Statens strålevern
Norwegian Radiation Protection Authority

StrålevernRapport 2018:5

Ukrainian Regulatory Threat Assessment 2017

Reassessment of threats in regulation of nuclear and radiation safety in Ukraine

Reference:
Siegien K, Sneve M, Kostenko I, Yesypenko Y, Pecherytsia O. Ukrainian Regulatory Threat Assessment: identifying priorities for improving supervision of nuclear and radiation safety and security.
StrålevernRapport 2018:5. Østerås: Statens strålevern, 2018.

Key words:
Nuclear legacy, threat assessment, regulatory challenges, cooperation road map

Abstract:
This report reassess the main nuclear and radiation threats to safety and security in Ukraine from a regulatory perspective and identifies the current main challenges, threats and gaps in the Ukrainian regulatory framework.

Referanse:
Siegien K, Sneve M, Kostenko I, Yesypenko Y, Pecherytsia O. Ukrainian Regulatory Threat Assessment: identifying priorities for improving supervision of nuclear and radiation safety and security.
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Emneord:
Nuclear legacy, trusselvurdering, regulatoriske utfordringer, samarbeid veikart

Resymé:
Denne rapporten revurderer de viktigste kjernefysiske og strålingstruslene mot sikkerhet i Ukraina fra et regulatorisk perspektiv og identifiserer de nåværende hovedutfordringene, truslene og hullene i det ukrainske regelverket.

Head of project: Malgorzata K. Sneve
Approved:

Per Strand, director, Department of Nuclear Safety and Environmental Radioactivity

106 pages.
Published 2018-04-13.
Cover design: 07 Media.
Printed number: 50 (04-18)

Norwegian Radiation Protection Authority, P.O. Box 55, N-1332 Østerås, Norway.
Telephone +47 67 16 25 00, fax + 47 67 14 74 07.
E-mail: nrpa@nrpa.no
www.nrpa.no

ISSN 0804-4910 (print)
ISSN 1891-5205 (online)

StrålevernRapport 2018:5

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Østerås, 2018

Program Coordinators:

Malgorzata K Sneve, NRPA
Per Strand, NRPA
Iryna Kostenko, SNRIU

List of Contributors:

For NRPA:

Katarzyna Siegien (Project manager)

For SNRIU:

The main performers: Oleksandr Grygorash, Viktor Pashchenko, Ruslana Tripailo, Nataliia Rybalka, Nataliia Rumezhak

For SSTC NRS:

Yuliia Yesypenko (Project manager)
The main performers: Oleksandr Pecherytsia, Yuliia Yesypenko, Anatolii Shanchuk, Dmytro Vorontsov, Oleksii Shugailo, Volodymyr Bogorad, Oleksiy Ligotskyy, Oleksandr Kukhotskyi, Svitlana Chupryna, Ihor Kuzmyak, Ievgen Nikolaiev, Inna IARMOSH, Iryna Kutina, Oleksandra Slepchenko, Tettiana Lytvynska, Sergii Kondratiev, Oleksandr Pasyeka

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Executive summary

The Norwegian Radiation Protection Authority (NRPA) introduced its Bilateral Regulatory Cooperation Program in Ukraine within the Norwegian Government Nuclear Action Plan and commenced cooperation with the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in 2014. The activities are funded by allocations from the Norwegian Ministry of Foreign Affairs.

Positive experience in the initiation of bi-lateral cooperation work between NRPA and regulatory authorities in other countries was achieved through the carrying out of Regulatory Threat Assessments. A Regulatory Threat Assessment is a holistic study to identify the most significant nuclear and radiation threats which require the most urgent and significant improvements regarding their regulatory supervision.

Based on this experience, the SNRIU and its Technical Support Organization, the State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) completed an initial Ukrainian Threat Assessment Report in September 2015, with the guidance and support of NRPA experts. At that time 43 threats were identified and categorized as needing to be minimized or eliminated in the areas of: radiation and nuclear safety; radioactive waste management and decommissioning; emergency preparedness and response; nuclear installation safety and organizational and general principles. The report was published by NRPA in 2016. Based on the results, NRPA and SNRIU developed a Roadmap of Cooperation for 2016-2017, which defined a number of first-priority projects to improve the Ukrainian national regulatory framework for nuclear and radiation safety.

Since the formulation of that Roadmap, a number of regulatory measures have been implemented, including several within the continuing bi-lateral cooperation program. There have been new experiences and lessons learned in the application of international recommendations and guidance. Therefore, during the bilateral meeting between NRPA and SNRIU in March 2017, it was decided to reassess the regulatory threats identified in 2015. The general objective was to review the current state of the Ukrainian legislative framework on nuclear and radiation safety and to update the recommendations of the 2015 report.

This report presents findings of the updated regulatory threat assessment. It recognizes new gaps and priorities for regulatory attention, and provides information on current and planned SNRIU activities aimed at addressing the identified threats.

A substantial part of the report is dedicated to international cooperation and in particular, projects within the Norwegian-Ukrainian bilateral program that were set up to address the initially recognized regulatory gaps and threats. Information is also provided about on-going and planned projects and their influence on the situation regarding both the regulatory body and the Ukrainian regulatory system. This approach facilitates analysis of, and engagement with, all international activities, so as to avoid overlaps and gaps, and enable a very effective and complementary approach.

The final section of the report reprises the threats recognized in the 2015 Assessment, including activities undertaken to mitigate them, and sets out the new threats and the measures planned to address them.

It is hoped that the presented experience and results support continuing multinational activities to address regulation of nuclear and radiation safety including complex legacy sites and other important regulatory challenges.

