	0,85	0,85	0,76	0,93
- surgeons, cardiologists, urologists, anesthesiologists, endoscopists	***1,08***	***0,89***	***0,98***	***0,82***	***0,89***
Dosimetry and spectrometry	0,44	0,45	0,62	0,52	1,42
X-ray therapy	0,53	0,46	0,44	0,49	0,47

Table 10

Dynamics in Collective Doses for Medical Personnel by Applications of Radiation Sources for 2019-2023

Medical applications of radiation sources	Collective doses, mSv				
	2019	2020	2021	2022	2023
Contact therapy with sealed sources *(group as a whole)*	194,7	173,9	193,7	139,3	158,4
Remote radiation therapy	266,5	290,7	293,0	249,2	248,0
Radionuclide therapy and diagnostics (department of nuclear medicine)	154,8	162,6	140,5	117,6	137,4
X-ray diagnostics	1847,2	1744,0	1813,9	1230,6	1563,2
Interventional radiology	453,0	389,3	422,4	314,9	446,3
Dosimetry and spectrometry	37,1	33,9	45,6	32,00	29,9
X-ray therapy	25,0	20,8	30,8	15,02	13,2

Table 11

Humanitarian Aid Provided to the SNRIU and the State Register of Radiation Sources and Individual Doses in 2023

From the IAEA

No.	Description		Number
1	Cisco Switch – WS-C3850-24P-S		1
2	HP ProLiant DL380P Gen 8 Server		1
3	ThinkVision Flat Panel Monitor: T221-10		4
4	APC Smart UPS P/N SMX3000RMLV2U		1
5.	Ludlum Model 3000 Digital Survey Meter		14
6.	Ludlum Model 42-31H Neutron Detector		14
7.	LMI Lumic Datalog Kit, Model 3000-Series		14
8.	Mobile case for ball neutron counters		14
9.	XEROX B305 Multifunction Pinter		30
10.	Toner Cartridge for XEROX B305 Multifunction Printer		60
11.	Starlink/ Starlink High Performance Terminal		10
12.	Charge for Business 500 Satellite Service Option 1 (12 months), EUR 395 per month per terminal		10
13.	Business 500 Satellite Activation Service Option 1 (one-time charge)		10
14.	DACIA DUSTER 4×4 car, gray color, four-cylinder engine with a displacement of 1461 cubic centimeters, winter tires, tinted windows, manufactured in 2022. The package includes: one fire extinguisher, Webasto heating system, travel kit.	VF1HJD40X70454069 VF1HJD40670454070 VF1HJD40870454071 VF1HJD40270419199 VF1HJD40870454068	5
15	Vehicle tracking system (GPS/GSM)		5
16	Server, Serial Number 8471.49		1
17	Computers with SSD, 8 GB RAM, 250 GB disk, array serial number 8471.41		2
18.	Portable individual dosimeter		20
19.	Additional battery for dosimeters Order No. 11 AG dated 6 March 2023		20

From the USA

No.	Description	Number
1.	ARMAK APJ-33 Diesel Generator	1
2.	Logitech Microphone for Video Conferencing	2
3.	GoalZero Charging Station	2
4.	GoalZero Solar Panel Order No. 35 AG dated 2 July 2023	2
5.	Aver VC520 Pro 2+ Video Conferencing System Full HD 1080p, PTZ rotary, USB 3.1 and IP, 12x optical buzzer, 10 presets	1
6.	USB 3.0 AM-AF extension cable, 10 m, active PowerPlant (CA912858)	1
7.	Logitech Wireless Presenter R400 Remote Control	1
8.	Logitech MeetUp Conference Camera (EMEA Model L960-001102)	2
9.	3.5" 18TB One Touch Desktop External Drive with Hub Seagate (STLC18000402)	3
10.	HP 15s-fq 15.6” laptop, 1920x1080 (FullHD), IPS, Intel Core i5-1235U (3.3 – 4.4 Hz), 16 GB RAM, 512 GB SSD, Intel Iris Xe Graphics, DOS, TPM module, 1.69 kg, black, Installed OS: Win10 + drivers	3
11.	Microsoft Office Professional Plus 2021 BOX	13
12.	FortiToken Mobile Redemption: Electronic License for Two-Factor Authentication, remote access for 260 users	1
13.	Personal computer consisting ofi: - Impression P CPU + Intel Core i5 10400/ASUS H510M-R/DDR4 16GB 3200/SSD GOODRAM 512GB CX400/LP 6108 400W/Win 11 Pro; - Samsung LF27T350FHIXCI monitor; - Logitech mouse and keyboard	10
14.	Canon i-SENSYS MF453dw: A4 Black-and-White Multi-functional Printer (MFP) with Wi-Fi (5161C007BA)	2
15.	Additional Canon 057 Black 3.1K Cartridge (3009C002)	1
16.	Xiaomi Pad 5 6/128GB Cosmic Gray Global Tablet Order No. 23 AG dated 13 May 2023	2
17.	Cobham 6075 INMARSAT Communication Terminal	1
18.	IRIDIUM Extreme 9575 Satellite Phone Set Order No. 3 AG dated 11 January 2023	4

The report on nuclear and radiation safety in Ukraine for 2023 was prepared by the editorial board of the SNRIU under the chairmanship of ***O. Korikov****, including representatives of structural units of the SNRIU (****N. Rybalka, A. Havriuk****,* ***T. Kutuzova, A. Myshkovska, Yu. Novikova, N. Rumezhak, L. Tomko****,* ***O. Fazly, N. Kharchuk, R. Baranovskyi****) and SSTC NRS (****I. Shevchenko****).*

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