REPORT

ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2022



State Nuclear Regulatory Inspectorate of Ukraine

2023

Dear Readers and Colleagues!



In accordance with Article 24 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Statute approved by Resolution No. 363 of the Cabinet of Ministers of Ukraine on 20 August 2014, the State Nuclear Regulatory Inspectorate of Ukraine prepares annual reports on nuclear and radiation safety in Ukraine, as well as reports and reviews on nuclear and radiation safety on the territory of Ukraine, and submits them to the Verkhovna Rada, the President of Ukraine, the Cabinet of Ministers of Ukraine, other state authorities, local self-governments and public organizations in compliance with the procedure established by law.

The Report on Nuclear and Radiation Safety in Ukraine for 2022 provides a comprehensive summary of the joint efforts made by the state regulatory body and organizations involved in the use of nuclear energy. The aim is to sustain the achieved level of safety amid unparalleled challenges to nuclear safety regime, security and nonproliferation safeguards arising from the full-scale military invasion by the russian federation into the territory of sovereign Ukraine. The national system for state regulation of nuclear and radiation safety, developed over the years of Ukraine's independence with due regard of the Chornobyl and Fukushima lessons and strengthened as found by the Integrated Regulatory Review Service (IRRS) mission conducted by the International Atomic Energy Agency (IAEA) to verify compliance with IAEA safety standards, continued to perform its legally defined functions despite the imposition of martial law through Presidential Decree No. 64/2022 at 05:30 on 24 February 2022 in connection with the military aggression of the russian federation against Ukraine.

The nuclear and radiation safety in Ukraine faced unprecedented challenges caused by the brutal and reckless actions of the "great nuclear power", which began its invasion through the Chornobyl Exclusion Zone, seized the Chornobyl NPP and the Zaporizhzhia NPP and, in flagrant violation of the United Nations Charter, principles of international law and safety standards, turned facilities intended for peaceful use of nuclear energy into military bases. This poses a threat to the nuclear energy sector not only in Ukraine but also all civilized countries.

The nuclear and radiation safety in Ukraine today largely depends on the professional actions of personnel at nuclear and radiological facilities, who are at the forefront of responding to unforeseen threats and deserve immense appreciation and respect for their courage and commitment to safety.

Public attention to nuclear and radiation safety in Ukraine requires a responsible attitude of the licensees towards the fulfillment of their obligations established by national legislation and international treaties of Ukraine and towards the continuity of state regulation to ensure that the benefits of using nuclear energy and radiation technologies for peaceful purposes outweigh the associated radiation risks.

To achieve the fundamental safety objective of protecting people and the environment against excessive exposure to ionizing radiation, the SNRIU performs functions of regulating nuclear and radiation safety, with the exception of facilities and activities on temporarily occupied territories. Furthermore, the SNRIU maintains the necessary capabilities to perform tasks related to national remediation plans, including the development of latest nuclear and radiation technologies in energy, medicine, and agricultural and industrial sectors. The key events relating to nuclear and radiation safety in 2022 were as follows:

preparation and presentation of Ukraine's Report at the Seventh Review Meeting of the Contracting Parties under the Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management in June 2022;

preparation of Ukraine's report for the Joint Eighth and Ninth Review Meeting under the Convention on Nuclear Safety;

adoption of a regulatory decision to commission a new nuclear facility, namely the Centralized Spent Fuel Storage Facility for Ukrainian NPPs;

Sincerely Yours Acting Chairman of the SNRIU – Chief State Inspector for Nuclear and Radiation Safety of Ukraine collaboration between Ukraine, international organizations and partner countries to prevent nuclear and radiation accidents in wartime, ensure prompt response to incidents and other emergencies, etc.

These and other important events in the area of nuclear and radiation safety are addressed in more detail in respective sections of the Report offered to your attention.

We appreciate and support the IAEA's efforts in promoting safety measures at Ukrainian nuclear facilities, respecting the sovereignty and territorial integrity of Ukraine. We are grateful to all international partners for their effective assistance in ensuring nuclear and radiation safety amidst the ongoing russian military aggression, we believe in our Victory, and we are steadfastly working towards it through our joint endeavors as the key to safeguarding nuclear and radiation safety in Ukraine and around the world.



Oleh KORIKOV

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LIST OF ABBREVIATIONS

ARMS C(I)SIP	_ _	Automated Radiation Monitoring System Comprehensive (Integrated) Safety Improvement Program for
		Nuclear Power Plants
	_	Chornobyl Exclusion Zone
	-	Chornobyl Nuclear Power Plant
CLISF	-	Centralized Long-Term Storage Facility for Disused Radiation
		Sources Control Production Site
CDME		Centralized Radioactive Waste Management Enterprise
	_	Centralized Nadioactive Waste Management Enterprise
		Dipro Interregional Affiliate
	_	Dry Spent Fuel Storage Facility
FDR	_	Exposure Dose Bate
Energostom	_	National Nuclear Epergy Generating Company "Epergoatom"
ENSDE	_	Engineered Near-Surface Disposal Facility for Low- and
	_	Intermediate-Level Short-Lived Waste
		Furgean Nuclear Safety Regulators Group
FII	_	European Union
ECSE	_	Einal Closure and Safe Enclosure
HERCA	_	Heads of the European Radiological Protection Competent
HENCA		Authorities
нир	_	Hydrometallurgical Plant
	_	International Atomic Energy Agency
	_	Incident and Emergency Center
		Industrial Complex for Solid Padioactive Waste Management
		Industrial Complex for Solid Radioactive Waste Management
	_	Interim Spent Fuel Storage Facility
KPIV		Kharkiy Interregional Affiliate
KhNDD		Khalkiv Interregional Anniate Khallovitsky Nuclear Power Plant
		Lyiv Interregional Affiliate
		Liquid Badioactive Waste Storage Facility
IRTP	_	Liquid Radioactive Waste Treatment Plant
IRW	_	Liquid Radioactive Waste
Neutron Source	_	Nuclear Subcritical Facility "Neutron Source Based on a Subcritical
Neution Source		Assembly Driven by a Linear Electron Accelerator"
NPP	_	Nuclear Power Plant
NRBU-97	_	Radiation Safety Standards of Ukraine
NRR	_	VVR-M Nuclear Research Reactor
NRS	_	Nuclear and Radiation Safety
NSC	_	New Safe Confinement
NSC-Shelter	_	New Safe Confinement and Shelter
OIA	_	Odesa Interregional Affiliate
PNPP	_	Pivdennoukrainsk Nuclear Power Plant
PSRR	_	Periodic Safety Review Report
Radon Association	_	State Specialized Enterprise "Radon Association"
Radwaste	_	Radioactive Waste
RICS	_	Radioactive Waste Interim Confinement Sites in the Exclusion
		Zone
RNPP	_	Rivne Nuclear Power Plant
RS	_	Radiation Source
RWDS	-	Radioactive Waste Disposal Site
RWTP	_	Radioactive Waste Treatment Plant

SAUEZM	_	State Agency of Ukraine on Exclusion Zone Management
SBC	_	Salt-Bitumen Compound
SESU	_	State Emergency Service of Ukraine
SkhidGZK	_	State Enterprise "Skhidnyi Mining and Processing Plant"
SNF	_	Spent Nuclear Fuel
SNRIU	_	State Nuclear Regulatory Inspectorate of Ukraine
SRRF	_	Solid Radioactive Waste Retrieval Facility
SRSF	_	Solid Radioactive Waste Storage Facility
SRTP	_	Solid Radioactive Waste Treatment Plant
SRW	_	Solid Radioactive Waste
SSE	-	State Specialized Enterprise
SSE ChNPP	-	State Specialized Enterprise "Chornobyl NPP"
SSTC NRS	-	State Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety"
UkrHMC	-	Ukrainian Hydrometeorological Center of the State Emergency Service of Ukraine
Vektor	_	Vektor Production Site
VVER	_	Water-Cooled Water-Moderated Power Reactor
WENRA	_	Western European Nuclear Regulators' Association
ZNPP	-	Zaporizhzhia Nuclear Power Plant

INTRODUCTION

In accordance with the Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006), https://www.iaea.org/publications/7592/ fundamental-safety-principles, the fundamental safety objective of protecting people, individually and collectively, and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks.

To ensure the highest standards of safety that can be reasonably achieved, measures shall be taken to:

a) control the radiation exposure of people and the release of radioactive material to the environment;

b) limit the likelihood of events that may leads to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other radiation source;

c) mitigate the consequences of such events if they were to occur.

The fundamental safety objective applies to all facilities and activities and to all lifetime stages, including planning, siting, design, equipment manufacturing, construction, commissioning and operation, as well as decommissioning and closure of facilities, radioactive material transport and radioactive waste management.

The IAEA member states, in cooperation with other international organizations, established ten safety principles to serve as a basis for developing safety requirements and achieving the fundamental safety objective. These safety principles are interconnected and applied in their entirety. The proper application of these principles is a necessary condition for the safety of activities relating to the use of nuclear energy and remains relevant under the martial law.

The seizure of Ukrainian NPPs by russian forces obstructed the implementation of these fundamental principles in the occupation conditions, resulting in the degradation of nuclear and radiation safety and security of the Zaporizhzhia NPP.

Nevertheless, these principles are important for reassessing the capability of the licensees to continue their activities following de-occupation and restoration of state regulation of nuclear and radiation safety on the liberated territories.

Principle 1. Responsibility for safety

The person or organization responsible for any facility or activity that gives rise to radiation risks or for carrying out a programme of actions to reduce radiation exposure has the prime responsibility for safety. Not having an authorization would not exonerate the person or organization responsible for the facility or activity from the responsibility for safety.

Principle 2. Role of government

An effective legal framework for ensuring safety, including an independent regulatory body, shall be established.

Government authorities shall ensure that arrangements are made for preparing programs of actions to reduce radiation risks, including actions in emergencies, for monitoring radioactive releases to the environment, and for disposing radioactive waste. Government authorities shall provide for control over radiation sources for which no other organization has responsibility, such as some natural sources, orphan sources, and radioactive residues from some past facilities and activities.

The regulatory body shall:

have adequate legal authority, technical and managerial competence, and human and financial resources to fulfil its responsibilities;

be effectively independent of the licensee and of any other body, so that it is free from any undue pressure from interested parties;

set up appropriate channels of informing the public and other interested parties and the information media about the safety aspects (including health and environmental aspects) of facilities and activities and about regulatory processes;

consult parties in the vicinity, the public and other interested parties, as appropriate, in respective processes.

The government and regulatory body thus have an important responsibility in developing standards and establishing the regulatory framework for protecting people and the environment against radiation risks. However, the prime responsibility for safety rests with the licensee.

Principle 3. Leadership and management for safety

Safety shall be achieved and maintained by means of an effective management system. The management system shall also ensure the promotion of safety culture, regular assessment of safety performance indicators and application of lessons learned from experience. Safety culture includes: individual and collective commitment to safety on the part of the leadership, the management and personnel at all levels; accountability of organizations and of individuals at all levels for safety; and measures to encourage a questioning and learning attitude with regard to safety.

To prevent human and organizational errors, human factors shall be taken into account and good performance and practices shall be supported.

A facility may only be constructed and commissioned or an activity may only be commenced after it has been demonstrated to the regulatory body that the proposed safety measures are adequate.

Principle 4. Justification of facilities and activities

For facilities and activities to be considered justified, the benefits that they yield shall outweigh the radiation risks associated with them, taking into account all significant consequences from the operation of facilities and the conduct of activities.

Principle 5. Optimization of protection

The optimization of protection requires determining the relative significance of various factors, including: the number of people (workers and the public) who may be exposed to radiation; the likelihood of their incurring exposures; the magnitude and distribution of radiation doses received; radiation risks arising from foreseeable events; economic, social and environmental factors, etc. The optimization of protection also involves using good practices and common sense to avoid radiation risks as far as practical in day-to-day activities.

The resources devoted to safety by the licensee and the application and scope of regulations shall be commensurate with the magnitude of the radiation risks and their amenability to control. The need for regulatory control is determined by the magnitude of radiation risks. Regulatory control may not be needed if this is not warranted by the magnitude of the radiation risks.

Principle 6. Limitation of risks to individuals

Measures for controlling radiation risks shall ensure that no individual bears an unacceptable risk of harm.

Justification and optimization of protection do not in themselves guarantee that no individual bears an unacceptable risk of harm. Consequently, doses and radiation risks shall be controlled within specified limits and supplemented by the optimization of protection.

Principle 7. Protection of present and future generations

Radiation risks may transcend national borders and may persist for long periods of time. The possible consequences of current actions now and in the future shall be taken into account in determining the adequacy of measures to control radiation risks. The generation of radioactive waste shall be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material.

Principle 8. Prevention of accidents

The most harmful consequences arising from the operation facilities and the conduct of activities come from the loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or another source of radiation. Consequently, to ensure that the likelihood of an accident having harmful consequences is extremely low, measures shall be taken to:

prevent the occurrence of failures or abnormal conditions (including breaches of security) that could lead to such a loss of control;

prevent the escalation of any such failures or abnormal conditions if they occur;

prevent the loss of, or the loss of control over, a radioactive source or another source of radiation.

Principle 9. Emergency preparedness and response

The licensee, the employer, the regulatory body and appropriate state bodies shall establish, in advance, arrangements for preparedness and response for a nuclear or radiation emergency at the scene, at local, regional and national levels and, where so agreed between States, at the international level.

When urgent protective actions shall be taken promptly in an emergency, it may be acceptable for emergency workers to receive, on the basis of informed consent, doses that exceed the occupational dose limits normally applied, but only up to a predetermined level.

Principle 10. Protective actions to reduce existing and unregulated radiation risks

Radiation risks may arise in situations other than in facilities and activities that are in compliance with regulatory control.

Such situations concern exposure to natural sources, particularly to radon in dwellings and workplaces, exposure that arises from past activities that were not subject to regulatory control or were subject to less rigorous control and protective actions and remediation measures taken following an uncontrolled release of radionuclides to the environment.

The protective actions are considered justified only if they yield sufficient benefits to outweigh the radiation risks and other detriments associated with their implementation and shall produce the greatest benefit considering their costs.

Ukraine has established a legislative framework and a legal mechanism for ensuring safety in line with these fundamental principles. The State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) is the central executive body that promotes the formation and implementation of state policy for safety in the use of nuclear energy.

The key SNRIU tasks encompass:

state regulation of safety in the use of nuclear energy;

powers of the competent body for the physical protection of nuclear material and nuclear facilities in compliance with the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities; safe transport of radioactive materials in accordance with the regulations of nuclear and radiation safety for radioactive material transport; and emergency notification in accordance with the Convention on Early Notification of a Nuclear Accident. In 2022, the SNRIU ensured the continued performance of its primary tasks despite the imposition of martial law pursuant to the requirements of legislation, international treaties of Ukraine, Decrees of the President of Ukraine and ordinances of the Cabinet of Ministers of Ukraine.

In its activities, the SNRIU is also guided by the documents adopted by international organizations regarding the situation in Ukraine, in particular, Resolution A/RES/ES-11/4 of the UN General Assembly "Territorial integrity of Ukraine: defending the principles of the Charter of the United Nations" (text athttps://bit.ly/3CUzWAb or https://bit.ly/3egZdZj), which reaffirms the commitment to the sovereignty, independence, unity and territorial integrity of Ukraine within its internationally recognized borders, extending to its territorial waters, strongly demands the russian federation to withdraw all its military forces from the territory of Ukraine and includes provisions on:

recognizing the illegality of territorial annexations as a result of the threat or use of force;

recognizing that parts of Ukrainian regions have been under the temporary military control of the russian federation as a result of aggression, in violation of the sovereignty, political independence and territorial integrity of Ukraine;

demanding the russian federation to immediately and unconditionally reverse its decisions related to the status of four regions of Ukraine, as they violate the principles of the United Nations Charter;

emphasizing that any political dialogue and negotiations must take place with respect for the sovereignty and territorial integrity of Ukraine within its internationally recognized borders and in accordance with the principles of the United Nations Charter;

reaffirming the demand for the russian federation to immediately, completely and unconditionally withdraw all its military forces from the territory of Ukraine within its internationally recognized borders.

I. STATE REGULATION OF NUCLEAR AND RADIATION SAFETY

State regulation of safety in the use of nuclear energy encompasses:

establishment of regulatory criteria and requirements that determine conditions for the use of nuclear energy (rule-making);

issue of authorizing documents for the implementation of activities relating to the use of nuclear energy (licensing);

state oversight of compliance with legislation, terms of authorizing documents, standards and rules on nuclear and radiation safety, requirements for physical protection of nuclear facilities, nuclear material, radioactive waste, and other radiation sources, accounting and control of nuclear material and other radiation sources, including enforcement measures (state oversight).

Under the special legal regime of martial law, the system of state regulation for nuclear and radiation safety encountered new challenges:

loss of regulatory control over occupied facilities and territories and need to restore control after their liberation;

need to inspect the integrity of protective barriers to the spread of radionuclides to the environment after enemy attacks and shelling;

preservation and restoration of critical infrastructure for the safe operation of nuclear and other facilities for peaceful use of nuclear energy;

maintenance of emergency preparedness and capabilities to respond in the conditions of military operations;

preservation of the life and health of the personnel who remained at their workplaces and replenishment of human resources necessitated by forced displacement and irreversible losses.

The SNRIU, jointly with the relevant ministries and agencies, intensified efforts to strengthen the physical protection of nuclear facilities, with due regard of the military invasion lessons. The regulation of nuclear and radiation safety under the full-scale military aggression of the russian federation remains a pressing matter, requiring additional analysis and comprehensive review. In 2022, the number of SNRIU employees was 276 (191 state inspectors). The actual number was 190 people (131 state inspectors, including 61 women).

Throughout the year, 45 employees were appointed, including 26 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. 51 employees were dismissed, including 23 state inspectors. 147 experts (83% of the total number of employees) improved their qualifications through various types and formats of training.

Rule-making

The legislation of Ukraine pertaining to nuclear energy safety comprehensively regulates all aspects related to the peaceful use of nuclear energy and the assurance of nuclear and radiation safety. The development and improvement of national nuclear legislation continued even in the period of martial law.

The main results from the implementation of legislative initiatives and rule making efforts to align the national legislation of Ukraine for the safety of nuclear energy with the provisions of EU law (EU acquis) in 2022 are as follows:

Law of Ukraine No. 2758-XX "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, which will be implemented one year after its entry into force and is intended for introducing an institute of radiation protection experts for professional consultation for entities that use nuclear energy, state authorities, and other legal entities and individuals regarding compliance and implementation of legislative requirements for nuclear and radiation safety. The Law establishes basic requirements for persons who intend to become radiation protection experts and identifies the body to recognize the competence of such experts. The introduction of an institute of gualified radiation protection experts will contribute to higher quality and efficiency of radiation protection for personnel and the public in the use of nuclear and radiation technologies for peaceful purposes;

Law of Ukraine No. 2762-IX "On Amendment of the Law of Ukraine on Nuclear Energy Use and Radiation Safety" dated 16 November 2022 entered into force and was implemented. The amendments made to this Law are intended to bring some of its provisions into compliance with EU law, considering the actual application of the Law. The implementation of the Law unifies the terminology of Ukrainian legislation with the terminology of EU legislation; establishes qualification requirements for contractors of entities that intend to perform activities relating to the use of nuclear energy; specifies requirements regarding the obligations of the nuclear facility operator to take all measures to prevent accidents and mitigate their consequences if they occur; complements the SNRIU powers regarding regular assessments of the regulatory framework in the area of nuclear energy and conduct of international peer reviews;

Law of Ukraine No. 2755-IX "On Amendment of Certain Laws of Ukraine for Improvement of Licensing Activities in Nuclear Energy" dated 16 November 2022 entered into force and was implemented. The Law is intended to regulate the issue of authorizations pertaining to the use of nuclear energy in accordance with EU law, particularly, this Law provides for: notification of the state nuclear regulatory body by an organization that intends to carry out an activity before it begins; exclusion of the license renewal procedure; potential application for obtaining a license without review and grounds for making such a decision; change in the review period for license application documents etc.

To implement the Rule-Making Plan of the Verkhovna Rada of Ukraine for 2022, approved by Resolution No. 2036-IX of the Verkhovna Rada of Ukraine on 15 February 2022, with the objective of bringing the legislation for safety of nuclear energy into compliance with specific provisions of EU law pursuant to the obligations of Ukraine under the Association Agreement in the area of nuclear energy, the following draft laws were developed and agreed with the interested bodies:

"On Amendment of Some Laws of Ukraine Regarding Human Protection against Ionizing Radiation" (registered in the Verkhovna Rada of Ukraine under No. 8223 dated 23 November 2022). The draft Law provides for introducing a system of radiation protection for personnel and the public in exposure situations, taking into account EU legal provisions and experience in state regulation of nuclear and radiation safety;

"On the National Nuclear Regulatory Commission" to legislatively establish a special status of the state nuclear regulatory body as a central executive body to increase the effectiveness of its activities and independence in making regulatory decisions, considering the EU law provisions, IAEA documents and experience in state regulation of nuclear and radiation safety in Ukraine.

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 performing activities in the area of nuclear energy.

In 2022, in the fulfillment of individual orders and on its own initiatives, the SNRIU developed and the Cabinet of Ministers of Ukraine agreed:

Cabinet Resolution No. 847 dated 29 July 2022 to amend the Statute of the State Nuclear Regulatory Inspectorate of Ukraine and supplement the SNRIU powers with provisions regarding the application of enforcement measures to the licensees in accordance with the Law of Ukraine "On Sanctions", such as the cancellation or suspension of licenses for activities in the area of nuclear energy;

Cabinet Resolution No. 956 dated 27 August to recognize the SNRIU as an authorized state body responsible for activities on determining the design-basis threat to nuclear facilities, nuclear material, radioactive waste and other radiation sources in Ukraine. The implementation of this function is aimed at strengthening the national safety and security of Ukraine and at increasing the readiness to respond to and prevent potential threats of sabotage against nuclear facilities and radioactive material with the risk of radiation consequences, which is especially relevant in today's situation;

Cabinet Resolution No. 1254 dated 8 November 2022 to amend the Procedure for Decommissioning Main Oil and Gas Pipelines and Their Processing Products. These amendments are intended to solve issues identified in the implementation of the Procedure, order activities of economic entities in the oil and gas industry, and deregulate economic activities by eliminating the need for economic entities to obtain additional permits.

In the area related to safety of nuclear facilities, the regulation "Requirements for

Nuclear and Radiation Safety for Cyber Protection of Instrumentation and Control System of Nuclear Power Plants" was approved and introduced. This regulatory document establishes nuclear and radiation safety requirements for cyber protection of instrumentation and control systems of nuclear power plants, components (software/hardware systems, engineered automation features) and software of these systems and cyber protection of processes for their development, implementation, operation and upgrade, which is especially relevant in the hybrid war conditions.

The SNRIU order "On Improvement of Regulations Regarding Uranium Ore Mining and Processing" amended the Safety Requirements and Conditions (Licensing Conditions) for Uranium Ore Processing and approved Requirements for the Structure and Content of Safety Analysis Reports for Uranium Ore Mining and Processing.

Licensing

The specifics of authorizing activities in the area of nuclear energy are determined by the Law of Ukraine "On Licensing Activities in Nuclear Energy".

Under the martial law conditions, the Cabinet of Ministers of Ukraine adopted Resolution No. 165 "On Suspension of Periods for Providing Administrative Services and Issuing Authorizing Documents" dated 28 February 2022 and Resolution No. 314 "Some Issues on the Conduct of Economic Activities under Martial Law Conditions" dated 18 March 2022 to suspend the periods for providing administrative services and periods for applying for public services determined by law for the period of martial law and to extend the validity periods for authorizing documents.

The SNRIU did not terminate the review of applications submitted by the licensees for issuing, amending, and extending the validity period for authorizing documents. In 2022, 1373 licenses were issued/amended/ reissued, 31 individual permits were issued to operating organizations, as well as 29 permits for transport of radioactive materials and 14 packaging approval certificates were granted.

To simplify the conduct of activities with radiation sources by public and communal health care institutions and economic entities within the management sphere of the Ministry of Health of Ukraine in the martial law period, the Government amended Cabinet Resolution No. 314 "Some Issues in the Conduct of Economic Activities under the Martial Law Conditions" dated 18 March 2022. The amendments envisage that the entities may acquire the right for activities on the use of radiation sources such as receiving (purchase), transfer (sale), and storage of X-ray diagnostic generating devices under a declaration.

State Oversight and Enforcement

Under the martial law conditions, Cabinet Resolution No. 303 dated 13 March 2022 suspended the implementation of planned measures of state oversight and limited the implementation of unscheduled measures of state oversight (they are permitted only under a threat that affects the rights, legitimate interests, human life and health, environmental protection, national safety and security, and fulfillment of Ukraine's international obligations).

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, taking into account the Government's decisions adopted under martial law, state oversight was exercised by SNRIU inspectors through:

analysis of reported information on nuclear and radiation safety of facilities subject to state oversight and results of the licensees' self-assessment, including, as far as possible, licensees in the war zone and temporarily occupied territories;

issue of mandatory prescriptions and orders in case of detecting violations of nuclear and radiation safety requirements upon analysis of information on nuclear and radiation safety of facilities subject to state oversight;

application of enforcement measures envisaged by law to legal entities and individuals if they violate nuclear and radiation safety requirements and/or fail to comply with the requirements of prescriptions and orders.

Upon state oversight measures, 12 binding prescriptions were issued to eliminate incompliance with nuclear and radiation safety requirements.

State inspectors brought 12 individuals to administrative liability and collected fines to the state budget of Ukraine in the amount of 8670 UAH. Financial sanctions were applied to 11 economic entities and fines were collected to the state budget of Ukraine in the amount of 305,500 UAH in accordance with Article 17¹ of the Law of Ukraine "On Licensing Activities in Nuclear Energy".

II. SAFETY OF NUCLEAR FACILITIES

15 NPP Units are operated in Ukraine, of which 13 are VVER-1000 and 2 are VVER-440 with total installed capacity 13 835 MW.

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

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

Military aggression of the russian federation directly affected Energoatom's activities, in particular, implementation of the Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants (C(I)SIP) approved by Resolution No. 1270 of the Cabinet of Ministers of Ukraine dated 7 December 2011 and is implemented in accordance with Energoatom's schedules annually agreed upon by the Ministry of Energy of Ukraine, SNRIU and SESU (regarding the implementation of fire protection measures).

A total of 1,295 measures are planned to be implemented in the framework of the C(I)SIP. 1,083 measures (\sim 83.6%) were completed by the end of 2022, and the respective implementation reports were approved by the SNRIU/SESU.