List of Abbreviations

C(I)SIP	–	Comprehensive (Integrated) Safety Improvement Program for Operating Nuclear Power Units
ChNPP	–	Chornobyl Nuclear Power Plant
Complex	–	State Specialized Enterprise 'Complex' for Radioactive Waste Management and Decontamination
CSFSF	–	Centralized Spent Fuel Storage Facility
DSRS	–	Disused Sealed Radiation Sources
DSFSF	–	Dry Spent Fuel Storage Facility
EBRD	–	European Bank for Reconstruction and Development
EC	–	European Commission
Energoatom	–	National Nuclear Energy Generating Company 'Energoatom'
EU	–	European Union
FA	–	Fuel Assembly
HERCA	–	Heads of European Radiological Protection Competent Authorities
IAEA	–	International Atomic Energy Agency
ICRP	–	International Commission on Radiological Protection
IEC	–	Information Emergency Center
INES	–	International Nuclear and Radiological Event Scale
IRRS	–	Integrated Regulatory Review Service
ISF	–	Interim Spent Fuel Storage Facility
KhNPP	–	Khmelnitsky Nuclear Power Plant
KIPT	–	National Scientific Center 'Kharkiv Institute of Physics and Technology'
NATO	–	North Atlantic Treaty Organization
NPP	–	Nuclear Power Plant
NRBU	–	Radiation Safety Standards of Ukraine
NRPA	–	Norwegian Radiation Protection Agency
NSC	–	New Safe Confinement
PBPRM	–	Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials
PChP	–	Prydniprovsk Chemical Plant
PPS	–	Physical Protection System
PSAR	–	Preliminary Safety Analysis Report

R&D	–	Research and Development
Radon	–	Ukrainian State Corporation 'Radon'
Radwaste	–	Radioactive Waste
RHWG	–	Reactor Harmonization Working Group
RICS	–	Radioactive Waste Interim Confinement Site
RM	–	Radioactive Materials
RNPP	–	Rivne Nuclear Power Plant
RWDS	–	Radioactive Waste Disposal Site
SAEZ	–	State Agency of Ukraine on Exclusion Zone Management
SESU	–	State Emergency Service of Ukraine
SISP	–	State Interregional Specialized Plant for Radioactive Waste Management
SNRIU	–	State Nuclear Regulatory Inspectorate of Ukraine
SPPS	–	State Physical Protection System
SSM	–	Swedish Radiation Safety Authority
SSTC NRS	–	State Scientific and Technical Center for Nuclear and Radiation Safety
SUNPP	–	South Ukraine Nuclear Power Plant
TAR	–	Threat Assessment Report
Tekhnocenter	–	State Specialized Enterprise 'Tekhnocenter' for Man-Made Waste Processing and Disposal
TSO	–	Technical Safety Organization
U.S. NRC	–	United States Nuclear Regulatory Commission
UARMS	–	Unified Automated Radiation Monitoring System
USA	–	United States of America
USCPS	–	Unified State Civil Protection System
USSR	–	Union of Soviet Socialist Republics
VVER	–	Water-Cooled Water-Moderated Power Reactor
WANO	–	The World Association of Nuclear Operators
WENRA	–	Western European Nuclear Regulators Association
WGWD	–	Working Group on Waste and Decommissioning
ZNPP	–	Zaporizhzhya Nuclear Power Plant

1 Introduction

In November 2014, SNRIU and NRPA signed the Agreement [1] on cooperation in the area of nuclear and radiation safety. One of the first projects implemented under this Agreement was aimed at identification and assessment of the main threats for nuclear and radiation safety regulation. The SNRIU and SSTC NRS experts assessed the identified threats with support from NRPA. Further analysis [2] revealed the challenges for SNRIU and issues to be solved to improve regulatory functions. The major challenge ware recognized as the need of improvements in the regulatory and legal framework governing activities in the following areas:

- safety of nuclear installations;
- radioactive material transport;
- emergency preparedness and response;
- radioactive waste management and decommissioning;
- radiation safety.

For each challenge, SNRIU and SSTC NRS proposed ways and methods to minimize and/or eliminate the associated threats, thus enabling SNRIU and NRPA to plan their cooperation activities in a well-grounded and efficient manner. The Threat Assessment Report provided to NRPA and international community a clear view of the existing issues adversely affecting regulation of nuclear and radiation safety in Ukraine, which should be solved in the framework of the NRPA and SNRIU cooperation.

This was followed by the development of the Roadmap for further cooperation, which prioritized activities presented in the Report and defined directions for cooperation during 2016-2017.

The financial and expert support of NRPA for the implementation of projects foreseen in the Roadmap enabled the development by SNRIU and SSTC NRS of the following six regulatory documents in the period from 2015 to 2017:

- Requirements for Administrative Control of Uranium Sites within Restricted Clearance from Regulatory Control [3];
- General Safety Rules for Medical Radiation Sources [4];
- General Safety Provisions for Predisposal Management of Radioactive Waste [5];
- Radiation Safety Rules of Using Radiation Sources in Brachytherapy [6];
- General Radiation Safety Provisions for Mining and/or Processing of Uranium Ore;
- General Safety Provisions for Disposal of Radioactive Waste.

Documents [3] - [6] have been put into effect to date. Other two documents are at the final stage of their official approval and registration in the Ministry of Justice of Ukraine.

As of December 2017, the remaining Roadmap projects are at different stages of implementation. They aim at development or revision of the following regulatory requirements and guidelines (working titles):

- General Safety Provisions for Decommissioning of Nuclear Facilities;
- Requirements for the Structure and Contents of the Operator’s Documents for Licensing Application for Decommissioning of Nuclear Facilities;
- Basic Safety Requirements for Use of Radiation Sources;
- Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials;

- Radiation Emergency Response Plan;
- Requirements for the Structure and Contents of NPP Emergency Documentation;
- Development of Guideline for Assessment of Safety Culture and Human and Organizational Factors in Operating Experience Analysis.

Since the development of the Threat Assessment Report [2], a number of important measures were implemented and several important events took place in the Ukrainian nuclear sector. They include but are not limited to the following.

The signature of the Association Agreement between Ukraine and the European Union significantly increased efforts on adaptation of the Ukrainian legislation to the EU legislation in the nuclear energy area. SNRIU prepared and the Government of Ukraine approved early 2015 the plans for implementation of the EU legislation in the field of nuclear and radiation safety: Council Directive 2013/59/Euratom [7], Council Directive 2006/117/Euratom [8] and Council Directive 2014/87/Euratom [9]. In accordance with these plans, SNRIU among other things:

- drafted the Law on National Nuclear Regulatory Commission, which envisages legislative consolidation of economic, political and financial independence of the regulatory body to ensure its competence and fulfilment of its functions fully in line with national regulations in nuclear energy and international agreements;
- submitted amendments to the basic Laws: On Nuclear Energy Use and Radiation Safety [10], On Authorizing Activity in Nuclear Energy [11], On Human Protection against Ionizing Radiation [12] and On Mining and Processing of Uranium Ores - for review by the Verkhovna Rada (Parliament) of Ukraine;
- developed and implemented a set of regulatory documents governing a wide range of nuclear and radiation safety aspects (including documents [3] - [6]).

In 2015, SNRIU got a status of a full member of the Western European Nuclear Regulators Association (WENRA). That was an important step in Ukraine's transfer to European standards in the regulation of nuclear and radiation safety.

In 2015-2017, implementation of the safety upgrades at Ukrainian NPPs continued in accordance with the C(I)SIP [13], taking into account additional measures resulting from the extraordinary in-depth safety reassessment of Ukrainian NPPs (stress tests). SNRIU continuously monitors all implementation stages of those measures (development of a concept, installation and pre-commissioning activities, trial and commercial operation) through a comprehensive technical assessment of safety justification documents and direct oversight of relevant modifications, amendment of operational documentation and personnel training.

In the second half of 2016, SNRIU made a decision on long-term operation of Zaporizhzhya units 1 and 2 for the next ten years, based on outcomes of the periodic safety review of those power units. The operating organization performed a series of major improvements and implemented a significant number of modernization measures. In 2017, the operating organization made efforts to prepare ZNPP units 3 and 4, RNPP unit 3 and KhNPP unit 1 for long-term operation. The design lifetime of these power units expires in 2017-2018.

The nuclear fuel diversification process is ongoing to reduce dependence on a single supplier. The process is verified and monitored by SNRIU, including the decision in principle on new fuel implementation to commercial operation. Trial operation of nuclear fuel produced by the Westinghouse Company is by March 2018, underway in mixed cores of SUNPP unit 2 and 3 and ZNPP unit 5. According to actions and plans of the operating organization approved by SNRIU, loading of the Westinghouse fuel within extension of its trial operation is also planned at ZNPP units 1, 3 and 4 in the nearest future.

The Key factor in strengthening Ukraine's independence in the nuclear sector is the progress reached in the construction of the centralized spent fuel storage facility (CSFSF) located in the Chornobyl exclusion zone. In July 2017, SNRIU issued a license to the National Nuclear Energy Generating Company 'Energoatom' for construction and commissioning of CSFSF. The storage facility is designed and being constructed using the technology by Holtec International.

In November 2016, the New Safe Confinement (NSC) was successfully moved over the Shelter at ChNPP unit 4, destroyed during the accident on 26 April 1986. This event became a key step towards the completion of the international program aimed at transformation of the ChNPP into an environmentally safe system. There are efforts underway to finish the construction of NSC over the sarcophagus and prepare it for commissioning by the end of 2018. The next step will cover dismantling of unstable Shelter structures, monitoring and retrieval of fuel-containing materials and other radioactive waste from the Shelter. SNRIU plans to issue a license to ChNPP (late 2018 – early 2019) for NSC operation considering it as a radioactive waste management facility.

The above examples demonstrate the general range of tasks, which SNRIU focused on its activities during 2016 - 2017. Most of these tasks remain relevant until today. The uniqueness and complexity of these tasks, as well as the current political, security and economic situation in Ukraine, deepen existing challenges and give rise to a significant number of new challenges that negatively affect the regulatory activity.

This Report presents the threat reassessment results, taking into account all actions performed by SNRIU during last two years. Sections 2 - 7 of the Report analyze the current situation in state regulation of nuclear energy safety in Ukraine in the areas defined in the Agreement [1]. The main attention in the analysis was given to the progress reached in the aforementioned areas from 2015 to 2017, the description of changes occurred in the national nuclear sector in the specified period and definition of the current and potential impact of these changes on the SNRIU activities. The structure of Section 8 is similar to the relevant sections of the Threat Assessment Report [2]. Section 9 is devoted to the analysis of projects either ongoing or planned to be implemented by 2020 and aimed at eliminating threats identified in the previous section. This Section presents information on the status and results of projects (as of autumn 2017) within the cooperation between NRPA and SNRIU. It also describes other ongoing projects or projects planned for implementation in cooperation of SNRIU with partner institutions in other countries and international organizations, as well as in cooperation with SSTC NRS.

Section 10 presents brief conclusions on the conducted activities focusing on the main results achieved to date.

2 Organization and general principles for activities of the Regulatory Authority

The Ukrainian Regulatory Threat Assessment Report [2] describes in detail basic principles of state nuclear safety regulation in Ukraine, as well as obligations and tasks entrusted to SNRIU in accordance with the current legislation. A Summary of the current information on organizational aspects of SNRIU activities is presented below with a detailed description of issues addressed in the development of this Section.

2.1 General Organizational Aspects of SNRIU Activities

The main functions of the nuclear regulatory authority determined by the Convention on Nuclear Safety [14] and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of

Radioactive Waste Management [15] are entrusted to the SNRIU (www.snrc.gov.ua), acting in compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine [16].

The main SNRIU functions are to:

- identify safety criteria and requirements to be met in the use of nuclear energy (rule-making);
- issue permits and licenses for activities in nuclear energy (licensing);
- conduct state oversight of compliance with laws, regulations, rules and standards on nuclear and radiation safety and apply enforcement measures according to legislation in case of incompliance (oversight).

The main SNRIU tasks are to:

- establish and implement state policy for the safe use of nuclear energy;
- exercise state regulation of nuclear energy safety;
- exercise powers of a competent body on physical protection of nuclear material and nuclear facilities in compliance with the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities [17], on safe transport of radioactive material in compliance with the Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials [18] and on emergency notification in compliance with the Convention on Early Notification of a Nuclear Accident [19].

As of mid-2017, the SNRIU conducts state regulation of nuclear and radiation safety of:

- 15 operating nuclear power units, two units (Khmelnitsky-3, 4) in construction, 3 units of the Chornobyl NPP in decommissioning (for more detail, see Sections 3,5 and 6 of this Report);
- two operating spent fuel storage facilities at the Zaporizhzhya and Chornobyl NPPs and two storage facilities under construction in the exclusion zone (for more detail, see Section 6 of this Report);
- two research reactors (for more detail, see Section 3 of this Report);
- neutron source based on a subcritical assembly driven by a linear electron accelerator under construction on the territory of the Kharkov Institute of Physics and Technology (for more detail, see Section 3**Feil! Fant ikke referansekilden.** of this Report);
- nuclear fuel fabrication plant (for more detail, see Section 3 of this Report);
- radioactive waste storage/disposal facilities and radioactive waste management enterprises (for more detail, see Sections 6 and 7 of this Report):
  - six specialized 'Radon' plants,
  - radioactive waste disposal and temporary confinement sites of Enterprise 'Complex',
  - storage/disposal facilities for radioactive waste from territories contaminated in the Chornobyl accident, operated and constructed by Enterprise 'Tekhnocenter',
- Shelter facility (for more detail, see Section 6 of this Report);
- uranium processing plants (for more detail, see 6 Section of this Report);
- radioactive material transport through Ukraine (for more detail, see Section 4 of this Report);

- use and fabrication of radiation sources and radiation technologies, including their application in medicine, industry, research etc. (for more detail, see Section 7 of this Report).