Force majeure circumstances related to the military aggression of the russian federation against Ukraine, damage to industrial enterprises and critical infrastructure, disruption of logistics, reduction in the number of personnel of design, construction, and pre-commissioning organizations due to mobilization and forced evacuation led to the impossibility to fully fulfill obligations under concluded contracts for the supply of necessary equipment, materials, products and other goods, and, as a result, to impossibility to perform a number of works and provide services within the scheduled terms. Therefore, the operating organization has reduced the scope of measures implementation in the framework of the C(I)SIP, and had to postpone the deadlines for their implementation.

The Annual Analytical Report on Nuclear and Radiation Safety at Energoatom NPPs (Analytical Report) comprises summarized data on radiation safety and radiation protection indicators at Energoatom NPPs. They include information on the gas-aerosol releases and water discharges of radioactive substances into the environment, radiation doses of NPPs personnel and staff of third-party organizations, results of monitoring the radioactivity of the process environments, radiation status of environmental compartments in the NPP location areas, as well as information on measures implemented at NPPs to increase the radiation safety level and ensure radiation protection of personnel and the public during the reporting period.

The Analytical Report was developed based on the annual reports on the state of radiation safety and radiation protection at the Rivne, Pivdennoukrainsk and Khmelnytsky NPPs for 2022. The information on the main radiation parameters of the ZNPP is given for January-September 2022. For the fourth quarter of 2022, no official information was received from the ZNPP by the Energoatom Directorate.

The indicators of the radiation safety state are presented in accordance with the requirements of the Energoatom standards: SOU NAEK 185:2019 "Radiation Safety Assurance. Rules for Developing Radiation Safety Reports at Nuclear Power Plants", SOU NAEK 079:2017 "System for Assessing the Level of Operational Safety and **Technical Condition of Nuclear Power Plants** with Water-Cooled Water-Moderated Power Reactors. General Requirements", as well as SOU NAEK 132:2017 "Methodological Recommendations for the Analysis of Collective Exposure Doses to Personnel during Repair Activities and Maintenance of NPP Equipment".

The Analytical Report is developed by the operator and provided to state bodies in the framework of oversight functions, for conducting a comparative analysis of the radiation parameters of nuclear power plants, informing regulatory authorities, ministries, scientific organizations, experts and the public on the radiation safety state.

The main criterion for assessing the NPP radiation effect are the exposure dose rates and the radiation protection level of personnel and the public.

The following technical means are used to measure individual doses of external exposure of personnel at NPPs:

At the ZNPP: RADOS thermoluminescent dosimetry system with MCP-N, -6, -7 detectors and a set of KDT-02M thermoluminescent dosimeters (DPG-03 dosimeters);

At RNPP: RE-2000 dosimetry system, which includes RE-2000 readers and TLD thermoluminescent dosimeters with DTG-04 (LiF) detectors;

At PNPP and KhNPP: HARSHAW thermoluminescent dosimeters.

DMC-2000S electronic direct-indicating dosimeters manufactured by MGPI (France) and gamma, beta, and neutron radiation dosimeters by HARSHAW are used for operational monitoring of external exposure doses.

Individual monitoring of internal exposure doses was carried out using whole body counters (WBC), which allow determining the activity of radionuclides in the human body with subsequent calculation of their intake amount and the internal exposure dose. In accordance with the methodological instructions developed and agreed with the Ministry of Health of Ukraine, the effective internal exposure dose was calculated at all NPPs.

According to SOU NAEK 025:2013 "Radiation Safety Assurance. Reference Levels of Radiation Parameters at Nuclear Power Plants (Group I Radiation and Health Regulations). Rules for Establishing" set administrative and process (administrative) levels of individual effective radiation doses of NPP personnel and reference levels of annual collective exposure doses for NPP personnel whose individual doses exceed 6 mSv/year (RL6) and 15 mSv/year (RL15).

In 2022, the number of monitored Energoatom's personnel constituted 13,448 (including seconded persons, amounting to 2,046 individuals). In 2022, the total collective exposure dose of the Energoatom's personnel amounted to 5093.52 man-mSv, which is 2838.19 man-mSv less than for the previous year (7931.71 man-mSv).

The average individual exposure doses of NPP personnel in 2022 were 0.188 mSv/person per year at ZNPP, 0.33 mSv/person per year at RNPP, 0.81 mSv/person per year at PNPP and 0.31 mSv/ person per year at KhNPP.

The highest collective personnel dose (825 man-mSv) was received under repair activities at the primary equipment during outage-2022 at power unit 2 PNPP due to leaking fuel assemblies in the reactor core. The silver isotope ^{110m}Ag makes the largest contribution to the dose rate at water purification systems and, as a result, to the collective dose. The isotope is the product of the activation of impurities of chemical reagents used to maintain the water chemistry and the product of corrosion-erosion origin of materials in contacting the coolant, and is the main dose-forming radionuclide during refueling outages.

The highest values of the collective dose: 2225.61 mSv and the average individual dose: 0.810 man-mSv were registered in 2022 at the Pivdennoukrainsk NPP, which is explained by the duration and scope of radiation-hazardous repair and reconstruction activities in the framework of long-term operation of the NPP Units.

At the ZNPP, the collective dose for 9 months of 2022 was 0.78 man-Sv, which is 3.4 times less than in the same period of 2021 (2.63 man-Sv) due to a significant reduction in the scope of the process and repair activities. The number of personnel from third-party organizations seconded to the ZNPP in 2022 also decreased by 5 times (141 persons in 2022 vs. 752 ones in 2021), the collective dose decreased by 100 times (3.8 man-mSv in 2022 against 390 man-mSv in 2021), and the average dose decreased by 19 times (0.027 man-mSv in 2022 against 0.519 man-mSv in 2021).

The level of the annual collective exposure dose of female personnel of reproductive age in Energoatom for the reporting year decreased compared to the previous year and amounted to 29.99 man-mSv (57.28 man-mSv in 2021). The average individual exposure dose of female personnel of reproductive age also decreased in the reporting year and amounted to 0.038 mSv per person per year, which is 10 times less than the average individual exposure dose of all the Energoatom personnel (0.378 man-mSv for the reporting year), and is 1.9% of the limit of additional exposure limitation for women of reproductive age.

The number of NPP personnel who received an annual individual exposure dose of less than 1 mSv was 89.5%. 5.23% of Energoatom's personnel is in the 1 - 2 mSv dose rage, 4.44% is in the 2 - 6 mSv range, 0.55% is in the 6 - 10 mSv range, and 0.3% is in the 10 - 15 mSv range. Not a single person was registered in the reporting year in the range of individual

doses close to the main DL20 dose limit of 15 - 20 mSv.

As in the previous period, the main limit of the individual exposure dose to personnel of Category A (DL20) was not exceeded at any of the Energoatom NPPs in an average of five consecutive years. Indicators of annual collective exposure doses of personnel per Energoatom NPP Unit over the past five years are graphically presented in Figure 1.

There is a trend to decrease the collective exposure dose per power unit. Threeyear average collective exposure dose for one Energoatom NPP Unit for 2020-2022 was 0.47 man-Sv, which corresponds to the level of the average ISOE indicator (0.46 man-Sv per unit).



Figure 1 – Annual collective exposure doses of NPP personnel (including personnel of third-party organizations) and average values per NPP unit for 2018-2022



Figure 2 – Dynamics of average annual (average over three consecutive years) collective exposure doses per Energoatom NPP unit with a trend line for 2013 - 2022



Figure 3 – Annual collective exposure doses of NPP personnel (including personnel of third-party organizations) at Energoatom NPPs for 2013 - 2022

General trends of changes in the absolute values of collective exposure doses of NPP personnel and their contribution to the total annual collective dose for Energoatom over the last ten years of observation are given in Figure 3.

During the reporting year, there were no cases of exceeding the main dose limit (20 mSv/year on average for 5 consecutive years) and the reference levels of annual collective exposure doses of personnel at the NPPs.

Monitoring of internal exposure doses was carried out by direct measurements of the activity of radionuclides in the human body or a critical organ (thyroid gland, lungs) using a human body counter (WBC) based on scintillation and semiconductor detectors, followed by conversion into an effective expected exposure dose.

In 2022, the content of ⁶⁰Co radionuclide of artificial origin above minimally detectable activity (MDA) was registered in 14 people (ZNPP personnel) at the ZNPP. New intakes were registered in 2 employees of the repair personnel in Quarter I 2022, based on the results internal exposure doses were calculated.

In the reporting year, all the measurement results of the radionuclide content in the critical organs of the personnel were below the study levels at the PNPP, RNPP and KhNPP. In 2022, the total number of individuals who underwent biophysical studies WBCs was 12,148.

The indicator of the total collective dose level at Energoatom improved compared to the previous year and amounted to 5.09 man-Sv compared to 7.93 man-Sv in 2021 against the background of a decrease in the indicator of electricity generated by nuclear power plants in the reporting year, which constituted 62.18 billion kWh (86.42 billion kWh in 2021).

The radiation impact of NPPs on personnel during the reporting year was within the limits established by the NRS standards and regulations.

Monitoring of the concentration levels of radioactive aerosols and gases in the air of the working area of the NPP strict access premises was carried out in accordance with the NPP Radiation Monitoring Regulations.

According to the radiation monitoring results, no exceeding of the established administrative and process levels of gamma EDR in the ZNPP working premises of the during Quarters I and II of 2022 was registered.

During 2022, no exceeding of the operational limits and safe operation limits based on the specific activity of the total amount of iodine radionuclides in the primary circuit water was recorded at the Energoatom NPPs.

The effectiveness of radiation protection of Energoatom NPPs is evaluated according to the following radiation safety indicators:

airborne release of radionuclides established for 1000 MW of installed capacity;

water discharge of radionuclides established for 1000 MW of installed capacity;

indices of releases and discharges of radioactive substances into the environment and others. The levels of NPP airborne releases into the atmosphere were determined based on the results of:

continuous monitoring of the radioactivity of inert radioactive gases, long-lived aerosols, iodine radionuclides in the NPP ventilation stacks by automated systems of airborne releases and regular radiation safety monitoring instrumentation;

gamma spectrometric analysis of aerosol samples deposited on filters and taken from the NPP ventilation stacks;

gamma spectrometric analysis of samples of gaseous and aerosol fractions of radioactive iodine taken from the NPP ventilation stacks.

Table 1 – Reference levels and limits of airborne releases of inert radioactive gases, long-lived nuclides and iodine radionuclides from NPPs to the environment

Monitoring parameter		ZNPP	RNPP	PNPP	KhNPP	
IRG,	RL	0,71	0,87	2,0	0,81	
TBq/day	LR	74	61	45	41	
lodine, RL		25,0	44,0	140,0	16,0	
MBq/day	LR	6200	5100	3800	3800	
LLN,	RL	3,9	15,0	4,3	5,9	
MBq/day	LR	770	400	800	690	
¹³⁷ Cs,	RL	55,0	42,0	55,0	80,0	
MBq/month	LR	13688	11254	13400	13687	
¹³⁴ Cs,	RL	63,0	48,0	55,0	85,0	
MBq/month	LR	15513	12775 13400		14296	
⁶⁰ Co,	RL	26,0	35,0	39,0	45,0	
MBq/month	LR	6338	5171	9730	10037	
⁵⁸ Co,	RL	-	-	-	-	
MBq/month	LR	365000	304167	425833	486667	
⁵⁴Mn,	RL	-	-	-	-	
MBq/month	LR	115583	91250	179458	170333	
⁵¹ Cr,	RL	-	-	-	-	
MBq/month	LR	24029167	21291667	25550000	30416667	
^{110m} Ag,	RL	-	-	-	67,0	
MBq/month	LR	19163	14904	15817	15208	
³ H,	RL	3,4 TBq/Quarter	0,44	0,36	0,48	
TBq/month	LR	180 TBq/Quarter	30,4	63,9	60,8	
¹⁴ C,	RL	-	-	-	-	
TBq/month	LR	3,3 TBq/Quarter	0,82	0,7	0,67	

Note. RL – reference levels; LR – limits of airborne releases; IRG – inert radioactive gases; LLN – long-lived nuclides

The percentage distribution of the contribution of each nuclear power plant in 2022 to the total Inert radioactive gases NPPs release at Energoatom compared to the previous year is: ZNPP: 24% (in 2021: 34%), RNPP: 56% (in 2021: 44%), PNPP: 10% (in 2021: 11%), KhNPP: 10% (in 2021: 14%). The largest contribution to the total lnert radioactive gases release at Energoatom NPPs, as in previous years, was the release through ventilation stacks of RNPP Units 1 and 2: 32%. There were no cases of exceeding the reference and permissible levels of gaseous Inert radioactive gases releases into the environment at Energoatom NPPs in the reporting year.

The average daily levels of releases of inert radioactive gases were much lower than the daily release limits established for each NPP, and in percentage correlation (release indices) they amounted to: ZNPP: 0.101%, RNPP: 0.278%, PNPP: 0.067%, KhNPP: 0.075%.

During the reporting year, not a single case of exceeding the reference and permissible levels of airborne releases of longlived radionuclides into the environment was recorded at the NPPs.

During the reporting year, no exceeding of the reference levels and discharge limits of radioactive substances into external water bodies was recorded at Energoatom NPPs.

Table 2 – Reference l	levels and	limits of	⁻ water d	ischarges f	for ref	ference rac	dionuclide	s into NPP
open water bodies in 2	.022, MBq/	'year		-				

Moni para	Monitoring ZNPP parameter			RNPP			PNPP				KhNPP					
137		RL		150			190			120			170			
		LD		88000		69000			15000				21000			
134		RL		220		35				56			240			
		LD		60000			47000				17000			2900	0	
60		RL		370				18			43	}		220		
~C0		LD	1	100000)		44	000			280	00		4000	0	
58		RL		-				-			-			-		
5.00		LD	3.	3400000			380000		620000			1300000				
540.4.0		RL		-		-		_			-					
		LD	3.	200000)	410000			220000			43000	00			
510 -		RL		-		-			-			-				
^{sh} Cr		LD	10	000000	00	45000000			45000000			9000000				
110m A		RL		-		-		-		-		-				
Ag		LD	1	600000)		2500000		100000		180000		00			
90 C #		RL		80		110		67		72						
²⁰ Sr		LD	240000			110000		3500			14000					
31.1		RL	9	9,1E+06		2,5E+06			2,6E+06			8,04E+06				
² H		LD	18	800E+0	06 2100E+06 120E+06		2100E+06		+06	1800E+06						
KhNPP	0,0	23,8	0,0	21,7	21,	,6	21,2	1,6	3,	1	0,0	1,6	18,8	0,0	113,4	

Note. RL – reference levels; LD – limits of water discharges.

Study of the content of radioactive substances in environmental compartments in the NPP location areas: in the open water bodies, in the atmospheric air and soil nearby settlements was carried out by the NPPs. The monitoring scope and methods are set forth in the Radiation Monitoring Regulations agreed with the regulatory authorities according to the established procedure.

The analysis of the content of radionuclides ¹³⁷Cs and ⁹⁰Sr in the NPP open water bodies compared to the "zero background" data demonstrates that these concentrations are values of the same order and can vary due to natural conditions: season, floods, drought, etc.

According to the reports for Quarters I-III, at the ZNPP, maximum concentration of ³H in the SFP water was 220.0 kBq/m³, and maximum concentration of ³H in the water of the Kakhovka reservoir was 16.0 kBq/m³.

In the reporting year, the average specific activity of ³H in the water of the Styr River before the start-up of the RNPP was recorded at the level of 5.0 kBq/m³, after the RNPP: 12.9 kBq/m³.

At the PNPP, the maximum concentration of ³N in the water of the Southern Bug River (after the NPP) was 16.0 kBq/m³, and 207.0 kBq/m³ in the SFP water.

The maximum concentration of ³N in the KhNPP SFP water was 81.5 kBq/m³, and 10.5 kBq/m³ in the water of the Horyn River after the KhNPP.

According to NRBU-97, the permissible concentration of ³H in drinking water is 30,000 kBq/m³.

At all Energoatom NPPs monitoring of atmospheric air contamination by radioactive aerosols was carried out in the control area, in the observation area at a 10 km distance to the control area, in the 10 - 20 km zone from the control area and in populated areas at a distance of more than 20 km from NPPs. Radiation monitoring was carried out by the aspiration method using filter units mounted at radiation monitoring posts. Sampling of aerosols was carried out by pumping air through a filtering cloth. Due to the low content of artificial radionuclides in the samples, the residues of the ashed filters were collected during a month period, and then for a Quarter, followed by their measurement on a gamma ray spectrometer. Radiochemical separation of ⁹⁰Sr (except RNPP) was carried out from samples collected for a Quarter.

In Quarters I-III of 2022, the average annual values of the concentration of radioactive substances in the atmospheric air were registered at the ZNPP at the level of: ¹³⁷Cs from 1.0 μ Bq/m³ to 4.0 μ Bq/m³, ⁹⁰Sr: < 0.1 μ Bq/m³. According to the "zero background" data, the concentrations of radionuclides in the atmospheric air before the start-up of the ZNPP were: ¹³⁷Cs - 2.2±0.7 μ Bq/m³, ⁹⁰Sr: 11.1±5.9 μ Bq/m³.

In the reporting year, the annual average values of the radionuclide ¹³⁷Cs content in the atmospheric air varied from 2.45 μ Bq/m³ to 7.45 μ Bq/m³ at the RNPP. According to the "zero background" data, the concentration of ¹³⁷Cs in the atmospheric air before the start-up of the RNPP was 11.1 - 59.2 μ Bq/m³.

In the reporting year, the content of radioactive substances in the atmospheric air was recorded at the PNPP at the level of: ¹³⁷Cs from 0.51 μ Bq/m³ to 5.0 μ Bq/m³, ⁹⁰Sr from 0.65 μ Bq/m³ to 9.75 μ Bq/m³. The increase in the concentration of ⁹⁰Sr in the atmospheric air compared to the previous year is due to the fact that the measurement of ⁹⁰Sr in the Quarter IV of 2022 was carried out using a radiometer with a higher MDA. According to the "zero background" data, radionuclide concentrations in the atmospheric air before the start-up of the PNPP were: ¹³⁷Cs (2.4 - 3.0) μ Bq/m³, ⁹⁰Sr (0.9 - 3.0) μ Bq/m³.

In the reporting year, the content of radioactive substances in the atmospheric air at the KhNPP varied: ¹³⁷Cs from 0.7 μ Bq/m³ to 2.31 μ Bq/m³, ⁹⁰Sr from 0.05 μ Bq/m³ to 0.35 μ Bq/m³. According to the "zero background" data, the concentrations of radionuclides in the atmospheric air before the KhNPP start-up were: ¹³⁷Cs (2.96 - 4.07) μ Bq/m³, ⁹⁰Sr (6.29 - 7.77) μ Bq/m³.

The radiation state of the atmospheric air in the NPP areas remained at the "zero background" level taking into account the impact of the ChNPP accident consequences.

At certain distances from the NPPs, outside the control areas, the density of soil contamination is higher than in the control areas themselves. Apparently, this situation can be explained by the disturbance (removal, mixing) of the upper soil layer, contaminated after the ChNPP accident as a result of technogenic activity within the control areas.

In 2022, no exceeding of operational limits and safe operation limits based data on the specific activity of the total amount of Table 3 – Contamination density with 137 Cs of the soil surface layer at radiation monitoring posts at different distances from the NPPs, Bq/m²

NPP	"Zero background"	Control area	Control area- 10 km	10-20 km	>
ZNPP	1180	-	-	-	-
RNPP	444 – 5070	715	1540	1990	397
PNPP	1376	251	400	494	255
KhNPP	1180	107	351	266	172

Note. The density of soil contamination is calculated based on a sampling depth of 5 cm.

iodine radionuclides in the primary circuit water, and no exceeding of the permissible and reference levels of iodine radionuclide release into the environment were registered at Energoatom NPPs. The main dose-forming nuclides are ¹³⁷Cs and ⁶⁰Co, the first of which is a fuel fission product, and the second one is the result of the activity of the reactor coolant system (RCS) corrosive materials. These two nuclides were chosen as reference radionuclides, according to which the analysis of the reported information was carried out. These radionuclides are the main components of the NPP Long-lived nuclides airborne releases, and the comparative characteristic of releases by long-lived nuclides for ¹³⁷Cs and ⁶⁰Co is more correct than by the total amount of Long-lived nuclides releases, which is a mixture of radionuclides with different exposure energies. The levels of airborne release of these radionuclides into the environment remain stably low at all NPPs.

Preparation for Long-Term Operation of Pivdennoukrainsk NPP Unit 1

According to license No. EO 001019 dated 2 December 2013, the term of Pivdennoukrainsk NPP Unit 1 operation expires on 2 December 2023. Energoatom continued conducting periodic safety review of Pivdennoukrainsk NPP Unit 1 to justify the possibility of long-term operation in accordance with:

The Program for Implementing Measures to Justify Further Operation of Pivdennoukrainsk NPP Unit 1 during the Period of Long-Term Operation (PM.1.3812.0263); "The Schedule for Periodic Safety Review of Pivdennoukrainsk NPP Unit 1".

In 2022, with the involvement of the SSTC NRS, the SNRIU completed the state nuclear and radiation safety review of the PSRR materials for Pivdennoukrainsk NPP Unit 1 according to the following safety factors:

plant design;

- current technical condition of systems and components;
- equipment qualification;
- ageing;

deterministic safety analysis;

- probabilistic safety analysis;
- analysis of internal and external events;
- operational safety; use of experience from other plants and research findings;
- organization, management system and safety culture;
- operational documentation;
- human factor;
- emergency preparedness and planning; radiation impact on the environment."

The operating organization continues resolving comments of the state NRS review of PSRR materials. The state NRS review of the PSRR Section "Comprehensive Safety Analysis" for Pivdennoukrainsk NPP Unit 1 has been started. The deadline for finalizing the periodic safety review for Pivdennoukrainsk NPP Unit 1 and agreement of the PSRR package by the SNRIU is 30 September 2023.

Zaporizhzhia NPP in the Conditions of Occupation

On the night of 4 March 2022, russian troops seized the ZNPP site posing an im-

mediate threat to the lives of the plant's personnel; equipment, building structures, and piping were damaged. As a result of shelling and fires, the buildings of the Training Center, power Unit 1 reactor compartment, the Unit transformer, as well as household and laboratory buildings were damaged. This damage did not lead to further failures of systems and components important to safety only owing to the professional and timely actions of the plant personnel. High-voltage power transmission lines were also damaged.

By the forceful seizure of the ZNPP and the subsequent illegal stay on the site of the rosatom and rostechnadzor representatives, the russian federation neglected the fundamental principles of the nuclear safety and security culture, turned the nuclear energy peaceful use facility into a military base with the deployment of military vehicles and equipment near the power units and in the NPP premises, which considerably deteriorated the state of fire safety and timely access to equipment in case of emergencies.

As criteria for assessing the current safety state in the war conditions, the IAEA Director General proposed "seven indispensable pillars of nuclear safety and security", which derive from the IAEA safety principles and standards:

1. The physical integrity of the facilities– whether it is the reactors, fuel ponds, or radioactive waste stores – must be maintained;

2. All safety and security systems and equipment must be fully functional at all times;

3. The operating staff must be able to fulfil their safety and security duties and have the capacity to make decisions free of undue pressure;

4. There must be secure off-site power supply from the grid for all nuclear sites;

5. There must be uninterrupted logistical supply chains and transportation to and from the sites;

6. There must be effective on-site and off-site radiation monitoring systems and emergency preparedness and response measures;

7. There must be reliable communications with the regulator and others.

All these "seven indispensable pillars of nuclear safety and security" were compromised by shelling, forceful seizure

and occupation of the ZNPP, however, they continue to be used by the IAEA as indicators of the current state of ZNPP safety, which indicate a decrease in the level of nuclear and radiation safety due to violation of the integrity of systems and components, equipment degradation without timely repairs and proper maintenance, a significant decrease in the number of qualified personnel and fatigue of personnel due to physical and psychological pressure, destruction of the emergency preparedness and response infrastructure on the site and beyond it, loss of reliable communication with the regulatory authority, etc. The presence of outsiders and russian personnel on the site, who do not possess experience in the operation of upgraded ZNPP power units threatens the safe plant operation.

Ukraine's ability to fully comply with the provisions of the Convention on Nuclear Safety in wartime has become limited, in particular, in terms of liability for nuclear damage of the license holder, ensuring priority to safety and maintaining an appropriate state of emergency preparedness at the ZNPP site.

Due to a gross violation of nuclear and radiation safety requirements: placement of military vehicles and equipment in the industrial premises of ZNPP Units 1, 2 by the occupiers, the SNRIU has amended the operation licenses of Zaporizhzhia NPP Units 1 and 2.

According to SNRIU Order No. 501 dated 18 August 2022, the operating organization operates Zaporizhzhia NPP Unit 1 in refueling and cold shutdown states, and Zaporizhzhia NPP Unit 2 is in cold shutdown state. The basis for amending the licenses was Energoatom's application and supporting documents, as well as the SNRIU Board Resolution of 4 August 2022 "On Current Safety of Zaporizhzhia NPP Units under Military Occupation of the russian federation". Amendments to the licenses were made in accordance with the Law of Ukraine "On Licensing Activities in Nuclear Energy" taking into account recommendations of the SNRIU Licensing Commission of 16 August 2022. Energoatom was obliged to immediately take measures to determine the safe configuration of the Zaporizhzhia NPP Units in the conditions of the site occupation by the russian military and hostilities in the area of the NPP site location.

with In connection the illegal construction of additional structures of unknown purpose on the ZNPP DSFSF site by the occupiers, which is a violation of the license for the right for activities at the life cycle stage "Operation of the Nuclear Installation "Zaporizhzhia NPP", para. 1.9 of the Requirements for Modifications of Nuclear Facilities and Procedure for Assessing their Safety, operation of the state oversight facility ZNPP DSFSF was limited due to impossibility of eliminating identified violations of nuclear and radiation safety requirements, and construction, mounting and pre-commissioning activities in the scope of reconstruction and modernization were prohibited by Order No. R-1/15 of 28 October 2022.

To reduce the risk of a nuclear accident and obtain objective information on the state of nuclear safety, physical protection and safeguards, since 1 September 2022, representatives of the IAEA are permanently present at the ZNPP site in accordance with the Terms of Reference agreed between Ukraine and the IAEA through the exchange of diplomatic Notes.

The main purpose of the permanent IAEA Mission at the Zaporizhzhia NPP on a rotating basis is to prevent a nuclear accident. As a result of shelling and damage to the main and backup power supply lines from August to December 2022, the ZNPP completely lost its off-site power supply five times, nuclear fuel cooling was ensured by the backup systems (diesel generators).