The SNRIU organizational structure is shown in Fig. 2.1.

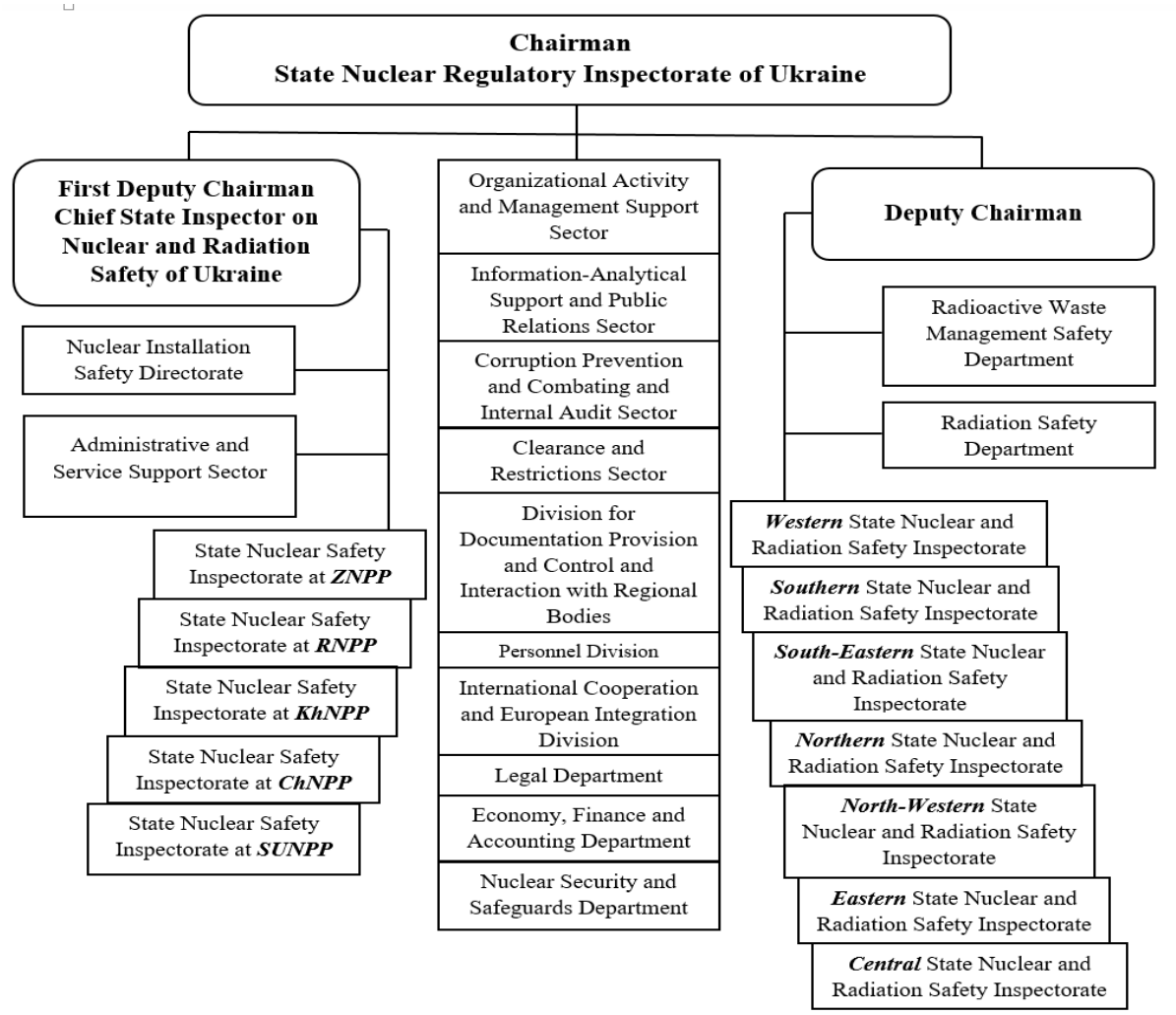

Fig. 2.1 SNRIU organizational structure

As of mid-2017, SNRIU staff consists of 201 employees. The distribution of SNRIU experts by age and gender is presented in Fig. 2.2.

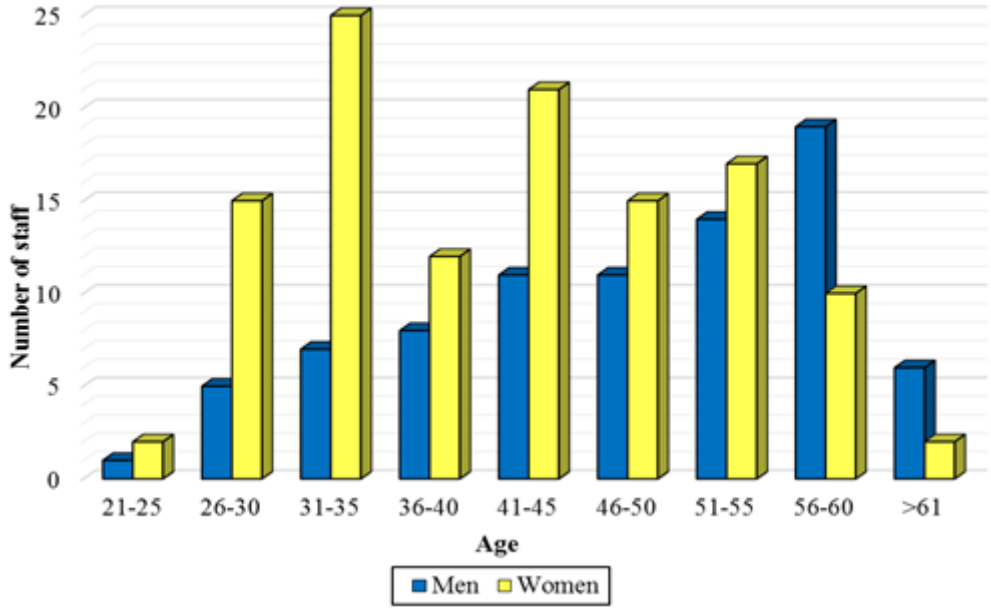

Fig. 2.2 SNRIU staff

Within the system of the State Nuclear Regulatory Inspectorate of Ukraine, there are also two TSOs:

- State Scientific and Technical Centre for Nuclear and Radiation Safety (www.sstc.com.ua), providing analytical, scientific, expert, technical, engineering, informational, consultative and methodological support to the state nuclear regulatory authority;
- State Centre for Regulation of Quality Control of Supplies and Services, providing technical support to the SNRIU as well as methodological and advisory support in updating regulatory requirements for quality assurance of equipment and services for nuclear power facilities.