Description of the safety state and trends in deterioration of ZNPP safety indicators under the conditions of occupation are recorded in the IAEA reports, which are available at:

https://www.iaea.org/sites/default/ files/22/04/ukraine-report.pdf

https://www.iaea.org/sites/default/ files/22/09/ukraine-2ndsummaryreport_ sept2022.pdf

https://www.iaea.org/sites/default/ files/23/02/nuclear-safety-security-andsafeguards-in-ukraine-feb-2023.pdf

The interaction of the IAEA with the state Ukrainian authorities is based on the official position and proceeds from the fact that the Zaporizhzhia NPP, its nuclear installations and nuclear material are the property of Ukraine. The legitimate operating organization, the ZNPP operator is Energoatom, which acts in accordance with the legislation and licenses issued by the SNRIU.

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). The stress tests for Ukrainian NPPs were performed in compliance with the stress test methodology for European NPPs (13 May 2011, Declaration of ENSREG, Annex 1 "EU Stress-Test Specifications") agreed by the European Commission and ENSREG. The National Action Plans (NAPs) contain safety improvement measures determined upon the stress tests, as well as schedules for their execution at NPPs and implementation status.

In 2021, the National Action Plan was updated (in accordance with the ENSREG requirements, it is updated every two years), the current state of implementation of measures to improve security, as well as the deadlines for implementation of individual measures, were updated. The number of planned measures and their scope did not change.

In 2022, a number of measures were implemented at Ukrainian NPP Units with the objective to develop materials and carry out equipment qualification, to conduct a detailed analysis of the need to make-up primary circuit in the event of an accident with a loss of power supply and/or final heat sink, analyze the possibility to implement in-vessel melt retention strategy, implement a forced containment venting system, ensure seismic resistance of equipment, piping, buildings and structures, develop seismic PSA, implement an external reactor pressure vessel cooling system at RNPP Units 1 and 2, etc.

Implementation of Westinghouse Nuclear Fuel

Until 2005, all nuclear fuel used at NPP Units was exclusively of russian production. In order to avoid dependence on a monopoly supplier and diversify nuclear fuel supplies, since 2006 Ukraine has started licensing (qualification) of nuclear fuel produced by Westinghouse (FA-W, FA-WR). As of December 31, 2022, operation of the Westinghouse nuclear fuel (FA-WR) continues in the cores of six Ukrainian NPP Units: PNPP Unit 2, PNPP Unit 3, ZNPP Unit 1, ZNPP Unit 3, ZNPP Unit 4 and ZNPP Unit 5. The cores of these power units consist exclusively of FA-WR. In addition, in 2022, trial operation of the FA-WR started at Rivne NPP Unit 3.

In connection with russian aggression against Ukraine, Energoatom took a decision to refuse TVEL fuel supplies since February 2022 and planned measures for gradual introduction of Westinghouse fuel at remaining Ukrainian power units, including with VVER-440 type reactors.

In 2022, the ŚNRIU reviewed:

industry technical solution on implementation of the "pilot" modification of FA-WR at ZNPP Units 2, 6, RNPP Unit 4, PNPP Unit 1 and KhNPP Units 1, 2;

conceptual technical solution on the introduction of Westinghouse VVER-440 fuel assemblies at Rivne NPP Units 1, 2 along with the justification materials;

technical specification for the design of Westinghouse VVER-440 fuel assemblies for the Rivne NPP.

Ukraine's experience in diversifying nuclear fuel supply sources has become the subject of attention of other countries that continue to operate Soviet-designed VVER type reactors.

Management of Spent Nuclear Fuel from the ChNPP High-Power Channel-Type Reactors

There is no spent nuclear fuel in the Chornobyl NPP Units 1, 2, 3, which are at the decommissioning stage. Until September 2020, all ChNPP SNF was stored in ISF-1, which is operated by the ChNPP in accordance with conditions of license EO No. 000859, issued by the SNRIU on 25 June 2008.

On 21 May 2021, individual permit No. EO 000859/1/15 was issued to ChNPP for unloading of conditioned spent nuclear fuel from the ISF-1 and its gradual transfer for long-term storage to the dry spent fuel interim storage facility (ISF-2).

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

ISF-2 is operated in accordance with the terms of the SNRIU License No. EO 001091, issued to the ChNPP on 23 April 2021.

As of 24 February 2022, 1,842 spent fuel assemblies were transported ISF-2, of which 1,767 were installed in double-wall dry shielded canisters, and the rest remained in the SNF processing facilities.

During the ChNPP occupation, the integrity of the protective ISF-1 and ISF-2 barriers was not violated. Transportation of spent nuclear fuel from ISF-1 to ISF-2 has not been resumed due to safety considerations of transport operations.

Construction and Commissioning of New Nuclear Facilities

The operating organization Energoatom continued to take measures on:

renewal of construction of Khmelnytsky NPP Units 3 and 4;

organization of fabrication of nuclear fuel elements;

preparation for the construction of Khmelnytsky NPP Units 5 and 6.

In accordance with para. 1 of Decree of the President of Ukraine No. 406/2020 of 22 September 2020 "On Urgent Measures to Stabilize the Situation in the Energy Sector and Further Development of Nuclear Energy", the Cabinet of Ministers of Ukraine was instructed to submit the draft law of Ukraine on siting, designing and construction of Khmelnytsky NPP Units 3 and 4 to the Verkhovna Rada according to the established procedure. The draft law of Ukraine was revised taking into account comments to the previous revision, but was not submitted to the SNRIU in 2022.

In March 2022, the SNRIU requested Energoatom to provide updated reports on the survey and confirming the durability and reliability of building structures and buildings of Khmelnytsky NPP Units 3 and 4.

Decree of the President of Ukraine No. 104/2019 of 4 April 2019 approved measures to support the development of nuclear energy and increase the safety level in the field of nuclear energy use. In 2022, the SNRIU did not receive information on implementation of the measures provided for in subsection 4 of para. 1 of the above-mentioned Decree on the immediate creation of domestic fabrication of nuclear fuel for Ukrainian NPPs with the involvement of entities generating electric power at NPPs.

On 31 August 2021, a Memorandum on the joint construction of power units in Ukraine was signed between Energoatom and Westinghouse Electric Company (USA). On June 2, 2022, the companies signed an Agreement to increase the number of NPP Units to be constructed in Ukraine using AP1000 technology. Energoatom has started preparations for the construction of Khmelnytsky NPP Units 5 and 6. Implementing its regulatory functions, the SNRIU reviewed the licensing plan for the construction and commissioning of Khmelnytsky NPP Units 5 and 6 and the draft Resolution of the Cabinet of Ministers of Ukraine "On Measures for the Construction of Khmelnytsky NPP Units".

In 2022, the following facilities were at the stage of construction completion and commissioning:

CSFSF: centralized dry spent nuclear fuel storage facility designed for long-term (within 100 years) storage of RNPP, KhNPP and PNPP nuclear fuel;

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

CSFSF is designed for long-term (within 100 years) storage of nuclear fuel of the Rivne, Khmelnytsky and Pivdennoukrainsk NPPs using the Holtec International (USA) technology.

The activities on the CSFSF construction completion are carried out in accordance with the conditions of the license to conduct "construction and commissioning of a nuclear facility: spent fuel storage facility (CSFSF)" issued by SNRIU on 29 June 2017.

In February 2022, the construction activities of the first CSFSF start-up stage and comprehensive tests were practically completed, and an inspection from 14 to 25 February was held to verify the completeness and reliability of the information contained in the documents enclosed to the Energoatom application of 31 January 2022 on issuing an individual written permit for the right to implement activities at the "commissioning" life cycle stage of a nuclear installation, to confirm availability of conditions for the safe conducting of activities in the field of nuclear energy use, works or operations and to assess the ability of Energoatom to carry out the declared activity in compliance with nuclear and radiation safety requirements.

It was established in the course of the inspection, that as of 23 February 2022, the actual situation corresponds to the information provided in the operator's application documents and confirms availability of conditions for the safe implementation of the declared activity.

However, in connection with the introduction of martial law in Ukraine in accordance with the Decree of the President of Ukraine No. 64/2022 and the notification of SAUEZM and ChNPP on seizure of the facilities located in the Exclusion Zone by military formations of the armed forces of the russian federation, the inspection Commission affirmed absence of grounds to consider the inspection results as reliable as of 25 February 2022.

Among other issues, the inspection report indicated the impossibility to exercise control over the CSFSF site, systems/components important to safety in connection with the seizure of the Exclusion Zone by the military formations of the russian armed forces and recommended to the operator to carry out the following after return of the CSFSF site under the control of Ukraine:

develop and submit for approval to the SNRIU a Plan of measures to eliminate the remarks stated in the inspection report;

ensure monitoring and confirm the readiness of the CSFSF site and systems/ components important to the CSFSF safety for receiving SNF from the Ukrainian NPPs.

After the de-occupation of the northern part of the Kyiv region at the beginning of April 2022, Energoatom specialists determined the scope of restoration activities for the CSFSF and developed reports on damage/losses. This facility did not suffer damage by shelling and no hostilities took place in its vicinity. However, as a result of the power outage, certain operational systems required repair. In addition, the access roads to CSFSF, such as the railway track and the bridge destroyed by the occupiers on the Ovruch-Vilcha section, which was damaged during hostilities in the Zhytomyr region need to be restored.

On 25 April 2022, the SNRIU issued individual permit OD No. EO 001060/1/15 to Energoatom for activities related to CSFSF commissioning.

As of December 2022, 7 conditions (out of 13) of the individual permit were fulfilled, which have to be performed before the first SNF delivery to the CSFSF site.

The SNRIU has also assessed the implementation status of modification projects for RNPP, KhNPP and PNPP Units as part of their preparation for SNF unloading using equipment developed according to the Holtec International technology.

Nuclear Subcritical Facility "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" (Neutron Source) is being constructed at the National Science Center "Kharkiv Institute of Physics and Technology" (KIPT) in accordance with the agreements reached at the Washington Summit, outlined 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 Neutron Source is intended for scientific and applied research in nuclear physics, radiation materials science, biology, chemistry and production of medical radioisotopes.

KIPT carries out activities based on an individual permit No. EO 001018/2/15 for the initial startup of the Neutron Source of 1 July 2020, issued in accordance with license EO No. 001018 of 10 October 2013 for construction and commissioning of the Neutron Source.

Before the aggression of the russian federation, the Neutron Source was in the stage of initial startup, during which the core was loaded with fresh nuclear fuel. On 24 February 2022, operational personnel of the Neutron Source transferred it into a deep subcritical state. KIPT is located near the Pyatikhatky residential complex in the north of Kharkiv, which was bombed and shelled several times by the aggressor country.

As a result of continuous shelling, the off-site power supply system, air conditioning system, the cooling system of the klystron gallery of the linear electron accelerator and the buildings where the facility is located, as well as the pumping and cooling towers, the isotope laboratory, were damaged. Remains of an explosive object, preliminarily classified as a 9K58 "Smerch" MLRS missile, were found in the immediate vicinity of the Neutron Source.

On 27 March, the Neutron Source came under fire again, as a result of which the thermal insulating cladding of the building suffered significant damage, partial spalling of the cladding in the facility experimental hall was recorded.

According to the inspection results of the site, additional damage to the buildings and infrastructure of the industrial site was established: in particular, the northern wall of the accelerator building annexed to the experimental hall, the ventilation ducts of the special ventilation system, the ventilation stack of the main building of the facility, the cooling system of the accelerator gallery, the diesel generator housings of the emergency power supply system were damaged as well as cladding of the main building.

The Neutron Source remains in deep subcritical state (long-term shutdown mode), since its transfer on 24 February 2022. The off-site power supply to the facility is absent. Operational personnel monitor the Neutron Source state NPP and continue taking measures to eliminate the consequences of hostilities and maintain the equipment functional, but their work is complicated and sometimes impossible due to the danger of new shelling of the site.

According to the portable dosimeter readings, the radiation situation in the experimental hall of the Neutron Source building did not change and was within normal limits. Fluctuations of EDR gamma radiation next to the Neutron Source building were within the natural background limits and amounted to 11-14 μ Sv/h. There were no releases of radioactive substances into the environment.

The probability of new damage to the Neutron Source, which may affect the state of nuclear and radiation safe-

ty, remains high due to the constant shelling of the city of Kharkiv by russian troops.



Photo 1 – Destroyed RU-0.4 kV substation



Photo 2 – Damage to the Neutron Source main building



Photo 3 – Damage to the Neutron Source main building



Photo 4 – 9K58 "Smerch" MLRS missile on the Neutron Source site

Safety of Nuclear Research Reactor (VVR-M)

The Nuclear Research Institute of the National Academy of Sciences of Ukraine (Kyiv) operates the VVR-M nuclear research reactor in accordance with the SNRIU license issued on 29 December 2014, which is valid until 31 December 2023.

The VVR-M nuclear research reactor (NRR) was commissioned on 12 February 1960 as a powerful source of neutrons for conducting fundamental and applied research in various fields of science and technology. Reliability and safety of the reactor are ensured by its design, professional operation of equipment and systems, constant upgrading and modernization of the equipment.

In the framework of long-term operation, the following activities were performed:

heat exchangers and part of special ventilation were replaced;

continuous monitoring system of radionuclides in the primary coolant of the reactor and SNF management system were created;

an ultra-sensitive neutron flux impulse measurement and control channel was introduced;

a new reactor physical protection system and an additional source of emergency power supply from the diesel generator were commissioned;

an advance radiation monitoring system for vehicles leaving the reactor and institute territory was implemented;

additional calculations for the reactor pressure vessel seismic resistance and strength were performed.

No emergencies at the research nuclear reactor were recorded in 2022. The decrease in the radiation dose rate of the NRR personnel compared to 2021 is explained by a significant reduction in the number of radiation hazardous activities strict access zone, since the reactor core was completely unloaded at the beginning of 2022.

According to the "Radiation Monitoring Program of the Nuclear Research Institute of the National Academy of Sciences of Ukraine", the volumetric activity of IRG in the air of the strict access zone premises is constantly measured by means of stationary radiation monitoring equipment, selectively by operational staff of the Radiation Monitoring Service using portable radiation monitoring equipment. Measurement of the volumetric activity of IRG and beta-aerosols in the air of premise 101 is carried out constantly since these indicators are the most representative ones from the point of view of assessing radioactive contamination of the working area air and are the main indicator of abnormal situations. The average and maximum values of the volumetric activity of IRG and beta-aerosols in the air of premise 101 were lower than 1.0E-01 Bq/m³ in the reporting period.

During 2022, EDR indicators of gamma radiation and surface contamination with beta radionuclides for all monitored premises did not exceed the established reference levels in accordance with the radiation safety categories of these premises and did not require additional measures to reduce EDR and radioactive contamination in the premises.





No exceeding of the levels of permissible and reference dose rate, radioactive contamination and volumetric activity of radionuclides in the air of the reactor building premises established for the NRR was recorded. The average monthly volumetric activity of ¹³¹⁻¹³⁵I radionuclides in the primary circuit water was below 1.1E+02 Bg/I in 2022.

Since the reactor was not operating at power in January-February 2022, the radioactive releases of IRG and iodine radionuclides into the atmosphere during this period were significantly less than the reference levels established for the airborne releases of the NRR. In addition, in March-January there were no releases at all NRR core unloading and its transfer to a safe state.

Indicators of the gamma radiation EDR from the airborne release of NRR for the period 2013 - 2022 in the reference points of the control and observation areas indicate that the average annual EDR value of gamma radiation did not exceed 0.15 μ Sv/h, which is less than the EDR reference level, which is 0.26 μ Sv/h.

The annual average gamma radiation EDR in the NRR control area during the last ten years remains in the range from 0.12 to 0.14 μ Sv/h, and from 0.08 to 0.15 μ Sv/h in the observation area (with a measurement error of ± 20 %), which testifies on the absence of man-induced impact of the NRR operation on the environment according to the gamma radiation EDR indicator.

The average quarterly beta-activity of the NRR discharge waters for the period 2013 - 2022 was from 0.25 to 0.93 Bq/l, i.e. it was at the level of the underground and surface water activity typical for the region where the NRR site is located.

According to the data on the of radiation safety state at the NRR provided in the Report for 2022, there are no negative trends in deterioration of the radiation safety state indicators according to the monitored parameters.

III. ANALYSIS OF NPP OPERATIONAL EVENTS

The "Provisions on the Procedure for Investigation and Accounting of Operational Events at Nuclear Power Plants" (NP 306.2.235-2021) came into effect on 1 January 2022. The Provisions significantly reduced the level of operational events to be reported by the operating organization to the regulatory body. Considering this fact and direct impact of military actions on the safety of NPPs, the number of recorded operational events significantly increased compared to the previous years.

In 2022, the SNRIU received and reviewed 54 notifications on operational events that occurred at NPPs that are currently in operation.

The distribution of operational events among the sites of operating NPPs is shown in Figure 5.

Most (≈ 35 %) of all operational events that occurred at NPPs led to reactor shutdown (categories P05/1, P08/2), unloading or disconnection of power units from the grid, reduction in the residual design life of equipment in systems important to safety,



Figure 5 – Distribution of NPP operational events for 2022

and decrease in the number of load cycles established for reactor components. The events considered by the operating organization to be important for safety and require corrective measures is ≈ 33 %.

The full-scale investigation of operational events that occurred at the ZNPP under occupation turned out to be impossible.



Number of events by category

IV. EMERGENCY PREPAREDNESS AND RESPONSE

The SNRIU, as the competent authority for emergency notification, 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 accordance with the requirements of standards and rules on nuclear and radiation safety and conditions of authorizing documents;

arranges and participates in exercises, trainings, 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 colleagues of authorities and organizations that have responsibilities for responding to nuclear and radiation emergencies.

To address the evolving requirements, the "SNRIU Civil Protection Plan for the Special Period" and "Procedure for Actions of SNRIU Personnel in the Event of an Air Raid Alert Signal for the Martial Law Period" were developed and approved to protect the life and health of the employees.

To ensure the proper performance of the single national point of contact in compliance with the Convention on Early Notification of a Nuclear Accidents, 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, the SNRIU maintains a 24/7 duty and permanent communication with the licensees, operational duty service of the State Emergency Service of Ukraine (SESU), other state authorities, IAEA Incident and Emergency Center (IAEA IEC) and competent authorities of other countries in the framework of international treaties.

On 25 February 2022, the first statement of the IAEA Director General regarding the situation in Ukraine appeared on the IAEA official website. Since then, the IAEA continues to closely monitor the events in Ukraine, paying special attention to the safety of its nuclear reactors and publishing updates on a specially created page https://www.iaea.org/ newscenter/pressreleases/update-iaea-director-general-statement-on-situation-in-ukraine-25-feb-2022

SNRIU Order No. 192 of 4 March 2022 activated the Information and Emergency Center (IEC) to carry out a 24-hour analysis of the situation regarding nuclear and radiation safety, prepare informational notifications for the public and mass media and place them on the SNRIU website and other information resources, and perform forecasting calculations of potential emergency consequences using the European JRODOS decision support system (DSS) in cooperation with the SSTC NRS, Ukrainian Hydrometeorological Center (UkrHMC), SESU, Energoatom, NPPs and other licensees dealing with the use of nuclear energy for peaceful purposes.

Information on events that influence or may influence nuclear and radiation safety is provided through the IAEA USIE1 secure website. In 2022, the SNRIU published 56 messages in the USIE system.

Information on radiological situation in places where high-level radiation sources are used and on their security is sent online to the 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.

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.

In cooperation with the Ministry of Health of Ukraine, needs were specified for compliance with the requirements of the Regulation on Iodine Prophylaxis in the Event of a Radiation Accident, approved by Order No. 408 of the Ministry of Health of Ukraine dated 9 March 2021 and registered in the Ministry of Justice of Ukraine under No. 526/36148 on 16 April 2021 and the Procedure for Implementation of Immediate Iodine Preventive Measures among the Public of Ukraine in the Event of a Radiation Accident, approved by SNRIU Order No. 154 dated 8 November 2011 and registered in the Ministry of Justice of Ukraine under No. 1353/20091 on 25 November 2011.

Upon analysis of the information from local governments and regional authorities, proposals were made to update and increase the reserves of potassium iodide pharmaceuticals through national manufacturers and international donors for personnel of organizations participating in response and protection measures, primarily SESU and National Police units, for the territories located within the NPP observations areas and for the public outside the NPP observation areas.

On 13–17 June 2022, a report was presented at the 11th meeting of the parties to the Convention on Early Notification of a Nuclear Accident at the IAEA headquarters (Vienna, Austria), and the Ukrainian regulator's notification actions were assessed as adequate situations and those that corresponded to the Convention objectives and procedures.

In the framework of cooperation and enhancement of coordination with the US Department of Energy/National Nuclear Security Administration (DoE/NNSA) in the area of emergency preparedness and response, periodic testing of communication with the Joint Special Operations Command (JSOC) and comparison of forecasting assessments performed by the DoE/NNSA National Atmospheric Release Advisory Center (NARAC) and the Center for Forecasting the Consequences of Radiation Accidents at the SESU UkrHMC using the JRODOS DSS was introduced.

The SNRIU participated in international IAEA exercises and arranged special training within bilateral agreements on prompt notification and information exchange:

ConvEx-1b to test that the national warning points are continuously available and the national communication points are capable of responding to the notifications in a prompt manner;

ConvEx-1b-2a to test the capabilities and skills of the competent authorities and the national coordinators of the INES in completing standard reporting forms following the development of a conditional emergency.

The on-site nuclear safety inspectorates conducted regulatory assessment of the licensees' training exercises. In particular, a common-plant exercise "General Accident Caused by a Military Emergency Resulting in the Loss of In-House Power at Unit 1" was conducted at the KhNPP.

On 19–20 August 2022, the Energoatom Directorate and the Ministry of Energy of Ukraine, jointly with central and local executive bodies, conducted staff training to test actions in the event of a radiation accident at the Zaporizhzhia NPP. These and other exercises were intended to check operation of communications and information exchange between the main and backup emergency centers of the operating organization and the SNRIU Information and Emergency Center.

In the framework of the European Commission "Implementation project of Nuclear and Radiological Emergency Preparedness and Response Requirements in EU Member States and Neighboring Countries", the SNRIU and SSTC NRS participated in case studies on review analysis of applying and emergency response mechanisms in a regional or international context using individual scenarios of conditional emergencies in European countries with transboundary consequences.

Upon invitation of the HERCA working group, with the involvement of experts from the National Research Center for Radiation Medicine and SSTC NRS, the SNRIU took part in the review and discussion of the draft document on assessment of radiological risks for Ukraine.

In 2022, regulatory decisions were considered and adopted for the facility-level emergency plans of the PNPP, KhNPP and NSC-Shelter, Emergency and Technical Center accident and emergency response plan and emergency plans of other licensees.

Coordination of Assistance to Ukraine within IAEA RANET

Upon meeting of the IAEA Director General, Rafael Mariano Grossi, with heads of the SNRIU, Ministry of Energy, and Energoatom in March 2022, the IAEA prepared the document on assistance to Ukraine with regard to nuclear and radiation safety, nuclear security and safeguards and distributed it among its member states. According to the document, starting from April 2022, the development of a list with humanitarian and technical assistance in the form of equipment, protection means and expert support missions, including those directly at sites and facilities, was started.

Request to the IAEA 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, using the IAEA Response and Assistance Network (RANET), covers equipment to ensure safety of nuclear facilities, radioactive waste management facilities, uranium sites, other radiation sources and radiation monitoring devices and protective equipment for the first responders to emergencies. In accordance with the official requests made by the SESU, Ministry of Health, SESU UkrHMC, SSE Chornobyl NPP, Radon Association, USIE Izotop and Energoatom, the list of needs is being updated and adjusted, including results of the IAEA missions in Ukraine.

The SNRIU, as the only competent national point of contact within the Convention on

Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and pursuant to the Provisions approved by Cabinet Resolution No. 363 dated 20 August 2014, coordinates interaction with the IAEA, including interaction on issues of receiving assistance to Ukraine through the RANET network upon requests of the end users.

12 countries offered their assistance to Ukraine through RANET, such as Australia, USA, Romania, Hungary, France, Germany, Sweden, Israel, Japan, Canada, Switzerland and Spain, and published their proposals on the provision of this assistance to Ukraine through the secure IAEA USIE system. Action plans for assistance to Ukraine were signed with 10 countries and are being implemented in compliance with the IAEA RANET administration procedures.

In 2022, humanitarian aid came from Romania, Spain, France, Australia, Hungary, Sweden and Germany.

The SNRIU continues organizational and advisory efforts and provides feedback on the RANET application to support the licensees' capability to ensure nuclear and radiation safety and security and prevent and response to emergencies if they occur.

V. RADIATION MONITORING ON THE TERRITORY OF UKRAINE (Beyond Nuclear Facility Sites)

The natural radiation sources are rocks, cosmic fallout and solar activity. In addition to the natural component, the current radioactive background is formed by the consequences of nuclear weapon tests and nuclear accidents, such as the Chornobyl accident and the Fukushima nuclear disaster in Japan.

The results of systematic observations conducted by all activity coordinators of radiation monitoring should be analyzed in comparison with the available data of multi-year observations in order to obtain an unbiased assessment of the influence of hostilities on the territory of Ukraine on changes in the radiation situation.

In addition, there are permitted releases and effluents of radioactive materials into the environment from nuclear radiation facilities. These releases are strictly controlled to protect the environment and provide adequate protection to the public who may be influenced by radiation.

An important and necessary component of release control is continuous monitoring conducted both at the source of the release and in the receiving environment to ensure the protection of the public and environment.

Uncontrolled radionuclide releases into the atmosphere, water or ground may occur in case of a nuclear or radiation accident. Monitoring of emergency release at the place of its occurrence and monitoring of environmental contamination with radionuclides are necessary to perform assessments and take measures in order to protect the public, take long-term countermeasures and make decisions for conducting remediation activities and assessing their efficiency.

Three categories of observations: "source monitoring", "environmental monitoring" and "personal dosimetry monitoring" are distinguished according to the radiation protection principles and safety guidelines. The main source of the systematized information on the radiation situation of the environment on the territory of Ukraine according to the indicators such as gamma radiation exposure dose rate in the near-surface layer of the atmospheric air, total beta activity of atmospheric aerosols and fallout on soil, concentration of strontium-90 and cesium-137 in surface waters is the network for hydrometeorological observations of the State Emergency Service of Ukraine, which has been monitoring radiation in the environment since the 1960s and has a multi-year experience in assessing the radiation impact of the Chornobyl accident.