In order to develop recommendations on significant issues and identify the most essential areas of nuclear and radiation safety regulation, the SNRIU Board is working on a permanent basis [20].

The SNRIU Board main tasks are to:

- review proposals for the formulation and implementation of state policy in the field of safe nuclear energy;
- define prospects and the most important areas in the development of the regulatory framework on state regulation of nuclear energy;
- analyze results and define policy and priorities of authorizing activity in the field of nuclear energy;
- analyze results and define policy and priorities of state oversight of nuclear and radiation safety;
- consider results of nuclear and radiation safety reviews and inspections of nuclear installations and radioactive waste disposal facilities in making decisions on issuing licenses to conduct activities at a separate stage of their lifecycle;
- extend international cooperation on safe nuclear energy and radiation safety;
- analyze the status of measures on the state policy implementation in all areas of SNRIU activities.

Fig. 2.3 Meeting of the SNRIU board to discuss long-term operation of Zaporizhzhya-1 based on periodic safety review, 13 September 2016

The SNRIU Board consists of SNRIU Chairman (Board Head), SNRIU and SSTC NRS management, leading independent experts and representatives of public organizations.

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

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

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

In 2016, SNRIU management decided to transfer the quality management system to the new version of ISO 9001:2015. Within the transfer, a number of activities were carried out, including a diagnostic audit of the quality management system, staff training, identification of processes, development/correction of documents, a full cycle of internal audits and relevant corrective measures.


TÜV NORD

CERTIFICATE

Management system as per
ISO 9001 : 2015

In accordance with TÜV NORD CERT procedures, it is hereby certified that

State Nuclear Regulatory Inspectorate of Ukraine
Arsenalna 9/11Str.
01011 Kyiv
Ukraine

applies a management system in line with the above standard for the following scope

Provision of regulatory services in the field of safety in nuclear energy use.

Certificate Registration No. 44 100 17 32 0197
Audit Report No. 3597 0934

Valid from 2017-09-21
Valid until 2020-09-20
Initial certification 2017

Certification Body
at TÜV NORD CERT GmbH

Plovdiv, 2017-09-21

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

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Fig. 2.4 Certificate of the SNRIU management system

In August 2017, the SNRIU (see Fig. 2.4) passed successfully a recertification audit of the quality management system for compliance with ISO 9001:2015 from the side of TÜV NORD certification authority representative on the territory of Ukraine.

2.2 SNRIU Independent Status: Issues

Under the deregulation of economic activity that has been underway in Ukraine in the last years, amendments to various laws of Ukraine were made. These amendments are related to some extent to the state regulation of safety in nuclear energy, in particular, licensing and oversight. The most significant examples, in terms of adverse impact, are provided below:

- The new version of the Law of Ukraine On Licensing of Economic Activities [21] envisages that activities in the area of nuclear energy shall be licensed according to this Law considering peculiarities defined by the Law of Ukraine On Authorizing Activity in Nuclear Energy [11]. Therefore, provisions established for licensing of economic activities partially apply to licensing in the area of nuclear energy. This covers conducting of unscheduled inspections to verify the licensee's compliance with licensing conditions in some cases only under approval of the State Regulatory Service of Ukraine issued based on the decision of the Expert and Appeal Board at SNRIU request.
- Article 1 of the Law of Ukraine On Administrative Services envisages that this Law does not establish any requirement or criteria to be met by the applicant. At the same time, Articles 32 and 33 of the Law of Ukraine On Nuclear Energy Use and Radiation Safety [10] establishes clear requirements for the applicant, for example, requirements for:
    - organizational structure;
    - staff competence;
    - physical protection;
    - material and financial resources;

– radiation protection of personnel, the public and the environment, etc.

Provisions of the Law On Administrative Services cannot apply to state regulation of nuclear energy safety since provisions of this Law contradict legislation in this area.

- Amendments introduced at the end of 2016 to the Law of Ukraine On Basic Principles of State Supervision over Economic Activities [22] envisage that the state supervision over compliance with nuclear and radiation safety requirements shall be performed according to the procedure established by this Law considering peculiarities defined by Laws in this area and international agreements. However, these amendments stipulate that authorities dealing with state supervision considering peculiarities shall ensure compliance with requirements of Law [22]. Law [22] establishes periodicity of supervision over facilities in different industries depending on the degree of risk for their activities. In particular, supervision over activities of entities associated with high risk can be performed not more often than every two years. Such restrictions and some other provisions of Law [22] are unacceptable for state supervision in the area of nuclear energy and do not comply with international agreements and obligations of Ukraine.

Under the Plan for Implementation of Council Directive 2014/87/Euratom [9], approved by the Government of Ukraine, the SNRIU developed a draft Law on National Nuclear Regulatory Commission, which:

- corresponds to the Memorandum of Understanding of Strategic Energy Partnership between Ukraine and European Union, together with the European Atomic Energy Community [23] regarding “strengthening the capacity and competences, as well as, assuring the full independence of national regulatory authorities”;
- is based on international experience in establishment of independent regulatory authorities.

The draft Law on National Nuclear Regulatory Commission envisages legislative consolidation of the economic, political and financial independence of the regulatory authority to fulfil its functions and competence fully in line with national regulations in the area of nuclear energy and international agreements and recommendations. The draft Law proposes establishing a permanent independent state collegial body, National Nuclear Regulatory Commission (Commission), with the purpose of state regulation of nuclear energy safety to ensure nuclear and radiation safety in the state.

According to the draft Law, independence of the Commission shall be ensured by:

- special procedure for appointment and dismissal of Commission members;
- procedure for exercise of powers (collegiality, transparency);
- appropriate financial support;
- prohibition of illegal influence, pressure or interference in Commission’s powers on state regulation of nuclear energy safety.

Moreover, the draft Law on National Nuclear Regulatory Commission presents amendments to the Law of Ukraine On Licensing of Economic Activities [21] and Law of Ukraine On Basic Principles of State Supervision over Economic Activities [22] to bring them into compliance with proposed provisions on the activities of the National Nuclear Regulatory Commission. The amendments foresee that:

- provisions of Laws of Ukraine [21] and [22] do not cover regulation in the area of nuclear energy;
- Commission conducts state licensing and supervision in the area of nuclear energy according to legislation for nuclear and radiation safety and international agreements.

The draft Law is currently under technical and legal review by the Presidential Administration, involving SNRIU consultation, to be further introduced by the President to the Parliament of Ukraine.

In parallel, SNRIU developed the draft Law On Amendments to Some Laws of Ukraine on Use of Nuclear Energy to introduce amendments simultaneously to Laws [21] and [22]. Major amendments are intended to exclude the application of these Laws to licensing and supervision in the area of nuclear energy. The draft Law was submitted for review and agreement to the involved Ministries according to the order of the Prime Minister of Ukraine; the review and agreement process is still ongoing.

In spite of the SNRIU's efforts and support of the European Commission and other partners of international cooperation (EBRD, IAEA, G-7) towards full independence of the regulatory authority, this issue remains unsolved. The respective threat (see also Section 8), which was noted in [2] is urgent. This challenge is also pointed out in 2017, the Country Review Report for Ukraine [24] resulting from the Seventh Review Meeting conducted in spring this year under the Convention on Nuclear Safety [14].

2.3 SNRIU Activities in State Physical Protection System

The Report [2] describes in brief the physical protection system. The updated and extended information is provided below.

2.3.1 Structure and Functions of State Physical Protection System

The State Physical Protection System (SPPS) was implemented in 2010 by Articles of the Law of Ukraine "On Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources" [25], according to which SPPS tasks are to:

- provide regulatory and legal framework for physical protection issues;
- provide security of nuclear facilities, nuclear materials, radioactive waste and other radiation sources taking into account design-basis threat;
- maintain physical protection regime in the state;
- establish and ensure functioning of a unified system of secure communication between public authorities and legal entities, whose powers include physical protection functions;
- perform state oversight and monitoring of physical protection state;
- arrange activities on information exchange on physical protection state and its storage.

SPPS entities include:

- specially authorized (competent) central executive body in the area of state regulation of physical protection: SNRIU;
- central executive bodies performing state management on physical protection;
- National Academy of Sciences of Ukraine;
- Security Service of Ukraine;
- National Guard of the Ministry of Internal Affairs of Ukraine;
- operating organizations (operators) and other licensees ensuring physical protection of specific facilities of the system and transport.

All SPPS activities are governed by the Procedure for State Physical Protection System [26]. The Procedure defines the entities and basic principles of SPPS.

Functioning of the State Physical Protection System results from assessing a threat of sabotage, theft or any other illegal seizure of radioactive materials. Threat assessment to be performed periodically is presented in the regulation Design-Basis Threat for Nuclear Installations, Nuclear Materials, Radioactive Waste and Other Radiation Sources in Ukraine [27]. According to the National Design-Basis Threat [27], the operating organizations and licensees (responsible for installations and facilities specified in the List [28]) define facility-level design-basis threats, establishment and maintenance of physical protection systems for facilities and materials. Thus, the physical protection regime is maintained at a facility level.

In order to meet the demand for highly skilled experts in physical protection, a state system of professional training, retraining and skill improvement for experts on physical protection, accounting for and control of nuclear materials was established. Unfortunately, due to the temporary occupation of Crimea, one of the main training centers, Sevastopol University of Nuclear Energy and Industry, was lost. Currently, activities to renew training of competent experts are carried out at the state level under the international support in the National Technical University of Ukraine 'Ihor Sikorsky Kyiv Polytechnic Institute'.

In addition to the entities mentioned above and SPPS facilities, it includes a regulatory framework of physical protection having a hierarchical structure and consists of three "standard" levels: Laws of Ukraine, Decrees of the President of Ukraine and Cabinet Resolutions, regulations approved by the SNRIU and other authorized central executive bodies. These regulations establish functions and responsibilities of physical protection entities, public administration, regulatory bodies and relations between them.

2.3.2 SNRIU Functions and Tasks in SPPS

The SNRIU as a competent SPPS body within the authorities granted by the legislation:

- participates in forming the state policy in physical protection area and develops a mechanism for its implementation;
- inspects activities of system entities when they perform system tasks including activities to form and ensure functioning of the unified system of secure communication;
- participates in functioning of the state system for professional training, retraining and skill improvement;
- participates in assessing the threat of sabotage, theft or any other illegal seizure of radioactive materials, as well as in defining the design-basis threat;
- arranges scientific and technical studies in the area of physical protection;
- coordinates activities of entities on improving the level of security culture;
- establishes requirements for quality management systems of physical protection of facilities;
- participates in ensuring security of facilities;
- receives from relevant government agencies the information on threats to facilities and informs licensees of such threats.
- develops and approves standards and rules on physical protection of facilities, makes proposals on physical protection legislation to the government;
- agrees regulatory documents on physical protection, from ministries and other central executive bodies;
- develops conclusions on meeting the requirements of physical protection in case of export/import and transit of radioactive materials through the territory of Ukraine;
- establishes the minimum allowable operational characteristics for the physical protection systems of facilities, permissible risk of sabotage against facilities depending on their categories and possible radiation consequences of sabotage;

- licenses activities on ensuring physical protection and participates in licensing activities in nuclear energy use;
- performs state review of the projects for establishment, reconstruction and technical re-equipment of physical protection systems of facilities including systems for transport of radioactive materials;
- performs state oversight of compliance with the requirements of the legislation on physical and fulfilling licensing conditions;
- conducts state inspection of physical protection systems of facilities and plans of interaction in case of sabotage;
- takes enforcement measures against licensees in case of incompliance with the requirements of the legislation on physical protection and licensing conditions;
- cooperates in physical protection area with the IAEA, other international organizations and relevant bodies of foreign states;
- informs relevant state authorities on the state of providing physical protection of facilities;
- is a participant of the state plan on the interaction of central and local executive authorities in the event of sabotage.

2.3.3 Basic Areas of SNRIU Activities within SPPS

According to the standards and rules on physical protection, operating organizations and other licensees assess the state and efficiency of physical protection systems of their facilities. Recently, the physical protection systems (PPS) of nuclear facilities and nuclear materials have been upgraded in accordance with the established procedure under the projects approved by the SNRIU. PPS projects for the new facilities are developed before their construction. All projects for PPS establishment, upgrade or reconstruction are subject to state review on nuclear and radiation safety and physical protection performed by the SNRIU under SSTC NRS technical and expert support.