In early 2022, observations of gamma background rate were carried out at 163 monitoring points of this network, observations of radioactive contamination of atmospheric fallout were conducted at 51 points, observations of the content of aerosols in the air were performed at 7 points (excluding the monitoring points located on the territory of the annexed Crimea and temporarily occupied Donetsk and Luhansk regions). Radiation and environmental monitoring of surface waters in Ukraine covers the Dnipro water system (Dnipro, Desna River and the Dnipro-Buh Estuary), the Pivdennyi Buh and Dunay River, as well as water bodies in the zones influenced by NPP.

Information on gamma radiation levels from the radiometric network of Ukraine is daily transmitted by the Ukrainian hydrometeorological Center of the SESU to the Unified Information Exchange System of EURDEP (European Radiological Data Exchange Platform) of the Joint Research Center of the European Commission and is available at https://remap.jrc.ec.europa.eu/ GammaDoseRates.aspx. In addition, this information is submitted to the International Radiation Monitoring Information System of the IAEA Center for Incidents and Emergencies (IRMIS).



Figure 7 – Schematic map showing layout of hydrometeorological observation points

The SESU Ukrainian Hydrometeorological Center continued to perform its legally defined functions under martial law and carried out activities to modernize and equip the observation points with modern automated tools and systems in accordance with the Operational Plan for the Implementation of the Strategy for the Integrated Automated Radiation Monitoring System by 2024.

Tracking temporal and spatial changes in the characteristics of the radiation situation in the environment is an important factor in providing information support to the state authorities for making decisions regarding the appropriate level of radiation protection of the public, as well as preventing and minimizing negative consequences in the initiation of radiation or nuclear hazards.

A separate division was established in 2016 with this purpose as part of the Ukrainian Hydrometeorological Center of the SESU, namely the Center for Forecasting the Consequences of Radiation Accidents, whose tasks are to collect, systematize and analyze the observation results, as well as predict radiological consequences of emergencies by mathematical modeling of spatial dynamics in the air.

The current programs of hydrometeorological observations mainly are focused on determination of residual radionuclides of Chornobyl origin in the environmental objects. However, the current radiation situation in the country and potential sources of radioactive contamination in the environment are dramatically changing, which requires a revision of the radiation monitoring principles, as well as significant optimization of the existing observation network with an emphasis on transboundary radioactivity transfer with air masses and surface waters, observations in the zones influenced by operating nuclear installations, radioactive waste management facilities, legacy uranium production facilities, etc.

The departmental regulations for the above-mentioned issues are particularly:

Order of the Ministry of Internal Affairs of Ukraine No. 931 dated 16 November 2018 "On the Approval of the Environmental Contamination Observation Program of Hydrometeorological Organizations of the State Emergency Service of Ukraine" Order of the State Emergency Service of Ukraine No. 777 dated 23 December 2013"On the Preparation and Provision of Operational and Regime Information on Environmental Contamination";

Order of the State Emergency Service of Ukraine No. 451 dated 16 September 2016 "On Amendments to the Algorithm for the Preparation, Processing and Submission of Regime Information on Environmental Contamination by Hydrometeorological Organizations and Institutions of the State Emergency Service of Ukraine";

Order of the State Emergency Service of Ukraine No. 171 dated 15 March 2018 "On the Approval of the Indicative List of Types of Public Information, which is managed by the State Emergency Service of Ukraine".

According to the Boris Sresnevsky Central Geophysical Observatory of the State Emergency Service of Ukraine <u>http://cgo-sreznevskyi.kyiv.ua/uk/</u>, the indicators of radioactive situation in the surface layer of the atmosphere on the territory of Ukraine in 2022 were stable and within the limits of long-term background and seasonal fluctuations.

According to the observations at 7 radiation monitoring points equipped with large-volume air-filtering units, the monthly total average volumetric beta activity of surface atmosphere aerosols was within 4.8×10^{-5} - 35.6×10^{-5} Bg/m³.

¹³⁷Cs concentrations in the surface air layer (aerosols on filters) at the observation points of the hydrometeorological network beyond the exclusion zone were observed within the range of 0.03×10^{-5} – 1.57×10^{-5} Bq/m³ with an average value of 0.20×10^{-5} Bq/m³, which corresponds to the levels of natural background and is 4 times less than the allowable concentration of ¹³⁷Cs in the atmospheric air according to NRBU-97, which is 0.8 Bg/m³.

No anomalous radionuclides of manmade origin were found in the samples. No exceeded permissible levels were registered on the territory of Ukraine by observation means of the hydrometeorological service in 2022.

The average monthly values of total beta activity of fallout at the observation points of the radiometric network of hydrometeo-rological stations were determined in the range of 1.1–2.0 Bq/m² per day, the average density of beta-active fallout throughout the country was 1.6 Bq/m² per day.

No exceeded established reference levels of total beta-activity of fallout (110 Bq/m² per day) were recorded.

¹³⁷Cs content in atmospheric fallout at most observation points (except for the territory classified as the zone contaminated resulting from the Chornobyl accident) was at the level of typical background fluctuations within 0.1-0.9 Bq/m² per month, with an average value of 0.28 Bq/m² per month.

Water samples from the surface water bodies are usually taken regularly on the rivers and all reservoirs of the Dnipro cascade once a month. Due to the wartime events, observations in the city of Nova Kakhovka were carried out only in January and February 2022, while sampling took place with interruptions in the city of Mykolaiv (Pivdennyi Buh). According to the analysis of water samples from the surface water bodies, the radionuclide content was at the level of long-term background activity concentrations with a slight increase in ⁹⁰Sr due to the residual impact of Chornobyl origin. According to the indicators of ¹³⁷Cs (soluble form) and ⁹⁰Sr content, the contamination levels were two or more times lower than the established permissible levels (TDU-2006) - for radionuclides of Chornobyl origin in the Dnipro water system they make up 2000 Bq/m³.

The average annual content of total alpha activity in the Dnipro Reservoir near the city of Zaporizhzhya was observed in the range of 0.02-0.05 Bq/m³ and did not exceed the reference screening levels of the content of alpha-emitting nuclides in water of 0.1 Bg/m³.

⁹⁰Sr concentrations in the water of Kyiv and Kaniv Reservoirs were subject to seasonal fluctuations due to some increase in their removal by the Prypyat' River to the Kyiv Reservoir. ¹³⁷Cs concentration increase was probably caused by an increase in the throughput of the Kyiv Reservoir and, accordingly, water turbidity during high and prolonged winter floods in the Pripyat' and Verhnii Dnipro Rivers.

According to the hydrometeorological observation network that is the state observation system independent of nuclear facility operators, the radiation situation at operating NPP sites remained stable in 2022. The exposure dose rate of gamma radiation at the observation points located in NPP impact zones was within the limits of longterm fluctuations. No exceeded established reference levels of radionuclide content in the air of 100-km zones around NPP were recorded.
Table 4 – Generalized data of background observations of ¹³⁷Cs and ⁹⁰Sr radionuclide content in the rivers and reservoirs of Ukraine for 2022

River/Reservoir and sampling point	Radionuclide	Range of specific activity in water Bq/m ³	Note
Prypyat' River, the city of Chornobyl	¹³⁷ Cs	13,5 -40,0	
	⁹⁰ Sr	24,5 – 88,5	
Dnipro River, the city of Nedanchychi	¹³⁷ Cs	2,2-3,5	Data for January and February
	⁹⁰ Sr	5,0,6.6	Data for January and February
Kyiv Reservoir, The city of Vyshhorod	¹³⁷ Cs	4,7 – 12,8	
	⁹⁰ Sr	16,2-45,3	
Dnipro River. The city of Kyiv	¹³⁷ Cs	2,7 – 7,3	
	⁹⁰ Sr	11,0 – 40,4	
Desna River, the city of Chernihiv	¹³⁷ Cs	0,3 – 1,8	
	⁹⁰ Sr	3,5 – 5,5	
Kaniv Reservoir, The city of Kaniv	¹³⁷ Cs	0,5 – 3,5	
	⁹⁰ Sr	7,4 – 17,0	
Kakhovka Reservoir The city of Nova Kakhovka	¹³⁷ Cs	0,3 -0,5	Data for January and February
	⁹⁰ Sr	12,1 – 16,2	Data for January and February
Pivdennyi Buh River, the city of Mykolaiv	¹³⁷ Cs	0,3 – 2,6	
	⁹⁰ Sr	4,3 – 6,5	
Dunay River, the city of Ismail	¹³⁷ Cs	0,5 – 3,1	
	⁹⁰ Sr	0,5 – 3,1 3,4 – 9,7	

Radiation and Environmental Monitoring on the Territory of the Chornobyl Exclusion Zone

Radiation and environmental monitoring (REM) on the territory of the Chornobyl exclusion zone is provided by SSE Ecocenter Subdivisions of the State Agency of Ukraine on Exclusion Zone Management (SAUEZM) in accordance with the Regulation agreed by SNRIU, the Ministry of Health of Ukraine and approved by SAUEZM that provides for the measurement of: exposure dose rate, soil contamination density, radionuclide concentration in the air (including working areas and premises), intensity of radioactive atmospheric fallout, radionuclide concentration in surface, underground, drinking and waste waters, as well as measurements of individual hydrometeorological parameters.

The radiation-hazardous objects and environmental components in the exclusion zone were not monitored during the occupation of the exclusion zone by the military forces of the russian federation from 24 February to the early April 2022. On 25 February 2022, the automated radiation monitoring system (ARMS) in the exclusion zone continued to perform its functions and recorded changes in the radiation situation at the observation points in real time (Figure 8) confirming a significant increase in gamma radiation at a significant number of the observation points. The recorded dose rate ranged from 2.05 to 9.46 μ Sv/h, which is 5-15 times higher than the reference levels of dose rates for this area based on the longterm observations.

According to SSE Ecocenter responsible for radiation and dosimetry control and monitoring on the territory of the exclusion zone, the causes for the increased dose rates could be loss of integrity of soil cover on radiation-contaminated territories in the exclusion zone, dust raising caused by the movement of heavy equipment of russian troops across the Belarusian border, etc.

ARMS data from the exclusion zone were no longer received automatically since 26 February 2022. The servers of SSE Ecocenter that accumulated the programs for processing, archiving and predictive assessments of the radiation situation, including programs for integrated data on the nonproliferation of nuclear and radiation materials beyond the exclusion zone were destroyed resulting from the occupation. Stationary and mobile devices for radiation and dosimetry monitoring, including the mobile radiation reconnaissance laboratory, office and computer equipment of SSE Ecocenter were stolen or disabled.

In March 2022, in response to public request for reliable information on radiation background in Ukraine during the military aggression of the russian federation and failure or termination of access to data from the standard automated radiation monitoring systems of NPPs and the exclusion zone, the Ministry of Environmental Protection and Natural Resources of Ukraine in cooperation with SaveDnipro Public Organization collected up-to-date data on radiation situation in Ukraine on the Saveecobot resource on a single online map available at <u>https://www.saveecobot.com/radiation-maps</u>

Owing to the cooperation with the owners of measurement data: the Ministry of Health, the State Emergency Service of Ukraine, UkrHMC, local authorities and



Figure 8 – Screenshot of EDR indicators of ARMS in the exclusion zone dated 25 February 2022

business entities, the information on the map is updated daily and remains a public information resource in times of the war.

On 29 April 2022, by Order No. 323-r of the Cabinet of Ministers of Ukraine, the Strategy for the integrated automated radiation monitoring system by 2024 was approved and the Operational Plan for the implementation of this Strategy was also approved, the expected results of which are as follows:

creation of the unified integrated radiation monitoring system;

synchronization of the Ukrainian radiation monitoring system with EURDEP and ECURIE European Platforms;

access to monitoring results in real time; implementation of mechanisms for early notification, assessment and prediction of the radiation situation in Ukraine in case of transboundary transfer of radioactive substances;

ability to make efficient operational decisions on radiation protection measures for personnel and the public in radiation hazard initiation.

After de-occupation, SSE Ecocenter assessed damage caused by russian aggression and developed priority measures to renew the functionality of the radiation safety system, radiation and dosimetry control on the territory of the exclusion zone and control and dosimetry points on the border of radiation-regime zones.

Owing to volunteer assistance and high professionalism of SSE Ecocenter personnel and other enterprises in the exclusion zone, the operation of SkyLink ARMS was renewed in May 2022: information on EDR was received from the automated monitoring points (AMP) in accordance with the regulations, the operation of ARMS database was also renewed, as well as the technical procedure for transferring data on EDR from ARMS to the international radiation monitoring system IRMIS (IAEA) in the international IRIX format through the State Data Transfer Provider - SESU UkrHMC Center for Forecasting the Consequences of Radiation Accidents and to EcoZahroza official resource of the Ministry of Environmental Protection and Natural Resources of Ukraine developed with the support of the Ministry of Digital Transformation of Ukraine for automatic collection and recording of information on environmental hazards in real time.

In addition to operation renewal of the main ARMS, an additional network for measuring indicators of gamma equivalent dose rate (EDR) using SPIDER GammaTracer dosimeters was created in the exclusion zone owing to the cooperation with the National Nuclear Security Administration (DoE/NNSA) of the US Department of Energy during the military state on the territory of Ukraine in order to ensure radiation safety and civil protection of the public, prevent occurrence of radiation accidents in places where control over radiation sources is lost as a result of the war, as well as counter misinformation in failure of stationary radiation monitoring systems.

The access control at two control and dosimetry points (CDP) was strengthened by the mobile radiation detection systems with the function of portal monitors for automatic scanning of vehicles and cargo containers for the presence of radioactive sources.

The priority measures to renew the radiation monitoring system in the exclusion zone allowed the following:

renew operation of ARMS points in limited operation mode;

create additional network for measuring the equivalent dose rate (EDR) of gamma radiation in the ChEZ by SPIDER GammaTracer dosimeters;

renew operation of sections in the central analytical laboratory of SSE Ecocenter, namely: gamma spectrometry, beta spectrometry, alpha spectrometry, radiochemical separation of strontium, isotopes of plutonium and americium;

renew operation of aspiration installations in the checkpoints in Dytiatky, Chornobyl, Kopachi and Buryakivka RWDS.

The monitoring network located on the left and partially right banks of the Prypyat' River remained inaccessible due to the military aggression (ARMS: Masheve, Zymovyshche, Starosillia, Benivka, Buryakivka; wells on Krasnyansk floodplain, Chystohalivka RWDS, regime network of the Prypyat water intake (506, 508, 511, 185Q1-3); surface water monitoring points: Brahinka River, Hlyboke Lake, polder near the village of Zymovyshche (Dam No. 7), Prypyat River (Usiv village).

The Information Report of SSE Ecocenter on radiation and environmental monitoring results in the exclusion zone for 2022 presents the observation results of the most dynamic natural environments and parameters: EDR, surface and ground waters, surface layer of the atmosphere in the exclusion zone.

Meteorological conditions, anthropogenic factors, the magnitude and physical and chemical form of emergency fallout resulting from the 1986 Chornobyl accident affected the radiation situation of the surface layer of the atmosphere in the exclusion zone in 2022.

The highest concentrations of ¹³⁷Cs in the air were recorded at the monitoring points in the near zone where volumetric activity varied within 4.5E-06 - 2.8E-03 Bq/m³, but did not exceed the reference levels (RL) for ¹³⁷Cs air contamination established by the health and safety standards "Basic Reference Levels, Release Levels and Action Levels for Radioactive Contamination in the Exclusion Zone and Zone of Unconditional (Mandatory) Resettlement".

The highest concentrations of ⁹⁰Sr in the air at the monitoring points in the near zone were registered at Naftobaza ARMS -1.9E-04 Bq/m³ in August 2022 without exceeded reference levels of ⁹⁰Sr air contamination.

The highest volumetric activity of ¹³⁷Cs of the air in the far zone were recorded in September at Chystohalivka ARMS at the points of the partially renewed observation system (10 km around ChNPP). The maximum volumetric activity of ⁹⁰Sr in the air in the far

zone was recorded in August and reached 1.1E-04 Bq/m³ at Chystohalivka ARMS point.

In the places of personnel longest stay in the exclusion zone, the volumetric activity of radionuclides in the air was: ¹³⁷Cs from 3.4E-06 to 2.6E-04 Bq/m³ in the city of Chornobyl with two cases of exceeded reference levels (RL) **2.6** times in May and **3.3** times in September (RL = 8.0E-05 Bq/m³), ⁹⁰Sr from 6.4E-07 to 1.1E-04 Bq/m³ (in August) with exceeded RL **2.5** times (RL = 4.0E-05 Bq/m³); ¹³⁷Cs from 3.8E-07 to 6.9E-05 Bq/m³ (in September) at Dytiatky Checkpoint without exceeded RL for air contamination, ⁹⁰Sr from 1.0E-07 to 4.4E-05 Bq/m³ (in August).

Exceeded reference levels at Chornobyl ARMS resulted probably from fire in the exclusion zone ecosystems and dry meteorological conditions in August and early September.

According to SSE Ecocenter, 86 cases of fire with the total area of about 24.276 hectares were recorded in 2022 on the territory of the ChEZ, including 8 cases of fire with burning area over 1,000 hectares. Information on the radiation situation related to fire spreading on the territory of the ChEZ was only evaluative and was based on NASA FIRMS existing information and remote data (Fire Information for Resource Management System) available at https://firms.modaps.eosdis.nasa.gov/map/.



Figure 9 – Dynamics of volumetric activity (Bq/m³) of ¹³⁷Cs in the surface layer of the air at Chornobyl ARMS in 2022 (data for the period from the beginning of the ChEZ occupation until operation renewal of the monitoring system are not available)



Figure 10 – Dynamics of volumetric activity (Bq/m³) of ⁹⁰Sr in the surface layer of the air at Chornobyl ARMS in 2022 (data for the period from the beginning of the ChEZ occupation until operation renewal of the monitoring system are not available)

Radiation monitoring of surface water in the exclusion zone and in 2022 included observing the hydrological regime and radiation situation in the city of Prypyat', the northwestern part of the Kyiv Reservoir, Chornobyl spent fuel pool, the inlet and outlet channels of ChNPP Stage 1 and 2, the outlet channel of Stage 3, backwaters and lakes fenced off from the Prypyat' River on its right-bank floodplain, and water bodies at the site of the water protection facilities on the left-bank floodplain. The control covered nine large and small watercourses, and 10 closed reservoirs in about 30 sections and points. The concentrations of the main contamination radionuclides ¹³⁷Cs and ⁹⁰Sr were determined in all water samples. The content of ²⁴¹Am and plutonium isotopes was monitored at different intervals in water of the Prypyat' River, ChNPP spent fuel pool, the left-bank polder in the upper bay of the hydrotechnical structure No. 7 and the Hlyboke Lake.

The renewal of surface water monitoring after the de-occupation directly depended on safety situation in the ChEZ, the ability of units to access observation points and technical capabilities of the SSE Ecocenter central analytical laboratory. It was impossible to renew monitoring of the water bodies in the exclusion zone, which are located on the left bank of the Prypyat' basin.

⁹⁰Sr volumetric activity in water in the controlled streams was on average at the level or below the long-term values. According to the design data of SSE Ecocenter, the removal of ⁹⁰Sr with Prypyat' River at the dam in Chornobyl in 2022 amounted to 0.93 TBg (25 Ci), which is approximately 1.7 times more than the removal value in 2021.

According to the design data, the removal of ⁹⁰Sr with Uzh River water has amounted to 0.05 TBq (1.4 Ci), which is 1.7 times more than the value for the previous year; for Brahinka River the value was 0.08 TBq (2.2 Ci), this exceeds two times the value for 2021. In total, 1.06 TBq (29 Ci) of ⁹⁰Sr was carried into the Kyiv Reservoir with surface water. The contribution of the Pripyat' River to the total removal of ⁹⁰Sr to the Kyiv Reservoir was 87%, the value for the Uzh River amounted to 5%, and the one for the Brahinka River made up 7%.

¹³⁷Cs content in water of small rivers in the ChEZ during the periods of runoff was at the levels close to those of recent years. The maximum value of ¹³⁷Cs is observed in the summer months in water of most closed reservoirs, first in ChNPP spent fuel pool (SFP).

Among the controlled water bodies, the maximum total values of ¹³⁷Cs volumetric activity (solution and suspension) are typical for the outlet channel of Chornobyl NPP Stage 3 (65 kBq/m³), for the inlet channel of the Chornobyl spent fuel pool (10 kBq/m³), Semykhodky Bay (8.9 kBq/m³) and Azbuchyn Lake (6.9 kBq/m³).

There was an increase in the volumetric activity of ⁹⁰Sr in the water of the Azbuchyn Lake during 2015 - 2022 (Figure 11). Possible cause for ⁹⁰Sr content increase in the closed water body of the lake is the entry of mobile radionuclide forms into the water from the dried bottom bed and shallow areas due to the drop in the water level in the lake from 107.50 mBS to the minimum level of 103.75 mBS (in 2017), as well as changes

in the mode of groundwater hydraulically connected with the lake.

Surface waters remain an important route for radionuclide removal beyond the ChEZ. ⁹⁰Sr removal with water of the Prypyat' River in the dam of Chornobyl depends on water content during the year. In 2022, water removal was determined according to the design data and taking into account the data obtained during the long-term observations: according to SSE Ecocenter, it amounted to 0.93 TBq for ⁹⁰Sr and 0.43 TBq for ¹³⁷Cs.

The observations of the radiation situation of groundwater determined that contamination of the Eocene and Cenomanian-Lower Cretaceous aquifers with ¹³⁷Cs and ⁹⁰Sr radionuclides did not exceed 20 Bq/m³. The indicators of contamination of the aquifer in Quaternary sediments with ⁹⁰Sr in 2022 reached 100.000 Bq/m³. A range of technical activities and laboratory investigations to analyze the dynamics of changes in ⁹⁰Sr indicators in the aquifer complex in the exclusion zone is under the control of the SAUEZM.

There is also an increase in the content of ⁹⁰Sr in water of the Hlyboke Lake (Figure 12). At the same time, water levels in the water body did not significantly change in contrast to the Azbuchyn Lake.



Figure 11 – Dynamics of ⁹⁰Sr volumetric activity in water of the Azbuchyn Lake for 2015-2022 (data for the period from the beginning of the ChEZ occupation to the renewal of the monitoring system operation are not available)



Figure 12 – Dynamics of ⁹⁰Sr volumetric activity in water of the Hlyboke lake for 2015-2022 (data for the period from the beginning of the ChEZ occupation to the renewal of the monitoring system operation are not available)

The water level in the Chornobyl spent fuel pool started to reduce after shutdown of the onshore pumping station (OPS) in 2014. By mid-2017, filtration losses were the main cause of water level decrease, and since 2018, level decrease resulted mainly from evaporation. In recent years, a new system of water bodies was formed within the basin of the spent fuel pool, in which their own hydrological regime is generated. The Dynamics of ¹³⁷Cs volumetric activity in the water bodies for 2015-2022 is shown in Figure 13.

The activity levels are indicated in accordance with the Health and Safety Standards "Basic Reference Levels, Release Levels and Action Levels for Radioactive Contamination in the Exclusion Zone and Zone of Unconditional (Mandatory) Resettlement" put into force by Order of the SAUEZM Chairman No. 01-467/3.2-22 dated 15 February 2022.

The laboratory capabilities of SSE Ecocenter to determine the content of transuranium elements (²³⁸Pu, ²³⁹⁺²⁴⁰Pu, ²⁴¹Am) (TUE) in water have not been updated, there are no monitoring results for this indicator for 2022.

¹³⁷Cs and ⁹⁰Sr content in water at ChNPP water intakes and in the city of Chornobyl was within 0.1-20 Bq/m³. The permissible level in 2006 for drinking water according to ⁹⁰Sr and ¹³⁷Cs content was 2000 Bq/m³. The maximum values of ⁹⁰Sr volumetric activity in water of the observation wells were recorded in the areas of the Stara Budbaza, Azbuchyn Lake, Yaniv Bay, Semykhodky Bay and amounted to 100.000, 90.000, 47.000, 41.000 Bq/m³. The maximum volumetric activity of ¹³⁷Cs reached 15.000 Bq/m³ near the village of Lisove in water of K-13D wells. The stable high values of ¹³⁷Cs volumetric activity in water of these wells are observed after flooding of RICS territory with melt and rain waters in 2013.

The observations of the radiation situation of groundwater determined that contamination of the Eocene and Cenomanian-Lower Cretaceous aquifers with ¹³⁷Cs and ⁹⁰Sr radionuclides did not exceed 20 Bq/m³ while indicators of aquifer contamination with ⁹⁰Sr in Quaternary sediments in 2022 reached 100.000 Bg/m³. The range of technical activities and laboratory investigations to analyze the dynamics of changes in ⁹⁰Sr indicators in the aquifer is under the control of the SAUEZM.

Given the importance of the issue related to the non-proliferation of radioactive contamination, maintaining control over the radiation situation in the ChEZ, radiation protection of personnel and the public, the system of radiation safety and radiation and environmental monitoring in the ChEZ requires adaptation to modern conditions that are currently developing in the ChEZ.

The renewal of radiation monitoring and control of nuclear and radiation safety at the nuclear infrastructure facilities in Ukraine that were occupied or suffered as a result of the military aggression of the russian federation (particularly, at ChNPP site and at other nuclear and radiation facilities in the territory of the exclusion zone), as well as the situation related to the accounting, control and security





of nuclear materials and radiation sources in the liberated and de-occupied territories of Ukraine remains an urgent task.

The Joint Survey Project implemented as part of the cooperation program between the SNRIU and the Norwegian Nuclear and Radiation Safety Authority (DSA) was aimed at surveying the territories in the Kyiv region influenced by the temporary military occupation by russian armed forces and hostilities.

The radiation survey was carried out by the crew of the RanidSONNI radiation reconnaissance vehicle of the State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) and included housing (private estates, apartments and houses), public institutions (schools, state medical institutions, office buildings, etc.) and a part of the intercity roads on the territory of the Kyiv region that was temporarily occupied by russian troops from 24 February to 1 April 2022.

30 trips of the mobile laboratory crew were carried out during the implementation of two phases of the Survey Project. The total length of the survey routes was more than 880 km that are shown on the map (Figure 14).

EDR measurements and identification of radionuclides in the environment by on-board (built into the radiation reconnaissance vehicle) detectors were carried out continuously. Manual measurements in this area were conducted every 2–10 km on the intercity roads and in the search mode when surveying the streets, yards and parks. The fortifications and remains of military equipment left on the roadsides were surveyed separately. In general, the measurement was carried out at more than 100 points in this area (except for the surveys on the territory of the exclusion zone and the zone of unconditional (mandatory) resettlement.

More than 60 apartments, 130 private houses and home gardens, about 130 public institutions, administrative buildings and public places were surveyed in accordance with the applications received from residents of the Kyiv Oblast and the local governmental bodies.