The state oversight of compliance with physical protection requirements is implemented according to the 'Procedure for State Inspection of Physical Protection Systems of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources and Plans of Interaction in the Event of Acts of Nuclear Terrorism' [30] and 'Procedure for State Oversight of Compliance with Nuclear and Radiation Safety Requirements' [30]. The SNRIU conducts both scheduled inspections envisaged in annual plans and unscheduled inspections. Inspections' frequency, grounds, procedure, criteria for assessing a degree of risk for the activity on transport of radioactive materials, registration of inspection results are also specified in [30]. In 2016, there were conducted six state inspections of the physical protection systems.

Within SPPS activities, efficiency of the administrative procedures and immediate actions of personnel of KhNPP Physical Protection Service was inspected during the force-on-force training in 2016. The joint field training exercise inspected efficiency of the Interaction Plan in case of sabotage regarding nuclear facilities and nuclear materials at KhNPP and its compatibility with the Emergency Response Plan. The force-on-force training was conducted at the regional level, involving units of the National Guard of Ukraine, Security Service of Ukraine, National Police of Ukraine, State Emergency Service of Ukraine, regional administrations, etc. The event was carried under the financial support of the Defense Threat Reduction Agency (U.S. Department of Defense).

Fig. 2.5 Training at Khmelnitsky NPP, 31 May – 2 June 2016

Other examples of cooperation in the area of physical protection are:

- Series of workshops on key attributes and architecture of the physical protection for NPPs and radiation sources arranged by the U.S. NRC and SNRIU, which took place from 2015 to 2017.
- International conferences on the physical protection, accounting and control of nuclear materials organized since 2003 and arranged by the George Kuzmycz Training Center for Physical Protection, Control and Accounting of Nuclear Material of the Institute for Nuclear Research of the NAS of Ukraine under the financial support of the SSM, NRPA and the Energoatom Company.

Fig. 2.6 US NRC Workshop on the Physical Protection of Nuclear Power Plants, 30 March – 2 April 2015

Fig. 2.7 US NRC Workshop on the Physical Protection of Radiation Sources 23-25 May 2016

Participation of the SNRIU in such events promotes experience exchange and open discussion with leading international experts and familiarization with the best world practices.

Activities of the SNRIU as a competent SPPS authority are mainly aimed at maintaining the physical protection regime as one of the most important components of the nuclear security regime. Current regulatory documents of Ukraine on the physical protection in general comply with up-to-

date approaches to safety and security regulation. In order to improve the regulatory framework in the area and apply a systematic approach to ensuring nuclear safety, there is a need of constant analysis of Euratom's nuclear safety and nuclear security regulations, as well as the IAEA standards on the main components and establishment of the nuclear security regime. The scope of such analysis should include but not be limited to the following documents:

- Council Decision 2007/513/Euratom of 10 July 2007, approving the accession to the amended Convention on the Physical Protection of Nuclear Material (CPPNM) [32];
- Commission Decision 2008/99/EC of 19 December 2007, establishing procedural rules concerning the accession of EURATOM to CPPNM as part of the Occupational Health & Safety Information [33];
- Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources, concerning among other security of sources and countering illicit trafficking of radioactive materials [34];
- Commission Staff Working Document SWD(2013)187 of 27 March 2013, accompanying the Specific Monitoring Report on research activities for nuclear safety and security [35];
- Council Decision 2013/517/CFSP of 21 October 2013 on the Union support for the activities of the International Atomic Energy Agency in the areas of nuclear security and verification [36];
- IAEA Nuclear Security Series No. 20. Objective and Essential Elements of a State's Nuclear Security Regime. Nuclear Security Fundamentals [37];
- IAEA Nuclear Security Series No. 13. Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (also INFCIRC/225/Revision 5) [38];
- IAEA Nuclear Security Series No. 14. Nuclear Security Recommendations on Radioactive Material and Associated Facilities [39];
- IAEA Nuclear Security Series No. 15. Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control [40];
- IAEA Nuclear Security Series No. 6. Combating Illicit Trafficking in Nuclear and Other Radioactive Material [41];
- IAEA Nuclear Security Series No. 17. Computer Security at Nuclear Facilities [42];
- IAEA Nuclear Security Series No. 23-G. Security of Nuclear Information [43].

Based on comprehensive study of the above documents and comparison of their provisions with the relevant regulatory framework in Ukraine, it will be required to determine a list of national regulatory documents on specific issues of physical protection and nuclear security requiring revision or development and justify the priority of individual actions in this area (see also Section 8)

2.3.4 SNRIU activities in WENRA

The SNRIU actively participates in the WENRA activities since 2009 firstly as an observer, and since March 2015 as a full active member. Ukraine became the first non-EU country having a status of the WENRA member. In particular, the SNRIU was involved in work in of the Reactor Harmonization Working Group (RHWG) and Working Group on Waste and Decommissioning (WGWD). The issues of harmonization of European regulatory requirements were discussed during the meetings, as well as documents and guidelines on technical issues of ensuring nuclear safety in Europe (requirements for new NPPs, long-term operation, periodic safety review, review of reference levels on safety, etc.) were developed. Within the WENRA RHWG activities, SNRIU representatives took an active part in the development of technical specifications for stress tests for NPPs [44] under European initiative after the Fukushima-Daiichi accident. These technical specifications were used directly for stress tests at Ukrainian NPPs as well. In addition, the SNRIU management regularly participated in WENRA plenary sessions where expressed its position on WENRA's strategy and plans of activities.

"Since they joined WENRA as an observer in 2009, Ukraine has contributed to the work of the WENRA and its working groups RHWG and WGWD in a constructive and cooperative manner. Ukraine have proved able and willing to comply with WENRA safety reference levels and technical criteria for the safe operation of its nuclear power plants. It is therefore with great pleasure that we today can announce the inclusion of Ukraine as a new WENRA member", WENRA Chair Hans Wanner, March 26, 2015, Geneva, http://www.wenra.org/archives/ukraine-new-wenra-member/ .

In 2013, the SNRIU initiated a process of self-assessment regarding compliance of the national requirements for nuclear safety of Ukraine with WENRA reference levels for reactor safety [45] with a view to further harmonizing the national regulatory requirements with the WENRA reference levels. At the same time, the self-assessment was conducted according to the methodology and criteria defined in document [46]. The peer review of self-assessment results and appropriate harmonization plan was performed within INSC project [47] involving representatives of the nuclear regulatory authorities of Finland, the Czech Republic, Bulgaria, and Slovakia.