Radiation survey of the road section from the city of Kyiv to the village of Ivankiv in Vyshhorod district (through the villages of Novi and Stari Petrivtsi, Lyutizh, Demydiv, Dymer,



Figure 14 – Routes of the RanidSONNI mobile laboratory

Katyuzhanka, Fenevychi, Rudnya-Shpilivska) was conducted on 14 June 2022.

Radiation survey of the road section from the village of Ivankiv in Vyshhorod district to the village of Dytiatky (through the villages of Sukachi, Prybirsk, Khocheva, Orane) was conducted on 15 June 2022. A point radiation anomaly with EDR of about 6 μ Sv/h was detected during the survey of the road section in the village of Orane, Dytiatky checkpoint on the side of the road when measured at a height of up to 5 cm from the soil surface, which was caused by cesium-137 isotope. EDR at a height of 1 m was 0.17 μ Sv/h, which is within the natural background typical for this area.

A survey with a metal detector did not reveal foreign objects, so it is possible that this point contamination was caused by the so-called "hot particle" that could have been transferred from the Chornobyl exclusion zone after the Chornobyl accident or taken out on tracks or wheels by occupation heavy equipment. There are no buildings, places of permanent or temporary stay of people, and there is no agricultural activity and grazing near the detected point contamination, therefore, the detected radiation anomaly does not pose a hazard to human life and health.

Radiation survey of the road section in the southeastern part of the exclusion zone and the zone of unconditional (mandatory) resettlement was conducted on 23 June 2022. Radiation survey of road sections, residential buildings and apartments in the cities of Bucha, Irpin, Hostomel and Vorzel, in the villages of Ozera and Dmytrivka was conducted from 27 June to 14 July 2022.

An aviation watch with a constant-action luminous mass containing Ra-226 was revealed during the survey in one of the private apartments in the village of Hostomel. EDR on the surface of the watch was 10 μ Sv/h. The owner of the watch was advised to hand it over to a specialized company for safekeeping, and call the police or the SESU.

The road sections, residential buildings, apartments, public places, educational and medical institutions in the villages of Ivankiv, Krasiatychi, Musiyki, Potaliivka, Termakhivka, Sydorovychi, Varivsk, Zhmiivka, Olizarivka, Stari Sokoly, Levkovychi, Vovchkiv, Lugovyky, Mlachivka, Maksymovychi, Radinka were surveyed during the period from 08 September to 27 October 2022.

Radiation survey of the road sections, residential buildings, apartments, public places, educational and medical institutions

in the village of Makariv, Maryanivka, Kolonshchyna, Berezivka, Mykolaivka, Kopyliv, Severynivka, Motyzhyn, Makovyshche, Vyshehrad, Havronshchyna, Plakhtianka, Andriivka, Chervona Hirka, Lypivka, Lozovyk, and Pochepin has been continued from 08 to 11 November 2022.

Radiation survey of the road sections near the village of Myrotske and Klavdievo-Tarasove was conducted on 16 November 2022.

Radiation survey of the road sections, residential buildings, apartments, public places, educational and medical institutions in the city of Bucha, in the village Myrotske, Blystavytsia, Synyak, Lubyanka, Zdvyzhivka, Babyntsi was conducted on 24-28 November 2022.

The road sections, residential buildings, apartments, public places, educational and medical institutions in the village of Borodianka, Nemishaieve, Druzhkivka, Pylypovychi, Nova Hreblya, Myrotske, Novyi Korohod, Dmytrivka, Zahaltsi, Maidanivka, Myrcha, Shybene, Zdvyzhivka, Nove Zalissya were surveyed from 30 November to 2 December 2022.

DP-63-A dosimeter with a permanent light mass containing Ra-226 was revealed during the survey of the educational institution in the village of Myrcha. Gamma radiation dose rate at the distance of 0.1 m from the dosimeter was up to 1.55 μ Sv/h, and it was up to $33 \,\mu$ Sv/h on the surface of the dosimeter. The information was submitted to the National Police, the State Emergency Service of Ukraine and SNRIU. The executive authorities of the Borodianka village territorial society arranged the cooperation with the Radon Association in accordance with Ordinance of the Cabinet of Ministers of Ukraine No. 813 dated 2 June 2003 "On the Approval of the Procedure for Interaction between the Executive Bodies and Legal Entities Carrying out Activities in the Field of Nuclear Energy Use in Revealing Illicit Trafficking of Radioactive Materials".

Gamma radiation dose rate measured on the routes of movement and at the observation points (except for the exclusion zone and the zone of unconditional (mandatory) resettlement) did not exceed 0.24 μ Sv/h, which corresponds to the data of long-term and seasonal fluctuations in the radiation background for this area. Exceeded EDR values (up to 0.44 μ Sv/h) revealed in some buildings were associated with the use of finishing materials containing an increased amount of natural radionuclides.

VI. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Safe management of radioactive waste (radwaste) is one of the most important factors for the sustainable development of nuclear energy in Ukraine, as well as the use of radiation and nuclear technologies in medicine, science and industry.

Radwaste Management at Operating NPPs

The production of electrical energy at NPPs is accompanied by generating radwaste of different activity and aggregation state, both directly during the implementation of the main technological processes for the operation of NPP nuclear installations, and during routine maintenance activities and operations. According to Energoatom annual reports, on average, for 1 billion kWh of electricity produced, depending on the reactor type, up to 27 m³ of solid radwaste and 35 m³ of liquid radwaste are generated.

Improvement of NPP radioactive waste management systems is an urgent need and is aimed at ensuring radwaste processing to a state that will meet the acceptance (or acceptability) criteria for their disposal in centralized radioactive waste storage facilities.

Measures for implementing the Energoatom technical policy in the field of radioactive waste management are provided by the Comprehensive Program for Radioactive Waste Management at Energoatom PM-D.0.18.174-21. According to this Comprehensive Program, the main functions of operating organization Energoatom in the field of radioactive waste management are to:

ensure safe operation for structures and equipment of the radwaste management system;

ensure radwaste accounting and physical protection, compliance with radiation safety standards and rules during radwaste management;

ensure radiation protection of personnel, the public and the environment;

minimize radioactive waste generation during operation of NPP units;

collect, process, decontaminate, condition, certify radioactive waste packages in order to prepare them for transfer to Vektor storage/disposal facilities for longterm storage or disposal;

provide temporary storage of radwaste in storage facilities at NPP industrial sites;

release radioactive materials from regulatory control.

Liquid Radwaste Management

The main liquid radwaste (LRW) source is drain water (radioactively contaminated effluents that enter the active drains) – uncontrolled primary leaks; leaks of the spent fuel pool; rooms, equipment decontamination water; discharges from showers, air locks; discharges from laboratories, including sampling; regeneration and washing water of a unit desalination facility and filters of special water treatment facilities (SWT); equipment operational flushing with reagents, in particular evaporators.

As a result of operation of SWT installations, the following LRW types are generated at NPP:

evaporation bottom – product of drain water and special laundry water processing at special water treatment installations;

spent filter materials coming from the filters of special water treatment installations in case of expiration of ion-exchange material service life;

sludge;

spent oils and mixed fluids.

In order to reduce the volume, evaporation bottom after the SWT-3 and SWT-7 special water treatment evaporators is evaporated in deep evaporation installations to obtain the solidified salt fusion cake, which is placed in special 200-liter packaging - KRO-200 (except for PNPP), which allows effectively reduce waste volume. Spent filter materials and sludge are collected and stored in tanks of liquid radwaste storage facilities under a layer of water. Filter materials are currently not processed.

LRW (evaporation bottom, spent filter materials and sludge) are stored in metal sealed tanks made of corrosion resistant steel equipped with an automated system for LRW level determination. To prevent an emergency LRW leak into the environment, all containers are placed in reinforced concrete rooms lined with corrosion resistant steel sheets to the height of an emergency spill of tanks and are equipped with leak control alarms.

Centrifugation installations for purification of drain water from solid fraction (sludge) are operated at Rivne and Khmelnytskyi NPPs. The dehydrated sludge is stored in packaging KT-0,2 at solid radwaste storage facilities.

А bituminization installation was implemented to process evaporation bottom in 1995 at Rivne NPP – at the only NPP among other Ukrainian NPPs. The principle of installation operation is to evaporate the evaporation bottom to a state with 5% humidity and simultaneous inclusion of salts into the bitumen matrix. The bituminization installation was finally closed in 2002 in accordance with the fire safety requirements. The salt-bitumen compound is accumulated in the amount of 147.8 m³ (739 packages).

In order to prepare for the transfer of the salt-bitumen compound (SBC) for disposal, RNPP developed Technical Solution on the Procedure for Processing the Salt-Bitumen Compound with Subsequent Disposal and agreed it with the State Nuclear Regulatory Inspectorate of Ukraine. According to this Technical Solution, in 2021, the first batch of SBC in the amount of 60 packages was transported to CRME (12 m³). In 2022, after studies to determine whether the material of the salt-bitumen compound belongs to explosives, it was planned to transfer the second SBC batch in the amount of 679 packages under a separate agreement. However, due to the full-scale aggression of the russian federation against Ukraine, temporary occupation of the exclusion zone, impossibility to conduct additional studies on the characteristics of the saltbitumen compound during the martial state, transport and transfer of containers with the salt-bitumen compound to CRME in 2022 was not carried out.

Due to the lack of installations for processing spent filter materials and sludge, the scope of such radioactive waste accumulation at NPPs increase. Therefore, one of the Energoatom priority tasks is to introduce technologies for immobilization of spent sorbents and sludge and start their processing. For this purpose, the activities are underway to develop formulations for immobilization of spent filter materials and sludge from NPPs and immobilization of an experimental batch of filter materials and sludge by fixing radwaste in a geopolymer matrix using a mobile unit. Processing technology should allow obtaining the necessary characteristics of solidified radwaste acceptable for its safe storage and disposal.

In general, for NPPs, the condition of tanks at the liquid radwaste storage facility (LRSF) at RNPP, KhNPP and PNPP is satisfactory, there were no leaks from the tanks into the rooms and into the environment in reporting year 2022, there were no failures and malfunction of drain water and LRW treatment installations. The data on the amount of generated and accumulated LRW, condition of LRSF tanks, as well as drain water and LRW treatment installations at ZNPP for 2022 are not available.

The Report on Radioactive Waste Management and Implementation of Measures of the Comprehensive Program for Radioactive Waste Management in the Energoatom for 2022 in terms of the dynamics for accumulation of evaporation bottom, filter materials and dehydrated sludge, shows that with stable operation of deep evaporation installations, the implementation of the measures planned in the Comprehensive Program for Radioactive Waste Management in Energoatom, empty LRSF tanks will be enough for safe long-term operation of power units.

The russian full-scale aggression against Ukraine, introduction of martial law, temporary occupation of ZNPP, shelling of energy infrastructure facilities negatively affect the operation of NPPs in general and, in particular, the plans and processes for radioactive waste management: condition of radwaste processing facilities at ZNPP is unknown; plans for the construction of radwaste processing facilities at KhNPP and PNPP have been postponed; radwaste packages have not been transported from RNPP to the Vektor site.

Solid Radwaste Management

Solid radwaste (SRW) sources at NPPs are materials generated during repair and maintenance of process equipment; personal protective equipment for personnel; parts of equipment and piping, spent special ventilation filters, etc.

SRW management at NPPs includes collection of waste into primary containers at the places of their generation; sorting by activity; transport of waste to centralized places of collection or processing; radwaste processing; transport of SRW containers to solid radwaste storage facilities (SRSF) using special vehicles; waste acceptance and its unloading in SRW sections; reporting on and accounting of radwaste. Solid radwaste storage facilities at NPP sites are reinforced concrete structures consisting of separate compartments for radioactive waste, depending on the level of activity. Prior to SRW placement for temporary storage, the following is performed:

preliminary treatment of low-level SRW - pre-compression (ZNPP and PNPP);

processing of low-level SRW at the installations of radioactive waste treatment plants (ZNPP and RNPP).

With putting radwaste treatment plants (RWTP) into commercial operation in 2019, processing and conditioning of low-level SRW to the state acceptable for disposal started at ZNPP and RNPP, which allows volume release of existing radwaste storage facilities for the safety of further long-term operation of power units.

Detailed information on the installations that are part of RWTP at ZNPP, RNPP and under construction at KhNPP is presented in the relevant section of the Report on the State of Nuclear and Radiation Safety in Ukraine in 2021.

In 2022, there was a decrease in the performance of RNPP RWTP by 34.7% compared to 2021, which is associated with a 29% decrease in the amount of SRW received for processing at RWTP. RWTP implementation (the effect of implementation) as a whole allowed reducing the amount of radwaste entering SRW storage cells for temporary storage by 40%. 136.63 m³ were accepted for processing at RWTP, 24.15 m³ – processing product obtained, number of KTRVf-0.2 packages - 115 pcs.

RWTP is operated in accordance with the requirements of the Technical Specifications for Safe Operation of the Radioactive Waste Treatment Plant. RWTP equipment is operated in accordance with the requirements of document "Radioactive Waste Treatment Plant. Safety Analysis Report". In accordance with para. 2.4.13.20 of the Technical Specifications and para. 7.3 of the "Certificate 175-154-A-TsDtaRAV of 27 December 2019. Acceptance of the RNPP Radwaste Treatment Plant into Operation (Commercial)", RWTP metal decontamination installation will he operated after implementing the procedure for the release of metal radwaste from regulatory control at RNPP in accordance with NP 306.4.159-2010 "Procedure for the Release of Radioactive Materials from Regulatory Control in the Framework of Practical Activities."

RWTP commissioning at KhNPP is scheduled for 2024. RWTP commissioning at PNPP is scheduled for 2028.

According to the Report on Radioactive Waste Management and Implementation of Measures of the Comprehensive Program for Radioactive Waste Management in the Energoatom for 2022, the dynamics of generating the main SRW categories and types is presented in tables.

Year	ZNPP, m ³	RNPP, m ³	KhNPP, m ³	PNPP, m ³
2017	516,4	279,7	134,2	338,2
2018	582,8	308,2	157,6	179,6
2019	638,9	290,7	208,25	245,0
2020	636,2	434,3	131,0	238,0
2021	549,98	228,04	185,02	226,4
Average for 5 years	584,6	308,2	163,2	245,3
2022	119,7*	264,93	121,3	157,3

Table 5 – Dynamics of generating low-level SRW at NPPs

* Available data as of 30 June 2022.

Year	ZNPP, m ³	RNPP, m ³	KhNPP, m ³	PNPP, m ³
2017	22,84	14,31	3,33	8,0
2018	28,92	16,22	2,21	8,0
2019	1,84	24,72	1,32	8,0
2020	57,61	17,66	0,31	10,8
2021	48,20	10,37	3,01	10,0
Average for 5 years	31,88	16,66	2,04	8,96
2022	4,7*	6,59	1,51	10,0

Table 6 – Dynamics of generating intermediate-level SRW at NPPs

* Available data as of 30 June 2022.

Table 7 – Dynamics	s of generating	the salt fusion cake at NPPs
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Year	Formation of salt fusion cake, m ³			Formation of salt fusion cake, packages		
	ZNPP	RNPP	KhNPP	ZNPP	RNPP	KhNPP
2017	179,4	77,6	24,0	897	388	120
2018	140,0	57,2	24,0	700	286	120
2019	180,8	45,8	20,4	904	229	102
2020	186,6	14,6	36	933	73	180
2021	146,0	35	21,6	730	175	108
Average for 5 years	166,6	45,3	25,2	833	230	126
2022	49,0*	31,6	25,2	245*	158	126

* Available data as of 30 June 2022.

Table 8 – Dynamics of generating high-level SRW at NPPs

,	5 5	5		
Year	ZNPP, m ³	RNPP, m ³	KhNPP, m ³	PNPP, m ³
2017	0,33	3,72	0,345	0,3
2018	1,92	1,18	0,178	0,4
2019	1,61	2,257	0,080	0,4
2020	1,93	5,45	0,190	0,35
2021	2,355	0,678	0,135	0,68
Average for 5 years	1,35	3,76	0,186	0,43
2022	0,06*	4,257	0,208	0,60

* Available data as of 30 June 2022.

All NPPs have the Reference Levels for Radwaste Generation and Transfer to Radioactive Waste Storage Facilities. The reference levels for SRW and LRW generation were not exceeded in 2022.

Radioactive materials that due to natural radioactive decay or decontamination/processing have reached the release levels may be released from further regulatory control, which is a well-established practice to minimize the amount of radioactive waste and reuse materials and equipment, if it is proved that the radiation risks can be ignored.

Release of Radioactive Materials Located at KhNPP from Regulatory Control

According to the statements of the Energoatom and documents attached to them (application documents were submitted in April and December 2022), SNRIU made the decision on:

1) unrestricted release of two batches (Batch No. 1-P and Batch No. 1) of radioactive materials in the form of BB-cube reinforced concrete containers in the amount of 92 pcs with a total weight of 552 tons from regulatory control by termination;

2) restricted release of two batches (Batch No. 2-O and Batch No. 2) of radioactive materials in the form of BB-cube reinforced concrete containers in the amount of 8 pcs with a total weight of 47.645 tons from regulatory control by termination.

Reinforced concrete containers, according to the design and operational documents, were used at the KhNPP site for the placement and safe storage of metal drums with a volume of 200 liters filled with radioactive waste in the form of salt fusion cake after processing at the UGU1-500 deep evaporation installation.

In 2016, metal drums with salt fusion cake and zeolite were unloaded from these reinforced concrete containers and transferred to cells 101/8 and 101/9 of the SRSF storage unit at Energoatom KhNPP. Before being released from regulatory control, all BB-cube reinforced concrete containers were empty at the KhNPP temporary storage site.

The Khmelnytskyi NPP decontaminated surfaces of the empty BB-cube containers and conducted relevant measurements of radiation parameters, based on which documents were drawn up to justify the possibility of release from regulatory control. According to the decision taken by SNRIU on unrestricted release for batches of radioactive materials in the form of reinforced concrete containers from regulatory control, these containers can be further used without restrictions.

Restrictedly released radioactive materials in the form of reinforced concrete containers are planned to be used at the KhNPP site as construction materials or protective fencing of the VRP-750 kV electrical equipment.

Radwaste Management at the RADON Association

The collection and storage of radioactive waste generated from the use of radiation sources in medicine, science, various industries, including disused radiation sources transferred to the category of radioactive waste, is provided by state specialized enterprise for radioactive waste management RADON Association, which includes the Central Production Site (CPS), Dnipro Interregional Affiliate (DIA), Lviv Interregional Affiliate (LIA), Odesa Interregional Affiliate (OIA), Kharkiv Interregional Affiliate (KhIA).

In accordance with the conditions of the licenses issued by SNRIU for processing, storage of radioactive waste, the RADON Association provides:

operation of storage facilities for radwaste container storage;

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

collection, conditioning and transport of radioactive waste to storage facilities;

operation of decontamination points for overalls, underwear, personal protective equipment;

maintenance of the state radwaste accounting system;

participation in the mitigation of radiation accidents.

Radwaste storage facilities operated by the RADON Association are hangartype buildings, which provide container storage of radwaste and disused radiation sources. These buildings were constructed on the RADON Association sites in the 1990s when the decision was made to transfer state specialized enterprises for radioactive waste management to the technologies of radioactive waste storage.

Finally closed radwaste repositories filled up to 1996 by the disposal technologies are a system of near-surface reinforced concrete radwaste disposal facilities of a modular type with a capacity of 200 m³ and 400 m³, constructed according to standard designs in the 1960-1970s. The RADON Association provides maintenance, monitoring and reassessment of their safety to make decisions on safety of each specific repository; periods during which these repositories can provide reliable isolation of radioactive waste; technological solutions on the removal of radioactive waste and decommissioning of repositories.

With the beginning of the russian military aggression on the territory of Ukraine, the RADON Association partially suspended the licensed activities for radwaste management, in particular, collection and transport of radioactive materials (disused radiation sources and radwaste); preparation for radwaste removal from radwaste storage facilities and radwaste transfer in the form of disused radiation sources to the CRME Centralized Long-Term Storage Facility (CLTSF) located in the exclusion zone, during its occupation by the russian troops and until the completion of demining.

During this period, the activities of the RADON Association CPS and interregional affiliates (KhIA, DIA, LIA OIA) were limited to routine activities for ensuring safety of radwaste storage facilities located at radwaste disposal sites (RWDS); radiation and environmental monitoring; ensuring physical protection of radioactive waste and disused radiation sources.

SNRIU analyzed information regarding the physical condition and state of physical protection of radwaste storage facilities located at radwaste disposal sites (RWDS) of the RADON Association CPS and interregional affiliates, results of radiation monitoring and environmental monitoring, routine maintenance under martial law to maintain radwaste storage facilities in a safe condition. Technical solutions were agreed regarding the acceptance of radioactive waste in the form of disused radiation sources for storage from business entities, their transport to CLTSF located in the exclusion zone for storage.

At the end of 2022, the RADON Association almost completely resumed its licensed activities in the field of radioactive waste management. According to the RADON Association, the engineering and technical means of the storage facilities at RWDS and physical protection systems are under normal operation and are operated in a regular mode.

Measures of radiation and environmental monitoring at RADON Association facilities are implemented by portable dose monitoring devices in the scope established by the Programs of Radiation and Dose Monitoring and Environmental Monitoring for each interregional affiliate of the RADON Association. The monitored radiation parameters were within the normal range in 2022: the indexes of gamma radiation dose rate were in the range of 0.08 - 0.20 μ Sv/h, alpha activity concentration < 0.05 Bq/m³, beta activity concentration < 0.5 Bq/m³. No cases of exceeding the reference levels were recorded.

In 2022, radwaste in the form of disused radiation sources in the amount of 48 pcs was transferred from the RADON Association to CLTSF for long-term storage.

The RADON Association is also involved in urgent actions of the competent authorities to eliminate emergencies related to the detection of abandoned radiation sources or radiation sources in illicit trafficking. All such radiation sources are sent to RADON Association CPS, DIA, LIA, OIA, KhIA storage facilities, which ensure their safe and controlled storage and confinement from getting into the environment and places accessible to the public.

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. Such radioactive waste is mostly very low level waste. According to the tasks assigned to the RADON Association, the enterprise carries out monitoring and routine maintenance of these decontamination waste storage and decontamination treatment sites sites.

Radwaste Management in the Exclusion Zone (Long-Term Radwaste Storage and Disposal)

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

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

CLTSF is an important element of the management system for radwaste in the form of disused radiation sources (DRS) and should ensure centralized placement of radwaste in the form of radiation sources

CLTSF operation includes acceptance, processing (conditioning) and long-term storage (50 years) of radwaste in the form of DRS of various types and design accumulated at the sites of RADON Association 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.

During 2022, CRME continued to conduct comprehensive (hot) tests of CLTSF using radiation sources.



Photo 5 – Radiation protective box at CLTSF

Since the start of operation, 21,851 disused radiation sources were accepted for storage at CLTSF with a total activity of 1.32E+14Bq.

Construction of Long-Term Storage Facility for Vitrified High-Level Radioactive Waste Resulting from VVER-440 SNF Reprocessing Coming from the russian federation

According to the Agreement between the Government of Ukraine and the Government of the russian federation on scientific, technical and economic cooperation in nuclear energy of 14 January 1993 and contractual obligations, vitrified high-level radioactive waste resulting from VVER-440 SNF reprocessing should be returned to Ukraine.



Photo 6 – Centralized long-term storage facility for disused radiation sources (CLTSF)

Due to the armed aggression of the russian federation, the Government of Ukraine decided in August 2022 to terminate this agreement (Resolution of the Cabinet of Ministers of Ukraine "On Termination of the Agreement on Scientific, Technical and Economic Cooperation in Nuclear Energy" No. 957 dated 27 August 2022 and measures are being taken to terminate the relevant contractual obligations with the enterprises of the aggressor country.

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

ENSDF was constructed 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 Radioactive Waste Liquid Treatment Plant (LRTP) and Solid Radioactive Waste Treatment Plant (SRTP). The disposal facility consists of two parallel sections, each has reinforced concrete compartments 11 (modules) equipped with a central drainage gallery, two mobile frame structures with overhead cranes. The disposal facility capacity is 50.210 m³ of radioactive waste packages.

CRME, according to the license to operate a radioactive waste disposal facility, continued to fill two symmetrical ENSDF modules A1 and D1. Since the start of operation, ENSDF has accepted 10948 radwaste packages for disposal, with a total volume of 2587.48 m³ of radwaste packages with a total activity of 1.94E+13 Bq.

Within disposal facility operation, the operator takes measures to ensure control over the state of civil structures of the disposal facility modules, functioning of the central drainage gallery under the disposal facility, implements up-todate methodologies for ENSDF safety assessment.

In 2022, within NPP radwaste transfer to the Vektor disposal facilities for disposal, measures were continued to prepare for the acceptance of the KTRVf-0.2 containers with immobilized solid radwaste manufactured at the RNPP radwaste treatment plant for disposal. In particular, the disposal facility operator developed the relevant technical documents approved by SNRIU based on the results of the nuclear and radiation safety review.

Buryakivka Radioactive Waste Disposal Site (Buryakivka RWDS)

According to the design, Buryakivka RWDS has 30 near-surface disposal facilities (trenches) for radwaste disposal, which are completely filled and finally closed. In order to expand the production capacity of RWDS Buryakivka, in 2018 an additional storage facility (trench) No. 21A was constructed.

Within the license to operate radwaste disposal facilities, CRME continued to operate radioactive waste disposal facility 21A Buryakivka RWDS, as well as maintain and support finally closed 30 radwaste disposal facilities of this site in a safe condition.

The total volume of radwaste in 30 trenches of Buryakivka RWDS is 690 thousand m³ with a total activity of 2.54E+15 Bq. Trench No. 21A of Buryakivka RWDS accepted for disposal 25190.6 m³ of radioactive waste with a total activity of 2.09E+12 Bq as of the end of 2022.

Pidlisnyi and ChNPP Stage III Radioactive Waste Disposal Sites

These disposal sites were constructed in 1986-1988 within the priority measures to mitigate the consequences of the Chornobyl accident.

During 2022, CRME carried out routine activities to ensure safety of the Pidlisnyi and ChNPP Stage III radioactive waste disposal sites (RWDS).

Radwaste Interim Confinement Sites (RICS)

RICS are trenches and piles constructed on the territories adjacent to ChNPP in the course of priority measures to mitigate ChNPP accident consequences for radwaste confinement. For the most part, such radwaste was civil structures, household items, topsoil, etc. contaminated due to the emergency release.

Nine RICSs are located in the exclusion zone: Yaniv Station, Naftobaza, Pishchane Plato, Rudyi Lis, Stara Budbaza, Nova Budbaza, Pripyat, Kopachi, Chystohalivka. The estimated number of trenches and piles of these RICSs is from 800 to 1000, the exact locations of some of them need to be clarified. Routine activities to ensure RICS safety is carried out by CRME in accordance with the Technical Specifications for Safe Operation of the radwaste interim confinement sites.



Photo 7 – RICS in the exclusion zone

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

There are two near-surface solid radwaste disposal facilities with a total capacity of 19.200 m³ at the final stage of construction at the Vektor site:

SRW-1 is a disposal facility for short-lived low- and intermediate-level radwaste in reinforced concrete containers (volume of 9800 m³);

SRW-2 is a disposal facility for shortlived low- and intermediate-level largesized, bulk radwaste, radwaste in drums, kraft bags, cage-type containers (volume of 9400 m³). In 2022, CRME performed activities to survey the current state of buildings and equipment, and their maintenance. In November 2022, CRME conducted acceptance tests of equipment and systems important to safety of the SRW-1 disposal facility in accordance with the Test Programs agreed by SNRIU. SNRIU inspectors and SSTC NRS experts took part in the tests.

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.

Within the European Commission's project INSC U.04.01/14B "Development of the National Plan for the Geological Disposal of Radioactive Waste in Ukraine and its Implementation Schedule", Technical Report "Development of a Detailed National Plan for Deep Geological Disposal" (Technical Report) has been developed.

This Technical Report was reviewed by SNRIU in 2022, with the involvement of experts from the Institute for Nuclear and Radiation Safety of France (IRSN) and SSTC NRS and comments were made for consideration in the development of the National Plan.



Photo 8 - SRW-1 disposal facilities at the Vektor site



Photo 9 - SRW-2 disposal facilities at the Vektor site

Personal Dose Monitoring of CRME Personnel

For 12 months of 2022, 1483 CRME employees were subject to personal dose monitoring (PDM). The reference level of ¹³⁷Cs in the body for PDM subgroup I is 11000 Bq, subgroup II - 7000 Bq.

The total number of people with the content of ¹³⁷Cs in the body is less than the minimum detected activity - 761, of which subgroup I -507 people, subgroup II - 254 people;

up to 2000 Bq¹³⁷Cs - 184 people, of which subgroup I – 137 people, subgroup II – 47 people; up to 7000 Bq – 4 people from PDM subgroup I.

The total collective exposure dose of CRME personnel for the reporting period and the last five years of operation is presented in Table 9.

The reference levels for external and internal exposure of CRME personnel were not exceeded in 2022. The maximum personnel external exposure dose for 12 months of 2022 was 1.19 mSv, the minimum dose was 0.05 mSv, and the average dose was 0.52 mSv.

Table 9 – Total collective exposure dose for personnel (DS) during the reporting period and the last five years

Subdivision (type of	Voor		External exposure		
activities)	rear	D3, 113V	DS, mSv	% of DS	
	2017	586,90	586,90	100	
In general, for CRME	2018	396,8	396,8	100	
	2019	989	989	100	
	2020	1129,63	1129,63	100	
	2021	1536,6	1536,6	100	
	2022	766,53	766,53	100	

VII. CHORNOBYL NPP DECOMMISSIONING

ChNPP-1, 2, 3 are decommissioned by the SSE ChNPP operating organization under license No. EO 000040 issued by SNRIU on 22 March 2002 and reissued on 3 November 2020, and individual permit OD No. 000040/8 of 31 March 2015 for the final closure and safe enclosure stage for ChNPP-1, 2 and 3 (FCSE).

ChNPP implements the FCSE stage in accordance with the "Program for the Implementation of the Final Closure and Safe Enclosure Stage for ChNPP-1, 2 and 3" and Project "Final Closure and Safe Enclosure of ChNPP-1, 2 and 3".

The operating organization made efforts to ensure nuclear and radiation safety at Chornobyl NPP site and to implement measures of the FCSE program under difficult conditions of the occupation and after the de-occupation. The activities related to preparation of the confinement in the safe enclosure zone envisaged in the FCSE program for 2022 were not fully completed because of the armed aggression of the russian federation and difficult situation related to financing. ChNPP developed corrective measures under the planned activities.

Within the FCSE stage, ChNPP performs dismantling of equipment that is not important to safety and is not subject to further safe storage.

During dismantling, significant amount of radioactively contaminated materials and equipment is formed, which can be released from regulatory control in the future. For this purpose, an installation for the release of radioactive materials from regulatory control is being implemented at ChNPP.

In 2021, ChNPP completed the trial and commercial operation of this installation. According to its results, in 2022, ChNPP developed the Report on the Trial and Commercial Operation of the Facility for Material Release from Regulatory Control and the Enterprise Standard. Management of Production Processes. The Procedure for Preparing Radioactive Materials for Release from Regulatory Control.

Radioactive Waste Management Facilities at ChNPP

Radwaste accumulated during ChNPP operation, mitigation of the accident consequences of 1986 that was generated during Units No. 1, 2, 3 decommissioning and Shelter transformation into an environmentally safe system is stored in radwaste storage facilities at ChNPP site: SRW storage facilities, LRW storage facilities, LRW and SRW storage facilities, or is transferred for disposal.

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) issued by the SNRIU on 20 May 2021.

The technological process of LRTP provides processing of LRW in the form of evaporation bottom of evaporators, pulp of spent ion-exchange resins, perlite pulp and sludge.

According to ChNPP report, 179 m³ of evaporation bottoms were processed in 2022, this resulted in 2002 packages with generated cemented radwaste.

In November 2022, ChNPP applied to the SNRIU with a statement regarding amendments to license No. OB 001092 on the postponement of the deadlines for "active" tests at LRTP with spent ionexchange resins and a mixture of ionexchange resins and evaporation bottom. The reason for these amendments to the license was the occupation of the Chornobyl NPP site by russian military formations and the impossibility of timely completion of the planned activities. SNRIU made a decision to make appropriate amendments to the license based on the consideration results of ChNPPapplication. 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) constructed at the Vektor site and commissioned in 2011, license No. EO 000968 dated 06 July 2011.

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

ISF HLW and LIL-LLW is designed for temporary storage of solid radwaste, which is pre-sorted at the solid radwaste treatment plant (SRTP) that is located at the Vektor site in the exclusion zone.

Radwaste accumulated during ChNPP operation, generated during decommissioning of ChNPP-1, 2, 3, Shelter transformation into an environmentally safe system, and ISF operation is subject to temporary storage.

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.

Commissioning of SRRF and SRTP (Lot 1, 2)

SRRF is designed to retrieve solid radwaste from the SRW storage facility, load it into containers and transfer this SRW for processing to SRTP.

SRTP is designed for processing of SRW accumulated during ChNPP operation, as well as radwaste generated during

decommissioning of ChNPP-1, 2, 3, ISF operation and Shelter transformation into an environmentally safe system.

The main technological processes of SRW processing are compaction, incineration and cementing.

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

Stage 1 - tests with homogeneous "sealed" SRW with known characteristics (completed under individual permit No. 000040/3 dated 13 May 2010),

Stage 2 - tests with homogeneous "unsealed" SRW with known characteristics (completed under individual permit No. 000040/6 dated 23 May 2014),

Stage 3 – tests with heterogeneous SRW with unknown characteristics.

CHNPP performs Stage 3 of SRRF and SRTP testing according to license No. OB 001096 issued by SNRIU on 01 October 2021 for radwaste processing and storage, namely for SRRF and SRTP commissioning.

In 2022, the activities envisaged in the license conditions and working programs for commissioning of 57PR-TSPTRO and 78PR-TSORO were completed, SNRIU considered and approved the "Report on Stage 3 of Comprehensive Hot Tests in ICSRM SRRF and SRTP".

In November 2022, ChNPP applied to SNRIU with an application to amend license No. OB 001096 concerning the processing of the "pilot" batch of sole bituminous compound (SBC) at Rivne NPP as part of SRRF and SRTP commissioning. SNRIU made a decision on 2 January 2023 to make appropriate amendments to the license based on the consideration results of the application and the nuclear and radiation safety review of these documents. The sole bituminous compound will be processed after the review and approval of the documents of CRME regarding SBC management.

VIII. CONFINEMENT–SHELTER OPERATION

The New Safe Confinement–Shelter (NSC–Shelter) system is operated under license No. OB 001094 issued by SNRIU dated 12 August 2021.

SNRIU provided regulatory support to operation of this system and Shelter transformation into an environmentally safe system in 2022.

SNRIU considered and approved the following as part of the current activities in 2022:

Specification of Maintenance and Repair of Equipment Important to Safety of the NSC–Shelter System at Chornobyl NPP;

Specification of Inspections and Tests of Systems Important to Safety of the NSC– Shelter System at Chornobyl NPP;

Classifier of the Systems, Structures and Components Important to Safety of the NSC–Shelter System;

Technical Decision "On Zoning of the Territory of the NSC–Shelter System".

In order to assess the safety of other documents on the operation of the NSC– Shelter system, the SNRIU also considered and agreed the following:

"Technical Specification for the Design, Production, Supply, Installation and Commissioning of the Equipment for Dismantling of Unstable Structures of the Shelter for Hanging on the Mobile Instrumentation Platform of the Primary Valve System in ChNPP NSC";

Technical Decision "On Further Management of Fragments of the Dismantled Ventilation Pipe of Chornobyl NPP Stage II (VP-2) Placed for Temporary Storage in Premise G-438 in Unit 3 Turbine Hall".

Nuclear and radiation safety of the NSC– Shelter system is ensured by the system of organizational and technical measures during the activities related to the current operation of the system and during the implementation of the projects to transform the Shelter into an environmentally safe system. Radiation and dosimetry control is ensured and dose loads of ChNPP personnel and third-party organizations are recorded during the implementation of these activities. According to ChNPP, the average individual dose of ChNPP personnel who worked at the site of the NSC–Shelter system was 0.78 mSv, the average level of individual doses of the personnel of third-party organizations was 2.01 mSv in 2022. No exceeded reference levels of individual annual exposure doses (13 mSv/year) of personnel of ChNPP and third-party organizations were recorded.

Solid and liquid radioactive waste (SRW and LRW) is generated during the activities performed at the NSC–Shelter system.

The source of the primary SRW in the NSC–Shelter system is decontamination, and the source of the secondary RAW are the used individual protective means and waste generated after the maintenance, repair and modernization of the systems and equipment in the NSC and the Shelter.

12.7 m³ (8.1 t) of low-level solid radioactive waste with the total activity of 1.38×10⁸ Bq were collected and transported to Buryakivka RWDS during the reporting period within the operation in the premises and on NSC-Shelter territory. No intermediate-level and high-level SRW was generated. Liquid radwaste is generated (radioactively contaminated water) resulting from decontamination of premises, equipment and tools, dust suppression and operation of checkpoints.

During 2022, 114 m³ of radioactively contaminated water with the total activity of 2.386×10⁹ Bq was collected and pumped from the Shelter premises in order to prevent the ingress of radioactive substances into groundwater and to improve the radiation situation.

Consequences of the Occupation of the Exclusion Zone and Chornobyl NPP Territory by russian military from 24 February to 31 March 2022

All the Chornobyl NPP facilities in the exclusion zone: ISF-1, ISF-2 spent fuel storage facilities; New Safe Confinement of the Shelter; Chornobyl NPP units 1, 2, 3 at the stage of decommissioning; radioactive waste management facilities, as well as



Photo 10 – New Safe Confinement



Photo 11 - Shelter

nuclear radiation objects in the exclusion zone were captured by the armed forces of the russian federation as a result of the military attack at about 5 pm on 24 February 2022. The military unit of the National Guard of Ukraine No. 3041 that guarded Chornobyl NPP has been disarmed.

Control over nuclear and radiation facilities in the exclusion zone was actually lost at 08:30 pm on 24 February 2022; SNRIU informed on this the International Atomic Energy Agency (IAEA) and other international partners of Ukraine.

Because of the armed aggression of the russian federation and the occupation of the territory of the exclusion zone by russian military formations from

24 February to 31 March 2022, the situation has developed on the territory of the exclusion zone that excluded normal operation of the enterprises. There were no conditions for the safe implementation of the licensed activities at ChNPP, CRME, SSE Ecocenter, there were no safe access routes for personnel (bridges and roads were destroyed, the threat of mining the territory of the exclusion zone), logistical routes for the delivery of the following to the objects in the exclusion zone were damaged: equipment, spare parts, materials and products for life support and stay of personnel necessary for the safe operation of the objects. Destruction, incapacitation and theft of computer, office and server

equipment, measurement devices, unique laboratory equipment of the Centralized Laboratory for the Characterization of Radioactive Waste of SSE Ecocenter, the mobile radiation laboratory of CRME, etc. was revealed in the office and working premises of CRME and SSE Ecocenter.

In this regard, in April 2022, SNRIU made a decision to suspend the validity of a number of licenses in the field of nuclear energy use and radioactive waste management on the basis of the analysis of the information received from the licensee enterprises as part of the implementation of the authorizing activity and licensing procedures envisaged by the legislation: CRME licenses for the implementation of activities at the stages of construction and operation of radioactive waste disposal facilities at the Vektor production site, for the operation of radioactive waste disposal facilities, for processing and storage of radioactive waste, as well as ChNPP licenses:

No. EO 000040 for the Decommissioning of Chornobyl NPP Units 1, 2 and 3;

No. OB 001092 for the Operation of Liquid Radwaste Treatment Plant (LRTP);

No. OB 001094 for the Implementation of Activity Related to the Processing, Storage of the Existing Radwaste and Waste Generated during the Shelter Transformation into an Environmentally Safe System during NSC-Shelter System Operation;



Photos 12 – 14 – Damaged infrastructure in the exclusion zone resulting from the invasion of the russian federation

No. OB 001095 for the Operation of the Interim Storage Facility for High-Level and Low- and Intermediate-Level Long-Lived Waste (ISF HLW and LIL-LLW);

No. OB 001096 for the Commissioning of the Solid Radwaste Retrieval Facility (SRRF) and Solid Radwaste Treatment Plant (SRTP) in the Industrial Complex for Solid Radwaste Management (ICSRM).

A decision was made resulting from the failure of the enterprises to comply with the conditions for conducting the types of licensed activities in accordance with the nuclear and radiation safety rules and regulations and license conditions due to force majeure circumstances related to the occupation and seizure of the territory of the exclusion zone by military formations of the russian federation.

From April to July 2022, the enterprises took a number of measures to renew the operability of the enterprise and confirm the ability to perform licensed activities in compliance with the nuclear and radiation safety standards and rules, namely: operability renewal of a number of systems important to the safety of facilities and activities; inventory of radioactive materials, radioactive waste, radiation sources; nuclear materials; checking of the availability and compliance of the reporting and accounting documents and databases; solving the logistics issues related to personnel and equipment transport; transfer to shift work; renewal of emergency preparedness; checking the absence of explosive devices in the radioactive waste management facilities, sites, etc.

SNRIU decided to renew the validity of the licenses of the enterprises in the exclusion zone in August 2022.

There is no experience in Ukraine and in the international practice related to the safety regulation of nuclear facilities that were under occupation by military formations, as well as the procedure to renew the regulatory control after deoccupation.

In order to determine the features of the safety regulation of the nuclear and radiation facilities in the Chornobyl exclusion zone that were affected by military actions, SNRIU with the involvement of the technical support organization (SSTC NRS) and with the support of the Norwegian Radiation and Nuclear Safety Agency (DSA) developed two special documents that were approved by Resolution of the SNRIU Board No. 08 dated 4 August 2022, namely:

"Recommended Approach to the State Regulation of the Safety of Nuclear and Radiation Facilities in the Chornobyl Exclusion Zone Affected by Military Operations". This basic document contains the recommendations regarding the scope and specifics of applying the principles, general provisions and safety requirements, as well as the specifics of applying the licensing procedures and state oversight of activities at nuclear and radiation facilities in the Chornobyl exclusion zone that were affected by military actions;

"Recommended Procedure to Renew the Safety Level of Nuclear and Radiation Facilities in the Chornobyl Exclusion zone Affected by Military Actions". This document defines the procedure of inspections at the nuclear and radiation facilities, the procedure for actions of licensees in detection of safety deficiencies as a result of inspections and renewal of the safety level at these facilities.

IX. SAFETY IN USE AND PRODUCTION OF RADIATION SOURCES

In the conditions of martial law, the priority area of the state nuclear and radiation safety regulation remains ensuring radiation protection of personnel, the public and the environment during the use and production of radiation sources.

In 2022, 4,620 Ukrainian economic activity entities in the field of nuclear energy use applied radiation sources in their activity. Among them, 2,886 entities use radiation sources, the activity of which is not exempted from licensing including 2,087 health care institutions of various ownership forms.

In total, as of the end of 2022, 26,558 radiation sources were registered in the State Register of Radiation Sources and Doses including:

8,420 sealed radionuclide sources;

18,138 non-radionuclide installations generating ionizing radiation (generating devices).

During the year, 1,223 radiation sources were registered in the State Register of Radiation Sources and Doses, including: 128 radionuclide RS and 1,095 generating devices.

In the conditions of martial law, the SNRIU pays special attention to ensuring the mandatory state registration of radiation sources to properly control their relocation and use on the territory of Ukraine and periodically reports to the Cabinet of Ministers of Ukraine on functioning and filling of the State Register of Radiation Sources and Doses.

In 2022, 499 generating devices, 261 radionuclide radiation sources were decommissioned and removed from the State Register. 234 radionuclide RS were transferred to the RADON Association, 20 RS returned to the manufacturer, service life was extended for 1039 sealed radionuclide sources.

In 2022, the State Register of Radiation Sources and Doses received information from Odesa and Kirovohrad regions on the loss of 7 sealed RS sources of the BIS-4AN type with the Sr-90/Y-90 radionuclide and activity of 9.3×108 Bq, which were used in the RIO-3A icing detectors. The radiation sources were lost as a result of hostilities. In total, according to the notifications received from the customs authorities, 51 radionuclide sealed RS were imported in 2022.

The manufacturers and suppliers of radionuclide RS that were imported to Ukraine in 2022 were the National Center for Nuclear Research (successor of the Institute of Atomic Energy POLATOM), Eckert & Ziegler BEBIG GmbH, Shimadzu Europa GmbH and others. The enterprises using radiation sources were NPPs, geophysical research institutions and others.

Intermediary enterprises that supplied RS were: State Enterprise "USIE Izotop", Severodonetsk Research and Production Association "Impulse", SHIMUKRAINE LLC. The total number of imported RSs (51 pcs) included:

radiation sources with radionuclide Co-60, type CoO.A86, activity 80.85 GBq (the supplier was Eckert & Zeigler BEBIG GmbH, Germany) for the use in radiation therapy equipment: 2 pcs;

radiation sources with radionuclide Ir-192, types IR2HCT and IR3HCT with activity up to 4440 GBq (the manufacturer and supplier was the National Center for Nuclear Research, Poland) for the use for gamma radiography at NPPs: 16 pcs;

radiation source with radionuclide Cs-137, activity 55.5 kBq (the supplier was Weatherford U.K. Limited, Great Britain) for the use in the field of geophysical research: 1 pc;

radiation sources of fast neutrons with radionuclide Am-241, type Am1.N26 with the activity of 17 GBq (12 pcs) and Am1.N27 type with the activity of 82 MBq (11 pcs), (he supplier was Eckert&Zeigler Isotope Products GmbH, the Netherlands), for the use at NPPs: 23 pcs;

radiation sources with radionuclide Am-241-Be with the activity of 185 GBq and 1.48 GBq (the supplier was WEATHERFORD U.K. Limited, England), for the use in the field of geophysical research: 2 pcs;

radiation sources with radionuclide Ni-63 with the activity of 370 MBq, ECD-2010 cell (the supplier was Shimadzu Europa GmbH, Germany) for the use in GC Shimadzu gas chromatograph: 2 pcs;

radiation sources with the radionuclide H-3, with the activity 92.5 GBq as part of neutron tubes of the VNT4-26 type (the manufacturer was All-Russian Research Institute of Automation named after M. L. Dukhov, russian federation), which are used in neutron generators of the ING-10-20 type 120TBT and ING-10-20-150T, which are used in a set of impulse neutron logging equipment: 2 pcs;

radiation sources with radionuclide Th-3, which is natural thorium: 5.5% of weight, natural uranium: 0.4% of weight, with the activity of 64 kBq (WEATHERFORD U.K. Limited, England), for use in the field of geophysical research: 3 pcs. Radionuclide generators and radiopharmaceuticals for health care institutions were supplied by the State Enterprise "USIE Izotop".

In total, 156 radionuclide generators Ts-99m (the manufacturer of Ts-99m radionuclide generators was Instytut Energii Atomowej (POLATOM) (05-400.Otwok-Swierk, Poland) and 1,746 radiopharmaceuticals based on I-131 and 107 ones based on Sr -89, with the total activity of 6,129,810 MBq (produced by the National Center for Nuclear Research Radioisotope Center POLATOM) were imported into Ukraine in 2022.

During 2022, **611** pcs of generating devices were also imported into Ukraine, mainly for medical purposes.

In March-April 2022, the Ministry of Health purchased medical equipment for the provision of emergency medical care at the expense of a World Bank loan and delivered it to health care institutions located in Ukrainian regions, including in the de-occupied Kyiv, Chernihiv, Sumy, Kherson regions. Portable X-ray machines Mobile X-ray Optima XR 240 were purchased from the companies GE Medical Systems SCS (French Republic): 100 pcs, and MobiEue700 purchased from MR Global (HK) Limited (Hong Kong, People's Republic of China): 100 pcs.

Under the supply of X-ray machines and linear accelerators, as in 2021, there were problems related to the violation of regulatory requirements in the field of nuclear energy use.

Thus, health care institutions of Ukraine received equipment or notices on its supply from suppliers in terms that did not allow for the timely submission to the SNRIU of applications for issuing licenses or introducing appropriate amendments to licenses for the right to carry out activities involving the use of radiation sources.

addition to In violating licensing conditions, the Procedure for State Registration of Radiation Sources was also not adhered to. To optimize the licensing process for specific activities involving the use of radiation sources in medical practices within state and municipally owned healthcare institutions, as well as economic entities under the Ministry of Health's jurisdiction, certain measures have been implemented. During the period of martial law, entities are granted the right to engage in nuclear energy use activities, specifically the acquisition (purchase), transfer (sale), and storage of X-ray diagnostic devices that ionizing radiation according to Resolution No. 1404 of the Cabinet of Ministers of Ukraine of 20 December 2022 "On Amendments to Appendix 2 to Resolution No. 314 of the Cabinet of Ministers of Ukraine of 18 March 2022 "Certain Issues of Conducting Economic Activities under Martial Law".

The monitoring of the commissioning of X-ray equipment, which was purchased under the program of the President of Ukraine "Great Construction", continued in 2022 to provide 190 basic health care institutions in with up-to-date X-ray equipment (X-ray diagnostic machines, angiographs and computer tomography machines). Table 10 – Territorial distribution of the number of radiation source owners by regions of Ukraine as of December 2022

Region	Total number of radiation source owners	Number of radionuclide radiation source owners	Number of gen- erating (non- radionuclide) radiation source owners	Number of owners with both radionu- clide and non- radionuclide radiation sources		
Northern part of Ukraine						
Kyiv city	453	41	436	24		
Kyiv region	204	34	181	11		
Vinnytsia region	152	5	149	2		
Zhytomyr region	125	16	113	4		
Chernihiv region	84	5	82	3		
Cherkasy region	111	6	109	4		
Total	1089	103	1034	48		
	Ea	astern part of Uk	raine			
Kharkiv region	324	63	306	45		
Poltava region	150	22	139	11		
Sumy region	200	12	196	8		
Total	660	95	627	62		
	C	entral part of Uk	raine			
Dnipropetrovsk region	402	51	376	25		
Kirovograd region	76	6	74	4		
Total	475	56	448	29		
	Sout	n-eastern part of	f Ukraine			
Donetsk region	450	55	421	21		
Zaporizhzhia region	191	16	185	10		
Luhansk region	210	24	196	10		
Total	843	90	794	41		
North-western part of Ukraine						
Volyn region	111	9	104	2		
Rivne region	141	6	138	3		
Ternopil region	123	3	122	2		
Khmelnytsky region	162	9	156	3		
Total	524	27	507	10		
	W	estern part of U	kraine			
Zakarpattia region	96	4	96	4		

Table 10 Continued

Region	Total number of radiation source owners	Number of radionuclide radiation source owners	Number of gen- erating (non- radionuclide) radiation source owners	Number of owners with both radionu- clide and non- radionuclide radiation sources			
Ivano-Frankivsk region	209	14	199	4			
Lviv region	256	22	247	13			
Chernivtsi region	73	6	72	5			
Total	616	44	596	24			
	Southern part of Ukraine						
Odesa region	241	37	222	18			
Mykolaiv region	94	9	91	6			
Kherson region	107	5	105	3			
Total	434	49	410	25			
TOTAL	4641	464	4416	239			

Note:

if a RS owner is included into the database, but as of the current date possesses no radiation sources, such owner is not considered in the statistics;

the number of owners in a certain part of Ukraine may not coincide with the total of the owners in each region of a certain part of Ukraine due to the fact that the same owner may possess radiation sources in different regions of the given part of Ukraine.

Table 11 – Summarized activity results of Regional SNRIU Inspectorates for 2022

	Total number			Number	Number of	Liconcocc	
Licensing	Number of entities	Number of Licensees	Number of procedures in 2022	Licensees in medicine	Licensees in the industry	performing maintenance	
Central	472	263	171	186	77	19	
North-Western	439	255	203	225	19	9	
South-Eastern	877	457	81	322	118	17	
Eastern	694	413	167	301	112	38	
Northern	1005	705	380	383	322	153	
Southern	434	337	141	283	54	16	
Western	615	392	242	334	58	26	
ChEZ Inspectorate	84	64	9	53	11	5	
Total	4620	2886	1394	2087	771	283	

Inspection	Total number	Radioactively contaminated metal scrap	Detected RS	Lost RS	RS in illicit trafficking
Central	-	-	-	-	-
North-Western	3	3	-	-	-
Eastern	2	-	-	2	-
Northern	3	-	-	-	3
Southern	1	1	-	-	-
Western	1	-	-	-	-
ChEZ Inspectorate	60			60	

Table 12 – Radiation incidents involving RS in 2022

Currently, there are risks regarding the loss of regulatory control over the radiation sources belonging to economic entities located in the temporarily occupied territory. And only after the de-occupation of these territories economic entities in the field of nuclear energy use will have possibility to carry out extraordinary inventories, based on the results of which it will be possible to compile an accurate list of lost/destroyed radiation sources and take measures to restore regulatory control over them.

Part of the territories of the Luhansk, Donetsk, Zaporizhzhia, Kherson, Kharkiv and Sumy regions were under the occupation of the armed forces of the russian federation, in particular, the entities using radionuclide RS of categories 1-3.

Table 13	8 – Number o	f economic entities	using radionu	clide RS of categories 1-3
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Region	Number of economic entities	Number of radionuclide RS of categories 1-3	Note
Luhansk	2	16	
Donetsk	3	35	Including 1 medical institution using 3 RS of category 1
Zaporizhzhia	3	158	Including 1 medical institution using 1 RS of category 1
Kharkiv	1	31	De-occupied
Sumy	1	1	De-occupied
Kherson	2	6	De-occupied
Total	12	247	

Reliable information on RS status in the occupied territories is missing.

There were no cases of regulatory control loss over radionuclide RS of categories 1-3 in the de-occupied territory of the Kherson region. RSs are under the control of economic entities.

From the de-occupied territories of Kharkiv and Sumy regions, the SNRIU received reports from 2 entities (National Scientific Center "Institute of Metrology", Sumy Customs of the State Customs Service) on probable loss of regulatory control over radionuclide radiation sources, including RS of categories 1-3. In connection with the minimum distance to the border with the russian federation, the threat of artillery and missile shelling, mining of the territory and limited access, staying in the specified territories is dangerous for the personnel and, accordingly, conducting a physical inventory of radiation sources, assessment of damage and identification of the number of lost RSs is impossible and will be carried out as safe conditions are established. These and other issues are under the control of the SNRIU.

RS Production in Ukraine in 2022

In 2022, 14 entities had licenses for the production of radiation sources. During the year, 376 pcs of non-radionuclide radiation sources were produced (including 45 pcs for the needs of Ukraine, and 331 pcs for export).

In the reporting year, "Elvatech" LLC produced 359 pcs of X-ray energy spectrometers SER-01 (ElvaX JL series) and SER-02 (ElvaX series), 331 pcs were exported and delivered to more than 15 countries, among which were India, Brazil, USA, Israel and others.

"NVK KRAS" LLC manufactured the "Medyks" X-ray diagnostic complex for 2 workplaces (1 pc) and the "Aspect" radiographic machine (4 pcs).

Open RSs were produced mainly for their own purposes by the Feofania Clinical Hospital of the State Administration and the Kyiv City Oncology Dispensary. Other manufacturers terminated their economic activity in connection with the introduction of martial law in Ukraine.

X. SAFETY OF RADIOACTIVE MATERIAL TRANSPORT

One of the priority areas of nuclear and radiation safety in nuclear energy use is safe transport of radioactive materials.

In accordance with the Ukrainian legislation, the nuclear material transport safety is regulated by means of:

development of regulations;

issuing authorizing documents, such as licenses for the right to carry out activities related to radioactive material transport, permits for international transport of radioactive materials (during import, export, transit), certificates of approval for the safe transport of radioactive materials;

state oversight measures.

Under the conditions of the martial law put in force by the Law of Ukraine "On the Approval of the Decree of the President of Ukraine "On the Introduction of Martial Law in Ukraine" dated 24 February 2022, the transport of radioactive materials has become significantly complicated and required a quick response considering the current situation.

In order to ensure specialized activities of the country's enterprises including nuclear fuel supply for nuclear power plants, radiopharmaceuticals to medical institutions, SNRIU considered 29 applications for obtaining or amending permits for international transport of radioactive materials; issued 14 certificates of approval in case of transport of radioactive materials including 7 certificates of approval for special conditions for the transport of radioactive materials and 7 certificates of approval for the design of transport packaging for radioactive materials; 7 licensing cases were considered, 6 licenses for the right to perform activities related to the transport of radioactive materials were issued and amended.

The SNRIU has chosen the justification principle for each specific transport as the priority of the state regulation for the safe transport of radioactive materials during the war considering actual risks and ensuring the implementation of radiation safety measures envisaged by the legislation.

XI. SAFETY OF URANIUM SITES

In Ukraine, extraction and processing of uranium ores are carried out by State Enterprise "Skhidnyi Mining and Processing Plant" (SkhidGZK) located in Zhovti Vody, Dnipropetrovsk region.

Measures to terminate activities, including reclamation and remediation in the radioactively contaminated territories of the former Production Association "Prydniprovsk Chemical Plant", in Kamyanske, Dnipropetrovsk Region, are carried out by State Enterprise "Barrier".

SkhidGZK was founded in accordance with the Decree of the Government of the USSR of 24 July 1951 and is subordinate to the Ministry of Energy of Ukraine. Its activities are aimed at solving the main task - produce natural uranium concentrate, a raw material from which, after further processing, fuel for nuclear power plants is produced.

SkhidGZK has in its structure separate subdivisions of the Smolinska, Novokostiantynivska and Inhulska which directly mines, carry out underground extraction of uranium ores based on the explored reserves of Novokostiantynivskyi, the Vatutinskyi, Michurinskyi and Tsentralnyi uranium deposits.

For the extraction of uranium ore from deposits, underground and surface technological systems are used, which are located at the industrial sites of these mines. Underground technological system (mining) includes: underground excavation mines, cargo-delivery shafts, shafts to lift down and lift up people, materials and equipment, ventilation shafts, embedded shafts and other installations for energy supply and ventilation of the mine field.

The surface technological system (additional ore processing facilities) includes: radiometric systems for sorting, crushing, ore enrichment plants or installations, transport of uranium ores (galleries), mine water treatment plants, hydraulic laying systems, warehouses of marketable ore, piles of empty rocks and off-balance ores.

In underground conditions, ore is crushed and transported to the surface system, where it is radiometrically sorted at radiometric enrichment plants or installations, accumulated in a warehouse, loaded into railway cars or special vehicles, and transported for further processing to the Hydrometallurgical Plant in Zhovti Vody, Dnipropetrovsk region. Geographically, the Smolinska, Novokostiantynivska and Inhulska uranium mines are located in the Kirovohrad region.

Smolinska mine

The Smolinska mine is located 3 km from the Smoline village, Kirovograd region. The territory of the industrial site of the mine is located outside the settlement. Waste rock and off-balance ore are used in the reclamation of spent cavities in the sand pit of the mine in accordance with Feasibility Study "SkhidGZK. Smolinska mine. Reclamation of the Sand Pit."

In 2022, 10,650 tons of ore were mined at the Smolinska mine, with a planned annual volume of 86,900 tons. In order to minimize the uranium ore extraction waste (UOEW), 196 m³ (510 tons) with a planned volume of 41000 m³ per year were transported to the pit for reclamation. Considering that the reserves of the Vatutinske deposit are practically exhausted, in 2021, the implementation of preparatory measures to terminate the activities of the Smolinska mine has started.

SNRIU approved a Draft Order of the Cabinet of Ministers of Ukraine on Approval of the Concept for the State Target Environmental Program "Decommissioning of Uranium Facilities for 2022-2026". The state nuclear and radiation safety review of feasibility study "Decommissioning of the Smolinska Mine. Feasibility Study. Volume 4. Basic Solutions on Radiation Safety" was performed with the provision of a positive SNRIU conclusion.

Inhulska mine

The Inhulska mine is located 1 km from Kropyvnytskyi, Kirovograd region. In 2022, 14,993 tons of ore were mined at the Inhulska mine, with a planned annual volume of 162,947 tons.

Waste rock and off-balance ore are dumped in piles on the territory of the mine industrial site (Pivnichnyi shaft).

Novokostiantynivska mine

The Novokonstiantynivska mine is located 720 m north of the Lutkivka village, Novoukrainskyi district, Kirovograd region.

The territory of the mine industrial site is located outside the settlement. There are agricultural lands on all sides of the industrial site territory.

In 2022, 75,765 tons of ore were mined at the Novokostiantynivska mine, with a planned annual volume of 226,570 tons.

Waste rock and off-balance ore are dumped in piles (No. 2 and No. 3) on the industrial site territory.

Hydrometallurgical Plant (HMP)

The hydrometallurgical plant (HMP) is located on the northern outskirts of the

Zhovti Vody, Dnipropetrovsk region. The purpose of HMP is processing of uranium ores from the Inhulska, Smolinska and Novokostiantynivska mines, chemical concentrate from bulk leaching and sludge from mine water treatment installations to obtain finished products in the form of natural uranium concentrate.

At a distance of 700 meters to the east of the plant, there is a lime acceptance point and an acid warehouse with acid storage facilities, pumping station and a railway tank unloading point.

Eight km to the south of the plant, in the Balka Shcherbakivska, there is a bulk-type tailing storage facility connected to the plant by a recycling water supply system and an 11 km long pulp piping. There are 5 pumping stations on the territory of the tailing storage facility.

At a distance of 200 meters to the north of HMP, there is a tailing storage facility in a brown iron ore pit (BIOP). Today, the tailing storage facility is finally closed due to its complete filling. Tailings have not been dumped after processing of uranium ores at BIOP since 1996.

Veer		Uranium-238			
rear	Monitoring point	mg/dm³	Bq/dm³		
Smolinska mine					
	Kilten River, 500 m above the discharge point	0,07	1,78		
2022	Kilten River, place of discharge	0,24	6,10		
	Kilten River, 500 m below the discharge point	0,09	2,29		
Inhulska mine					
2022	Inhul River, 500 m above the discharge point	0,038	0,965		
	Inhul River, place of discharge	0,048	1,219		
	Inhul River, 500 m below the discharge point	0,046	1,168		
Novokostiantynivska mine					
2022	Mala Vys River, 500 m above the discharge point	0,18	4,59		
	Mala Vys River, place of discharge	0,16	4,08		
	Mala Vys River, 500 m below the discharge point	0,14	3,57		

Table 14 – Monitoring results for radioactive discharges and releases

The main HMP radiation hazardous facilities are shops and areas of the main production, tailing storage facility in Balka Shcherbakivska, as well as pulp piping to transport uranium ore processing tailings (tailing pulp) to the tailing storage facilities in Balka Shcherbakivska.

On the territory of the hydrometallurgical plant there is the Central Research Laboratory, whose main production area is implementing research, pilot and industrial activities, as well as physicochemical, chemical and radiochemical analyzes of solid, liquid and gaseous samples.

Central Dust and Gas Dosimetry Laboratory (CDGDL)

CDGDL performs activities to control the working conditions of enterprise personnel, radiation monitoring of environmental objects, namely activities on:

control over working conditions at workplaces in the structural subdivisions of the enterprise (identifying the levels of radiation-hazardous factors and harmful chemicals in the air of the working area);

health and safety studies for the factors of the production environment and labor process in order to certify workplaces regarding working conditions;

control over sources of industrial releases; control over surface water and sources of decentralized water supply;

according to the Program for Radiation and Ecological Monitoring of Environmental Objects in the Territories of Industrial Sites, Control and Observation Areas;

on radiation, dosimetry and analytical control;

on radiation control during shipment of natural uranium concentrate for export;

CDGDL is located on the territory of the HMP industrial site in Building No. 12.

The results of radiation monitoring for each monitored parameter of the facilities are provided in the SkhidGZK annual reports.

Central Laboratory for Instrumentation and Control (CLI&C)

CLI&C is located in the residential area of Zhovti Vody. CLI&C personnel conduct installation, commissioning and maintenance of equipment and measuring means in SkhidGZK subdivisions at workplaces, where radiation-hazardous factors are present. Radiation safety and environmental protection groups are formed and work within SkhidGZK subdivisions. Their main task is to ensure functioning of an effective system for radiation safety management and environmental protection at the enterprise and to promote the improvement of activities for each subdivision in this area. Control over compliance with radiation safety standards and rules in subdivisions is implemented by radiation safety engineers.

Territory of the Former Prydniprovsky Chemical Plant

From 1948 to 1991, uranium ores and uranium concentrates were processed at the former Prydniprovsky Chemical Plant. According to the research results of the Ukrainian Research and Design Institute for Industrial Technology in Zhovti Vody, \approx 42 million tons of uranium ore processing waste with a total activity of 3.17×1015 Bq have been accumulated during the production activities at the Prydniprovsky Chemical Plant. From 1949 to 1991, the former Prydniprovsky Chemical Plant uranium-containing processed blast furnace slag, uranium concentrates and uranium ore from various deposits in the Soviet Union and Eastern Europe.

For the purpose of reclamation and remediation in radioactively contaminated management of uranium areas, ore processing waste and equipment contaminated with naturally occurring radionuclides, by Order of the Ministry of Fuel and Energy of Ukraine No. 562 dated 13 December 2000, State Enterprise "Barrier" was established. The following facilities are on the balance sheet of State Enterprise "Barrier":

Kamyanskyi site:

tailing storage facilities for uranium ore processing waste "Zakhidne" ("Z"), "Dniprovske" ("D"), "Tsentralnyi Yar" ("TsYa"), "Pivdenno-Skhidne" ("PS");

former uranium production buildings No. 46, 103, 104, 112, 168, and 186;

building No. 27 and gallery No. 26-27;

building No. 827 (measuring laboratory) and No. 847 (storage of samples contaminated with NORM);

buildings No. 82, 120 (decontamination shop according to the design);

site for temporary storage of the dismantled industrial piping and equipment contaminated with NORM and located near the Pivdenno-Skhidne tailing storage facility; site for temporary storage of pump and compressor pipes (territory of the Dniprovske tailing storage facility).

Sukhachivskyi site:

former warehouse of uranium raw materials, storage facility "Baza S";

storage facility for dismantled structures of blast furnace No. 6 ("DP-6");

storage of lanthanum fraction, building No. 602;

tailing storage facility "Sukhachivske" (I and II sections).

The main activities of State Enterprise "Barrier" are reclamation and remediation activities on the radioactively contaminated territories of the former Prydniprovsky Chemical Plant; operation and decommissioning of tailing storage facilities for uranium ore processing waste; decontamination of radioactively contaminated buildings, structures, equipment, and territories; transport of radioactive materials; technical and radiation control, as well as the organization and conduct of radiation monitoring at controlled facilities and adjacent territories within the State Target Ecological Program. The main goal of these activities is to reduce the impact of radiation from uranium raw material processing waste on the environment and to ensure the protection

of employees working at the industrial site of the former Prydniprovsky Chemical Plant, as well as the public living in the impact zone in the adjacent territories against the harmful radiation effects.

According to work project "Reconstruction and Conversion for Section II of the Sukhachivske Tailing Storage Facility. Stages I and II. The Concept of Reconstruction and Conversion of the Sukhachivske Section II Tailing Storage Facility", certain preliminary project studies were carried out:

technical oversight and maintenance for uranium facilities of State Enterprise "Barrier" and state of protective structures of tailing storage facilities;

dose monitoring for the state of workplaces of enterprise personnel;

radiation monitoring in the area of location of uranium facilities.

On the territory of the former Prydniprovsky Chemical Plant, the implementation of international technical assistance projects "Implementation of Urgent Measures to Eliminate an Emergency State of the Prydniprovsky Chemical Plant in Kamyanske (former Dniprodzerzhynsk) in Ukraine" implemented at the expense of the European Commission and "Risk Reduction, Control of Radioactive Contamination and Improvement of Environment Monitoring System at the Prydniprovsky Chemical



Figure 15 – General map of uranium facilities at the industrial site of the Prydniprovsky Chemical Plant
Plant in Ukraine" funded by the Government of Norway. As part of implementing the EC project, contractors carried out the following activities:

reconstruction completion for the ventilation system of State Enterprise "Barrier" measuring laboratory;

arrangement completion for the controlled areas at the industrial site of the former Prydniprovsky Chemical Plant;

current maintenance of the centralized water supply system on the land plot located on the territory of the industrial site;

radiation survey and characterization of radioactively contaminated materials in buildings No. 103 and 104;

radiation monitoring and radiation control;

clearing the territory from vegetation and engineering surveys to construct a storage facility for radioactively contaminated materials in the area of the Pivdenno-Skhidne tailing storage facility;

inspection of the geotechnical condition for the enclosing structures of the Dniprovske tailing storage facility "Formation of a Relevant Facility for Safe Temporary and/ or Long-Term Storage of Radioactively Contaminated Materials at the Former Prydniprovsky Chemical Plant in Kamyanske"

Technical oversight of the former uranium facilities, which are on the balance sheet of State Enterprise "Barrier", is constantly underway. If defects are detected at these facilities after intense or prolonged precipitation, snow melting, as well as during the transition to work in new seasonal conditions, an extraordinary inspection of the facilities is conducted, as well as cleaning of drainage trays, headers, grass mowing, cutting bushes.

Radiation monitoring in the area of location of uranium facilities and dose monitoring was carried out by the personnel of the measuring laboratory for radiation control and monitoring studies in accordance with the State Nuclear Regulatory Program for Radiation Monitoring of Uranium Facilities at State Enterprise "Barrier" for 2022-2023 approved by SNRIU and Dose Monitoring Program agreed by the Ministry of Health of Ukraine, respectively.

An integral index of radiation safety in terms of the impact on personnel, the public and the environment, as well as a qualitative (indirect) index of integrity and adequacy for the protective coating of storage facilities for uranium ore processing waste and uranium raw materials is gamma radiation value on the surface of storage facilities.

EDR of gamma radiation and flux density of beta particles were measured in the following buildings and tailing storage facilities: 103, 104, 168, 186, 112, 27, gallery 26-27, 46 and Pivdenno-Skhidne, Zakhidne, Tsentralnyi Yar, Dniprovske tailing storage facilities, storage site for pump and compressor pipes, Sukhachivske section I, Il tailing storage facility, building No. 602, Baza S storage facility, DP-6. A total of 1620 measurements were made at 135 points. The analysis of the obtained results in comparison with the results of previous periods indicates the stability of the radiation state in the studied areas and no significant changes in the nature of contamination.

XII. PHYSICAL PROTECTION OF NUCLEAR INSTALLATIONS, NUCLEAR MATERIAL, RADWASTE AND RADIATION SOURCES

In accordance with the Convention "On the Physical Protection of Nuclear Material and Nuclear Installations" (Convention) and its Amendment, each participating state informs the depositary (IAEA) on the status of its implementation. The SNRIU developed the "Report of Ukraine in Accordance with Paragraph 1 of Article 14 of the Convention" (Report) on the implementation of the provisions of the Convention and submitted it to the IAEA through diplomatic channels, which contributed to the increase of Ukraine's international authority and excluded accusation by russia in failing to ensure physical protection of nuclear material, non-compliance with international obligations, etc.

SNRIU specialists participated in the 21st and 22nd meetings of the IAEA Committee on the development of the IAEA's Nuclear Security Series (NSS) and the 10th meeting of the IAEA Working Group on Physical Protection of Radioactive Materials.

5-8 December SNRIU On 2022, representative with the support of the General Secretariat of Interpol in Istanbul, the Republic of Turkey together with representatives of the Administration of the State Border Service and the Office of the Chief Prosecutor took part in the 1st World Conference of the GEIGER Project, under which expert discussions were held on radiological and nuclear safety during armed conflicts, in particular, the experience of the countries of Central Asia and Southeast Asia related to different types of armed conflicts was considered.

Experts from different countries shared their knowledge and experience regarding new hazards related to unmanned aerial systems, technology of countermeasures, and mobile signal violation systems under the leadership of the criminal intelligence officer under the GEIGER Project. Trends in incidents of illicit trafficking of radioactive materials and their possible regional/global consequences were also considered. Increasing the Effectiveness of State Physical Protection System

The main objectives of physical protection are to minimize the risks of sabotage, theft or any other illicit trafficking of radioactive materials and to strengthen the nuclear nonproliferation regime. Physical protection is a factor of the national security of Ukraine.

In order to increase preparedness to respond and counteract potential hazards of sabotage in relation to nuclear installations and radioactive materials and unacceptable radiation consequences, the SNRIU developed a draft Resolution of the Cabinet of Ministers of Ukraine "Some Issues on Arranging Activities for Determining the Design-Basis Threat to Nuclear Installations, Nuclear Material, Radioactive Waste and Other Radiation Sources in Ukraine", which was adopted at the Government meeting on 27 August 2022 under No. 956.

In order to fulfill the tasks defined by the Resolution, the Interdepartmental Working Group on Design-Basis Threat Determination for Nuclear Installations, Nuclear Materials, Radioactive Waste and Other Radiation Sources in Ukraine was established whose members were approved by SNRIU Order No. 559 dated 16 September 2022. Activities are underway to determine the design-basis threat that will be approved by the relevant legal act. This will positively influence Ukraine's national security, preparedness to respond and countermeasures to potential hazards of sabotage against nuclear installations and radioactive materials, as well as unacceptable radiation consequences.

SNRIU physical protection specialists considered nine Acts for determining the physical protection level, 63 Lists of positions of employees whose work requires permit to perform special activities in order to prevent the hazard of sabotage, theft and other illegal actions by internal offenders. 24 SNRIU inspectors and 10 managers of privately owned enterprises using radiation sources were granted permission to perform special activities. As part of the licensing activity, amendments were made (extension of the validity period) to the license for training, skill improvement and advanced training of specialists in the physical protection of nuclear installations, nuclear materials, radioactive waste, and other radiation sources; four permits were issued for the use of land and water bodies located in the control area of nuclear facility, radioactive waste management facility and uranium facility.

Detection of Radioactive Materials in Illicit Trafficking

Five notifications on cases of revealed radioactive materials in illicit trafficking in Ukraine were sent in 2022 under information feedback with the IAEA database of incidents and illicit trafficking of nuclear and other radioactive materials.

Thus, two items of military purpose - KI-11 aviation compasses containing Ra-226 (Radium-226) were revealed in an international postal shipment when crossing the state border with the Republic of Poland at the Shehyni - Medyca checkpoint in the Yavoriv district of the Lviv oblast in February 2022. The exposure dose rate of gamma radiation at the distance of 0.1 m is 5.69 μ Sv/h. The items were seized and handed over to the Lviv interregional branch of the Radon Association.

On 21 April 2022, a local resident revealed suspicious object while а searching for metal objects in the forest near Lviv city-territorial community in the village of Rudno; it was handed over to representatives of the Security Service of Ukraine. According to the radiation survey results, the Lviv interregional branch of the Radon Association revealed and seized an object - a bioshielding unit with radiation sources affected by corrosion without markings and inscriptions and weighing 50 kg. The exposure dose rate of gamma radiation at the distance of 0.1 m is 6.3 μ Sv/h (according to the preliminary assessment of Cs-137 source in the amount of 3 pcs). The object was seized and handed over to the Lviv interregional branch of the Radon Association.

On 23 April 2022, representatives of the Mayak Plant revealed suspicious objects eight wooden boxes, one bag and one metal container with RID 1 radioisotope detectors in the amount of 600 pieces in production building No. 16 at the plant.



Photo 15 – KI-11 aviation compasses containing Ra-226



Photo 16 - DP-63A dosimeter



Photo 17 – Compass



Photo 18 – Bioshielding unit



Photo 19 – RID 1 radioisotope detectors

According to the survey results of the place where the materials were revealed, the commission established that the exposure dose rate of gamma radiation on the surface of the boxes is from 0.32 to 2.4 μ Sv/h. The objects were packed in polyethylene bags (15 units), sealed with the seal of the Obolon Police Department of the General Directorate of the National Police in Kyiv and transported to RWDS at the Central Production Site of the Radon Association.

On 21 July 2022, Ukrposhta representatives revealed suspicious objects on the territory of the Directorate for Mail Handling and Transportation in Kyiv. Specialists of the Central Production Site of the Radon Association conducted radiation survey of the postal shipment and revealed two items - DP-63A dosimeter and a compass. The exposure dose rate of gamma radiation at the surface of the objects is 15.5 μ Sv/h. The objects were packed in polyethylene bags, sealed with the seal and transported to RWDS at the Central Production Site of the Radon Association.

On 02 December 2022, SSTC NRS specialists as part of the crew of the RanidSONNI mobile radiological laboratory conducted a radiation survey on the territory of the village of Myrcha in Kyiv Oblast' under the SURVEY Project to detect radioactive contamination and radioactive materials that could have been taken by the occupiers beyond ChNPP exclusion zone as a result of violation of radiation safety regime.

During the survey of the communal "Mvrcha institution Basic Secondary Education Institution of Degree I-II, Preschool Educational Institution" located in the village of Myrcha in Borodyanka district of Kyiv Oblast', EDR increase was detected in one of the utility rooms in the institution. DP-63A dosimeter (manufactured in 1965) containing Ra-226 (Radium-226) was revealed resulting from the detailed survey. The exposure dose rate of gamma radiation on the surface of this object was 14.0 µSv/h. The object was packed in a plastic bag sealed and transported to RWDS at the Central Production Site of the Radon Association.

XIII. NUCLEAR WEAPON NON-PROLIFERATION SAFEGUARDS

The legal basis of the international nonproliferation regime is the Treaty on the Non-Proliferation of Nuclear Weapons, which Ukraine acceded to as a non-nuclear-weapon state in late 1994 and, in accordance with Article 3 of the Treaty, agreed to international control over all of its peaceful nuclear activities by signing an Agreement with the IAEA for the Application of Safeguards. According to this Agreement, the IAEA inspects the territory of Ukraine and checks the conformity of the reports provided by the state with the actual condition of nuclear materials in the country.

IAEA Inspection Activity in Ukraine

The IAEA conducted routine inspections, as well as provided additional accesses at nuclear installations and enterprises of Ukraine to confirm the declared inventory of nuclear materials and the absence of undeclared nuclear activities in 2022.

In 2022, SNRIU arranged 30 inspections, one technical visit by the IAEA and 10 additional accesses for IAEA inspectors to nuclear installations in Ukraine. SNRIU state inspectors took part in all the inspection activities of the IAEA (except for Zaporizhzhya NPP inspection).

The IAEA permanent monitoring mission started its activity at the temporarily occupied Zaporizhzhya NPP since September 2022. The work of the IAEA missions at Chornobyl NPP, Khmelnytsky NPP, Rivne NPP, Pivdennoukrainsk NPP, and KIPT was also arranged. The IAEA missions assessed the logistics of enterprises and the management of spare parts. This has provided a better understanding of the needs and further assistance that the IAEA can provide in nuclear safety and security.

State Accounting and Control of Nuclear Materials

SNRIU maintains 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. 146 reports on nuclear materials (60,156 records), three special reports on the loss of state control over nuclear materials as a result of the occupation of the territories of Ukraine by the russian federation and two preliminary notifications on the import of nuclear materials were received from 93 licensees, processed and prepared for the submittal to the IAEA in the reporting year. Other information on the Agreement was also regularly submitted, namely: amendments to the information on nuclear installation design, schedules for repairs of the main equipment during the opening of the core of nuclear installations, schedules for the receipt and shipment of nuclear materials at Ukrainian NPPs, information on radiation doses of IAEA inspectors received during inspection, etc.

An indicator of efficient functioning of the state system of accounting and control of nuclear materials and efficient SNRIU activities aimed at compliance with the international treaties are the final statements of the IAEA on the implementation of verification activities, as well as activities under the Additional Protocol to the Agreement. The statements indicate the achievement of the inspection purpose, compliance with the IAEA requirements for the completeness and timeliness of information submittal, presence of comments on admission of inspectors to the places indicated in relevant requests.

All final statements of the Agency contain positive assessments during the reporting period, which indicates that Ukraine has fulfilled its obligations to comply with the requirements of the Agreement and the Additional Protocol to this Agreement.

Implementation of the Additional Protocol to the Safeguards Agreement

The Additional Protocol to the Safeguards Agreement covers the entire nuclear fuel cycle from uranium ore mining to radioactive waste disposal including scientific research, and grants expanded powers to the IAEA in monitoring of peaceful nuclear activities in the countries. The purpose of the Additional Protocol is to ensure that non-nuclear states that have signed the Treaty on the



Photo 20 – Meeting of the Joint Ukraine - IAEA Safeguards Implementation Review Group at KhNPP on 20 October 2022

Non-Proliferation of Nuclear Weapons do not have undeclared nuclear material and do not conduct undeclared activities with nuclear material.

The information on export supply of agreed equipment and non-nuclear material from Ukraine was provided quarterly to implement the Additional Protocol to the IAEA Agreement in 2022; annual information updating was performed (33 declarations were submitted).

Meeting of the Joint Ukraine - IAEA Safeguards Implementation Review Group

Compliance international with the obligations in the safeguards for the nonproliferation of nuclear weapons in Ukraine is one of the SNRIU priority tasks. The annual meeting of the Joint Ukraine -IAEA Safeguards Implementation Review Group was held on 20 October 2022 at Khmelnytsky NPP site to discuss the working issues related to the implementation of the Safequards Agreement as well as to consider the implementation of IAEA safeguards in Ukraine with the participation of representatives of the SNRIU, IAEA, Ministry of Energy of Ukraine, Ministry of Foreign Affairs of Ukraine, Energoatom, Atomremontservice, Khmelnytsky NPP, Pivdennoukrainsk NPP, Rivne NPP and Chornobyl NPP.

During the meeting of the Working Group, the participants discussed current issues of the safeguards implementation in Ukraine and measures necessary to increase efficiency in implementing the Safeguards Agreement and agreed on the arrangement of relevant training by the IAEA for Ukrainian specialists in the field of nuclear weapon nonproliferation. The representatives of the IAEA also assured that they are ready to provide all the necessary assistance to renew the full functionality of those enterprises and nuclear facilities that were under the occupation of russian troops or were subjected to military influences.

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

During 2022, the information on international transport of nuclear materials was exchanged with:

EURATOM, according to the Agreement between the European Atomic Energy Community and the Cabinet of Ministers of Ukraine for Cooperation in the Peaceful Uses of Nuclear Energy;

Canadian Nuclear Safety Commission according to the Agreement between the Government of Ukraine and the Government of Canada for Cooperation in the Peaceful Uses of Nuclear Energy;

Australia's Bureau of Safeguards and Non-Proliferation in the framework of the Administrative Agreement between the SNRIU and Australian Bureau of Safeguards and Non-Proliferation in accordance with the Agreement between the Government of Ukraine and the Government of Australia on Cooperation in the Field of Use of Nuclear Energy for Peaceful Purposes.

XIV. INTERNATIONAL COOPERATION AND EUROPEAN INTEGRATION

During 2022, the State Nuclear Regulatory Inspectorate of Ukraine carried out active interaction with European institutions and associations, aimed at the implementation of technical cooperation projects, as well as Ukraine's fulfillment of obligations under international treaties in the context of strengthening the regulatory system of nuclear and radiation safety, as well as safety of NPP operation.

Jointly with the European Commission, in the framework of the Instrument for Nuclear Safety Cooperation (INSC), implementation of the project "Strengthening of State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) Capabilities Relevant for Regulation of Nuclear Activities and in Licensing and Severe Accident Management of Nuclear Installation" (U3.01/14-15, U3. 01/18 (UK/TS/51-58), which, among other issues, is aimed at developing a strategy to strengthen the regulatory capabilities and resource planning of the SNRIU, the introduction of HERCA-WENRA approaches to improve interstate coordination of the implementation of protective measures during nuclear accidents, support regulatory activities regarding radwaste management, decommissioning and remediation and support for licensing diversification of nuclear fuel supplies for Ukrainian NPPs.

In 2022, the EC initiated and supported four new tasks in the framework of the project: state nuclear and radiation safety review; justification of the safety of radiation sources management; regulation of priority urgent measures to check the safety state of nuclear and radiation facilities liberated from russian forces in the Chornobyl Exclusion Zone, as well as safety measures at radon and uranium facilities; support for emergency response preparedness; oversight over assessment of operational events in the NPP operation.

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 increasing the safety of NPP operation, radioactive waste management, updating relevant EU regulations, approaches regarding strengthening of cooperation with non-EU countries, etc.

On March 24, 2022, another meeting of the European High-Level Group on Nuclear Safety and Waste Management of the European Nuclear Safety Regulators Group (ENSREG) was held with the participation of the IAEA, WENRA, HERCA, the SNRIU and observer countries. All participating parties expressed their strong support for Ukraine in countering the armed aggression of the russian federation and readiness for further actions to help restore the appropriate level of nuclear and radiation safety of nuclear installations and other facilities using nuclear energy that were affected as a result of military operations, forced seizure and destruction.

The organizers of the ENSREG meeting informed the participants on the exclusion of the republic of belarus from the ENSREG observers, as well as on the uncertainty of prospects for further cooperation with this country. At the meeting, it was proposed to consider the issue of Ukraine's inclusion in the full membership of ENSREG.

On June 20 - 21, 2022, an ENSREG session was held in Brussels, during which Oleh Korikov, Acting Chairman of the State Nuclear Regulatory Inspectorate - Chief State Inspector for Nuclear and Radiation Safety of Ukraine, familiarized European experts with the current state of nuclear safety in Ukraine, primarily at energy enterprises, which are forced to work under conditions of occupation and russian aggression.

As part of the participation in the activities of the **Western European Association of Nuclear Regulators (WENRA)**, regular plenary meetings were held, during which a separate session was devoted to the current situation in Ukraine, which has developed in connection with the military aggression of the russian federation against our country. WENRA members discussed the role and functions of the association and possible ways of supporting the SNRIU in carrying out the functions of regulating nuclear and radiation safety under martial law, reviewed the report of a special group that was engaged in modeling the situation at the ZNPP, etc. The WENRA management and members supported the SNRIU's proposal to suspend the russian and belarusian state regulatory bodies for nuclear and radiation safety from WENRA plenary and other meetings, as well as from participation in the current tasks of WENRA and its working groups, until the end of russia's armed aggression against Ukraine.

As part of cooperation with the **International Atomic Energy Agency** (IAEA) in 2022, implementation of national projects of the Technical Cooperation Program for Ukraine was actually stopped.

On March 30, 2022, IAEA Director General Rafael Mariano Grossi visited the Pivdennoukrainsk NPP site. During the visit of the IAEA delegation, issues of the Agency's support for activities of Licensees in ensuring nuclear and radiation safety, physical protection of nuclear facilities, materials and radioactive waste and other radiation sources in the war conditions, maintaining and restoring regulatory control functions, etc. were discussed.

On April 26, 2022, the Director General of the International Atomic Energy Agency, Rafael Mariano Grossi, visited the Chornobyl nuclear power plant, the Exclusion Zone, honored the memory of liquidators of the consequences of the accident at the Chornobyl nuclear power plant, and headed the work of the IAEA expert mission, which carried out expert assessments at the Chornobyl nuclear power plant occupied by russian troops for five weeks.

As part of the IAEA mission, various types of equipment for radiation monitoring, including radionuclide identification devices and gamma dose rate measurement, personal protective equipment, etc., were handed over to Chornobyl NPP.

Following the results of the first mission, at the end of May, a second mission of IAEA experts visited the Exclusion Zone to assess the safety state of nuclear energy facilities after their liberation from the russian invaders and to detail the needs of international technical support provided to the Ukrainian party under the IAEA coordination.

During the final meeting of the mission held at the SNRIU, the IAEA experts informed on the work results, which included assessment of the state of safety and physical protection of the facilities at the Chornobyl NPP site: the spent nuclear fuel storage facility ISF-1-1 and ISF-2, confinement, liquid and solid radioactive waste treatment facilities, decommissioning progress of the ChNPP units 1, 2 and 3, as well as facilities for radioactive waste and nuclear fuel management located in the Exclusion Zone territory: Centralized spent nuclear fuel storage facility of operating nuclear power plants, facilities designed for radioactive waste management on at the Vektor site, the Buryakivka radioactive waste disposal site.

mission, considerable During the attention was paid to the issues of ensuring radiation dosimetry monitoring at the Exclusion Zone facilities and the territory, including the possibility of transferring current data to the international IRMIS system. In this regard, the mission experts detail the scope of equipment and software for restoring and improving the relevant activities of Ecocenter and UkrHMC. Inspections of other facilities that have suffered negative impacts and destruction as a result of active hostilities were planned as part of further IAEA missions.

On May 4-6, 2022, the delegation of Ukraine participated in the Fourth Extraordinary Meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management.

At the Seventh Meeting of the Consider Contracting Parties to the Fulfillment of Obligations under the Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management, held at the IAEA headquarters (Vienna), the Ukrainian delegation presented the Seventh National Report on Ukraine's Fulfillment of Obligations arising from the Joint Convention.

During the presentation, information on functioning and development of the radioactive waste and spent nuclear fuel management system in Ukraine during the reporting period, since the presentation of the previous Sixth National Report in 2018 was presented.

The presentation highlighted the issues covered by the Joint Convention, namely, the system of state management and regulation, measures to develop the regulatory framework, implementation of the national strategy and programs for the radwaste and spent fuel management, financial support, progress in creation and operation of facilities designed for radwaste and spent fuel management, decommissioning of nuclear facilities, spent radiation sources management remediation of radioactively contaminated facilities and territories.

The consequences of the full-scale military invasion of the russian federation in Ukraine, seizure and occupation of nuclear and radiation facilities, the increase in risks and emergence of security deficits associated with the war, the negative impact of hostilities on radiation safety and preservation of radiation sources were also presented.

The participating countries of the Seventh Meeting of the Contracting Parties to Review the Fulfillment of Obligations Under the Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management called on the russian federation to stop the illegal war against Ukraine, immediately withdraw troops and other personnel from the entire territory of Ukraine, including the Zaporizhzhia NPP, which was reflected in the official Statement of the countries that are contracting parties under the United Convention.

From September 26 to 30, 2022, the regular 66th session of the IAEA General Conference was held in Vienna. Ukraine was represented at the General Conference by an official delegation headed by Oleh Korikov, Acting SNRIU Chairman. During the plenary week, key issues of the organization's activities were discussed, in particular, the approval of the Agency's budget for 2023, determination of priorities according to the activity programs for ensuring nuclear and radiation safety, safety of radioactive waste management, and nuclear security. The results of the verification activities carried out in 2022 were also discussed, areas for improving the effectiveness of the existing system of Safeguards, areas for the development of the contemporary science and technology, planning of the technical cooperation program, etc. were agreed upon.

During his speech at the General Conference plenary session, the Head of the Ukrainian delegation noted, in particular, the following: for the first time in the history of mankind, a country using nuclear energy for peaceful purposes operating 15 nuclear power units, faced military seizure and occupation of nuclear installations - the largest in Europe Zaporizhzhia NPP, and Exclusion Zone, where spent nuclear fuel storage facilities are located, Confinement above the ChNPP unit 4, where the largest man-induced accident in history took place. Due to the actions of the russian federation, the world is on the verge of a nuclear disaster, the consequences of which will be global and it is currently impossible to predict them.

The Head of the Ukrainian delegation called on the world community not to be indifferent and not to expect that other countries will avoid the consequences of a possible nuclear accident, and to use all their leverages to stop the occupying country in its terrorist activities regarding nuclear installations and other facilities of peaceful use of nuclear energy. He thanked IAEA Director General Rafael Grossi for organizing and conducting missions to the Chornobyl NPP and ZNPP. He noted that the reports prepared based on the results of the missions became for the world community indisputable evidence of the crimes of the russian army in the occupied territories and are their documented confirmation. However, he noted that the report on the mission results at the ZNPP did not bring us closer to solving the main problems: stopping the shelling of nuclear facilities, de-militarization and deoccupation of the ZNPP.

It was also stated in the speech that Ukraine highly values the adoption of the Resolution GOV/2022/58 of 15 September 2022 "The Safety, Security and Safeguards" Implications of the Situation in Ukraine" by the IAEA Board of Governors and supports the call to the russian federation to immediately stop all actions against Zaporizhzhia nuclear power plant and any other nuclear facility in Ukraine and in relation to them, in order to restore full control by the competent authorities of Ukraine over all nuclear facilities within the internationally recognized borders of Ukraine, including the Zaporizhzhia nuclear power plant, to ensure their safe and secure operation, as well as for the full and



Photo 21 – Head of the Ukrainian delegation Oleh Korikov during his speech at the 66th Session of the IAEA General Conference

safe implementation by the Agency of its activities in accordance with the Agreement between Ukraine and the IAEA on the application of safeguards in connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Agreement between Ukraine and the IAEA for the application of safeguards in connection with the NPT) and the Agency Statute.

Oleh Korikov thanked the partner countries that have already provided and will provide equipment for Ukrainian organizations in the framework of RANET in the near future. This equipment is a necessary factor in restoring the capabilities of organizations that suffered during the occupation by russian troops and will be used to overcome the negative consequences for nuclear and radiation safety caused by hostilities on the territory of Ukraine. The speech emphasized that Ukraine remains fully committed to its obligations under the NPT in general and the Comprehensive Safeguards Agreement and its Additional Protocol in particular, even in wartime.

The delegations of the Republic of Poland and Canada included in the agenda the issue on the situation in Ukraine: security, safety and non-proliferation safeguards.

Delegations of the European Union, Poland, Great Britain, Australia, India, Japan, Turkey, Brazil, the USA, the russian federation, Venezuela, Mexico, and Ukraine made speeches during this session. The Canada issued a joint Statement on behalf of a group of countries (more than 57 countries joined this Statement). On behalf of Ukraine, the Head of the Ukrainian delegation, Oleh Korikov, made a statement, in which he noted, in particular, the following:

"Russia's unprovoked and unjustified aggressive war against Ukraine revealed a number of vulnerabilities from the point of view of the nuclear safety and security paradigm. In the past seven months, since the beginning of the russian invasion of Ukraine, nuclear safety has changed more than in the previous five decades.

From now on, Member States considering or starting to use nuclear energy must work hard to improve or strengthen national regimes for the physical protection of their nuclear infrastructure, based on the Ukrainian experience. The role of the Agency is to promote the efficiency and effectiveness of nuclear safety systems worldwide by developing a new paradigm of nuclear safety to counter new and evolving threats arising in the context of russia's war against Ukraine.

In its current state, russia's war against Ukraine involves the threat of using nuclear weapons, which coexists with the threat of using a peaceful atom for military purposes.

russia committed strikes on the Chornobyl and Zaporizhzhia NPPs, missile strikes and shelling of the Pivdennoukrainsk NPP and the Kharkiv Physical and Technical Institute, bombing of radioactive waste storage facilities, missile attacks on other nuclear power plants in Ukraine. These are just a few examples that clearly demonstrate how the russian paradigm of warfare involves a scenario where every nuclear facility can be used as a pre-installed nuclear bomb.

russia's absolute disregard for international rules and standards in the nuclear field only strengthens the need to reassess approaches to nuclear safety.

russia's invasion of Ukraine has farreaching consequences that go far beyond the violation of international law and the violation of Ukraine's territorial integrity. russia's neglecting of international nuclear obligations is even more serious violation - a violation of the non-proliferation regime established by the Treaty on the Non-Proliferation of Nuclear Weapons.

russia's complete disregard for legally binding agreements in the nuclear field, such as the IAEA's Comprehensive Safeguards Agreement, undermines the effectiveness of the overall safeguards mechanism established by the Treaty on the Non-Proliferation of Nuclear Weapons, thus questioning the IAEA's ability to provide comprehensive findings."

For generations, russia will be remembered as the only country that captured and occupied peaceful nuclear facilities on the sovereign territory of an IAEA member state. Such actions of the russian federation - a member of the IAEA and a state possessing nuclear weapons are a gross violation of international law, including the UN and the IAEA Charters.

russia is responsible for this crisis. russia must be responsible for the complete disregard for the international law and, in particular, for the violation of the IAEA Charter".

In their statements, the partner states condemned russia's terrorist actions at the nuclear facilities of Ukraine, called for an immediate seizure of shelling, the withdrawal of troops from the Zaporizhzhia NPP site, and the return of the ZNPP to the regulatory control of Ukraine. They emphasized respect for the territorial integrity, independence and sovereignty of Ukraine and condemned the illegal "referendums" held by the russian federation in the temporarily occupied territories of Kherson, Zaporizhzhia and Kharkiv regions.

From September 1 to September 4, 2022, an IAEA mission led by the Director General Rafael Mariano Grossi worked at the Zaporizhzhia NPP, which was occupied by the russian invaders. As part of the mission, the International Atomic Energy Agency inspected the implementation of the Agreement between Ukraine and the IAEA in connection with the Treaty on the Non-Proliferation of Nuclear Weapons. The inspection was carried out by the Agency's inspectors. In the process of their activity, the IAEA inspectors checked the documentation on the accounting and control of nuclear materials and conducted an inspection of the nuclear material in the declared places of its storage. Maintenance of the IAEA's storage and surveillance facilities has been carried out as well.

In the mission report, the IAEA inspectors noted that the russian federation has placed military personnel, vehicles and equipment on the ZNPP territory, in particular in the turbine halls of power units No. 1 and No. 2. It has been confirmed that representatives of "rosatom" are present at the ZNPP and this "this may result in interference with day-to-day operational management and potentially create friction within the decision-making process". It is noted that the presence of representatives of the russian federation has a negative impact on the plant personnel, who work under stressful conditions. The experts of the mission recorded the damage suffered by the ZNPP during the shelling. The IAEA Director General also informed on the start of consultations on urgent establishment of a nuclear safety and protection zone at the ZNPP. Based on the results of the mission led by the IAEA Director General, a decision was made on the permanent presence of the IAEA at the ZNPP (ISAMZ mission).

The work of the ISAMZ mission is ensured based on the Terms of Reference developed by the central executive power bodies and approved by exchanges of Notes between Ukraine and the IAEA. Every week, institutions and organizations of Ukraine are provided with a report on the activities of the mission, and the results of the week's activities are discussed with the Ukrainian party through video conferences.

"On the sidelines" of the General Conference, O. Korikov signed a Joint Statement of Intent on scientific and technical cooperation in the field of nuclear safety between the State Nuclear

Regulatory Inspectorate of Ukraine and its technical support organization - the State Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety" (SSTC NRS) and by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of the Federal Republic of Germany and its technical support organization – the Society for the Safety of Installations and Reactors and the Memorandum of Understanding between the State Nuclear Regulatory Inspectorate of Ukraine and the Radiation and Nuclear Safety Authority of Finland (STUK) regarding cooperation and information exchange in the field of nuclear and radiation safetv.

In the framework of cooperation with the **U.S. Nuclear Regulatory Commission**, a number of important events took place in 2022, including signing of the updated Executive Agreement on the participation of the SNRIU in the program for application and support of radiation protection codes (the RAMP Program).

On May 20, 2022, during a working online meeting with the Chairman of the U.S. Nuclear Regulatory Commission, Christopher HANSON, the issues of abandoning the use of fuel fabricated by the russian federation at VVER-440 units of Ukrainian nuclear power plants, regulating nuclear and radiation safety in the context of hostilities were discussed.

The future areas of bilateral cooperation were also outlined, in particular, this is the support of the Ukrainian regulator in the further study of the experience of licensing advanced nuclear technologies implemented in the designs of the AR1000 and SMRs. In addition, technical assistance is planned to strengthen the functioning of the SNRIU Information and Emergency Center and commissioning of the State Register of Individual Exposure Doses of Personnel and the Public, which is advanced hardware and software, the list of which was submitted to the IAEA in the framework of RANET.

On September 28, 2022, in the framework of the IAEA General Conference, the Acting Chairman of the State Nuclear Regulatory Inspectorate - Chief State Inspector for Nuclear and Radiation Safety of Ukraine Oleh Korikov and Chairman of the U.S. Nuclear Regulatory Commission (U.S. NRC) Christopher Henson held a meeting in Vienna (Austria). Participants of the Ukrainian and American delegations at the IAEA General Conference discussed the situation at the Ukrainian nuclear power plants -Zaporizhzhia and Pivdennoukrainsk NPPs. Oleh Korikov informed his American colleague in detail on the threats to nuclear and radiation safety that arose due to the unprovoked aggression of the russian federation and the occupation of Ukrainian nuclear facilities by its troops.

The meeting participants also discussed the issue of diversification of nuclear fuel for the needs of the Ukrainian nuclear energy industry. In Ukraine, the gradual replacement of russian-fabricated nuclear fuel with the Westinghouse nuclear fuel is successfully taking place, and seven out of fifteen Ukrainian power units are already using Westinghouse fuel assemblies. The SNRIU Head reported that during the operation of the Westinghouse fuel assemblies during 2015-2022, no violations of the safe operating conditions of the power units were recorded at the VVER-1000 reactors.

The process of continuing the process of nuclear fuel diversification is especially relevant today, when russia is carrying out military aggression against Ukraine, and is using its own energy resources as a tool of blackmail and pressure.

The U.S. NRC Chairman Christopher Henson, assured that the U.S. will continue providing comprehensive support to Ukraine, in particular, in ensuring nuclear and radiation safety, as well as continue cooperation and implementation of bilateral projects in the nuclear energy field.

The scheduled implementation of the cooperation project with the U.S. Department of Energy "Improving Security of Radiation Sources Used in Ukraine" as part of the "Global Threat Reduction Initiative" under the general coordination of the Office of Radiological Security of the U.S. Department of Energy continued. In particular, modernization of engineering and technical means of physical protection systems of oncology dispensaries, facilities using high-level radiation sources, and radioactive waste storage facilities in Ukraine was carried out.

Based on the results of the meetings with the project donor, the areas for the expansion of the project "Improving Security of Radiation Sources Used in Ukraine" were determined by including



Photo 22 – Oleh Korikov, Acting SNRIU Chairman, and Rafael Mariano Grossi, IAEA Director General

urgent issues related to restoring and strengthening of the physical protection systems of individual SAUEZM enterprises and facilities that were damaged as a result of the armed aggression of the russian federation against Ukraine, and a decision was made on: the installation of an optical fiber communication line between the Pidlisnyi, Buryakivka, and ChNPP Stage III and their connection to the Vektor site, for which the donor decided to purchase 120 km of optical fiber cable; purchase of 4 Renault Duster cars for the rapid response unit of the SSE CRME.

In this area, a decision was made to involve professors of higher educational institutions of the Ministry of Internal Affairs of Ukraine as observers in the development and implementation of a pilot training course on responding to nuclear security related events; the issue of the possibility to provide assistance in the arrangement of classrooms for relocated universities of the Ministry of Internal Affairs of Ukraine was considered.

During the reporting year, SNRIU duty officers ensured continuous monitoring of operation of the Central Station for monitoring the security of radiation sources, which comprises 32 facilities.

Cooperation with the Norwegian Radiation and Nuclear Safety Authority (DSA) was carried out in the framework of 11 bilateral cooperation projects, including three new ones:

"Development of Priority Regulatory Documents to Ensure Safety Regulation when Restoring Control over Nuclear Hazardous Facilities and Sites Affected by the Hostilities". Project "ZONE";

"Radiation Survey of the Territories Affected by the Hostile Military Occupation of Ukrainian Territory and War Peculiarities. Project "SURVEY" Phase 1: Conducting Radiation Survey in Kyiv region";

"Radiation Survey of the Territories Affected by the Hostile Military Occupation of Ukrainian Territory and War Peculiarities. Project "SURVEY" Phase 2: Conducting Extended Radiation Survey in Kyiv Region".

In 2022, the State Nuclear Regulatory Inspectorate intensified bilateral cooperation with the Radiation and Nuclear Safety Authority of Finland (STUK) and the National Atomic Energy Agency of Poland (PAA).

At the end of 2022, at the request of the Government of Ukraine, short-term IAEA missions were carried out at all operating NPP sites, as well as at the Chornobyl NPP, and development of a joint terms of reference as a basis for the permanent presence of IAEA experts at all Ukrainian NPPs was started to provide expert support to personnel, safety monitoring and unbiased recording of the impact of hostilities on the safety state of nuclear installations.

The main events that had an impact on the state of nuclear and radiation safety, security and non-proliferation safeguards during 2022 were reported on the official website of the State Nuclear Regulatory Inspectorate of Ukraine https://snriu.gov.ua/, on the Facebook page and in the Telegram channel of the SNRIU; analytical reviews on issues of nuclear safety, radiation protection and non-proliferation of nuclear weapons were published on the website https://www.uatom.org/, topical safety issues were highlighted in statements, speeches and interviews of the Acting SNRIU Chairman Oleh Korikov.

The state of nuclear and radiation safety in Ukraine in 2022, with the exception of the territories temporarily occupied by the russian federation, remained stable and was under the control of the national regulator with the support of the International Atomic Energy Agency and Ukraine-friendly member states of the IAEA, the EU and NATO.

However, the risks of nuclear and radiation emergencies in the war conditions remain high, and only cessation of military aggression by the russian federation and the regaining Ukraine's full control over the Zaporizhzhia NPP and other temporarily occupied territories can be a guarantee of nuclear and radiation safety for Ukraine, Europe and the world.

The report on nuclear and radiation safety in Ukraine for 2022 was prepared by the editorial board of the SNRIU under the chairmanship of **O. Korikov**, including representatives of structural units of the SNRIU (**I. Baglai, G. Borzdova, I. Kyrylenko, T. Kniazhnytska, T. Kutuzova, A. Myshkovska, Yu. Novikova, N. Rybalka, N. Rumezhak, O. Fazly, R. Khalenko, N. Kharchuk**). and SSTC NRS (**V. Boichuk**).

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9/11, Arsenalna str., Kyiv, 01011, Ukraine tel.: +38 044 277 12 02 https://snriu.gov.ua