At the end of 2014, the SNRIU initiated a process of self-assessment regarding compliance of the national requirements for nuclear and radiation safety of Ukraine with the WENRA reference levels for decommissioning. Self-assessment results were reviewed by WGWD representatives from the nuclear regulatory authorities of France, Germany, Italy, the Netherlands, Sweden, and Slovenia. The recommendations of the WGWD representatives were taken into account in SNRIU plans for further harmonization of the safety requirements with the WENRA reference levels.

Fig. 2.8 SNRIU Chairman Serhii Bozhko and WENRA Chair Hans Wanner, 26 March 2015

In order to ensure an efficient participation of the SNRIU in the WENRA's activities the own infrastructure was established, in particular the SNRIU Commission on Harmonization of the National Standards and Rules on Nuclear and Radiation Safety of Ukraine with the WENRA Reference Levels. The SNRIU Chairperson heads the Commission. Main tasks of the Commission are to:

- form unified approaches regarding SNRIU and WENRA interaction;
- review and approve plans to harmonize the national standards and rules on nuclear and radiation safety of Ukraine with the WENRA reference levels;
- develop and submit proposals to the SNRIU Regulatory Commission on developing and amending the SNRIU regulatory plans;
- consider draft amendments to the national standards and rules on nuclear and radiation safety of Ukraine developed to harmonize them with the WENRA reference levels;

- arrange and coordinate accomplishing the tasks defined during WENRA plenary meetings and meetings of WENRA working groups.

In addition, after Ukraine became a WENRA member, SNRIU:

- defined permanent SNRIU representatives in the WENRA working groups;
- participated with all WENRA member states in implementing the updated WENRA reference levels for operating reactors in the regulatory requirements;
- completed self-assessment regarding compliance of the requirements of the Ukrainian regulations on decommissioning with the WENRA reference levels on safety. The self-assessment results related to decommissioning were considered by WGWD members;
- participated in developing WENRA guidelines on natural threats, which clarify and specify provisions of WENRA reference levels for operating reactors;
- participated in preparing for the first topical review for meeting the provisions of Article 8e, Council Directive 2014/87/Euratom [9] ("aging management").

The issue on harmonization of the national regulatory requirements for nuclear and radiation safety with WENRA reference levels was identified as one of the challenges for Ukraine in Report [24] following the review of the National Report of Ukraine during the Seventh Review Meeting under the Convention on Nuclear Safety [14]. This issue remains one of the SNRIU priority areas (see also Section 8). The main source of SNRIU international support in this area is one of the components of INSC project 'Strengthening of SNRIU Capabilities Relevant to the Regulation of Nuclear Activities and Licensing and Severe Accident Management of Nuclear Installations (U3.01/14 and U3.01/15)'. Activities under this international project, which will be performed by a consortium of leading European institutions (including NRPA), will start in the nearest future.

3 Safety of nuclear instalations

3.1 General Information

Ukraine currently operates the following nuclear installations:

- 15 power units at four NPPs with VVER reactors;
- two research reactors;
- spent nuclear fuel storage facilities.

For Ukraine, nuclear power is a strategically important element in the production of electricity. The current and projected nuclear contribution comprises more than 50% of the electricity produced in the country. Effective and sustainable nuclear power is one of the necessary conditions to ensure national safety and security.

3.2 Nuclear Power Plants

Ukraine operates 15 power units, ranks the tenth in the world for this indicator, and takes the seventh place in the installed capacity. The only operator of all operating nuclear power plants in Ukraine is the National Nuclear Energy Generating Company 'Energoatom'. The Energoatom Company manages four nuclear power plants (see Fig. 3.1).

Fig. 3.1 Ukrainian NPPs

Ukraine ensures stable and safe operation of NPPs under the Law of Ukraine On Nuclear Energy Use and Radiation Safety [10] and the Convention on Nuclear Safety [14]. Safety improvement measures are under implementation at operating NPPs of Ukraine on a systematic basis in compliance with national regulations and standards on nuclear and radiation safety and recommendations of the International Atomic Energy Agency (IAEA), taking into account best international practices.

Peer reviews of WANO and IAEA confirmed operational safety of Ukrainian NPPs and validity of safety upgrades implemented under safety improvement and long-term operation programs.

3.2.1 NPP Safety Improvement

The safety improvement measures at Ukrainian NPPs are under implementation in compliance with the 'Comprehensive (Integrated) Safety Improvement Program for Operating Nuclear Power Units approved by Cabinet Resolution No. 1270 on 7 December 2011 [13]. The Cabinet Resolution of 30 September 2015 extended the C(I)SIP [13] until 2020. The C(I)SIP [13] objective is to:

- improve operational safety of NPP units;
- decrease risks of NPP accidents during natural disasters or other hazards;
- improve the effectiveness in management of design-basis and beyond design-basis accidents at NPPs and minimize their consequences.

The C(I)SIP [13] includes safety improvement measures of the previous program document 'Concept for Safety Improvement of Operating Nuclear Power Units' [49] which were not implemented at the chronological end of the Concept [49]. The C(I)SIP [13] also takes into account results and recommendations of the IAEA design safety review mission conducted at all NPPs under the Memorandum of Understanding in the Field of Nuclear Energy between Ukraine and EC [23]. After the Fukushima-Daiichi accident, the program was extended with additional measures upon extraordinary in-depth safety reassessment for Ukrainian NPPs (stress tests) (see Fig. 3.2) and additional fire safety measures (see

Fig. 3.3 and Fig. 3.4). Safety improvement measures are among conditions for long-term operation of NPPs.

Fig. 3.2 Implementation of measures identified upon stress tests at Ukrainian NPPs

According to C(I)SIP schedules, the main efforts of the operating organization in 2016 were focused on the development and implementation of measures for ZNPP units 2 and 3 and RNPP unit 3 within long-term operation activities. The experience in measures taken at the so-called pilot units is further extended to other operating power units.

Fig. 3.3 Implementation of the filtered containment venting concept in the event of a severe accident at SUNPP-1

Modifications important to safety of nuclear installations (changes to nuclear installation configuration, bringing a nuclear installation into compliance with current regulations and standards, changes to operational documents) are implemented upon agreement with the SNRIU. SNRIU constantly monitors all stages of modifications (concept development, installation and pre-commissioning, introduction into trial and commercial operation) through in-depth and comprehensive safety assessment of safety justification submittals and agreement of appropriate technical decisions, as well as through direct supervision over modifications, introduction of changes to operational documentation and staff training. The results of these activities are discussed at open meetings of the SNRIU Board.

The SNRIU ensures appropriate technical quality and representativeness of nuclear and radiation safety reviews of justifications for safety upgrades and also monitors their implementation on a

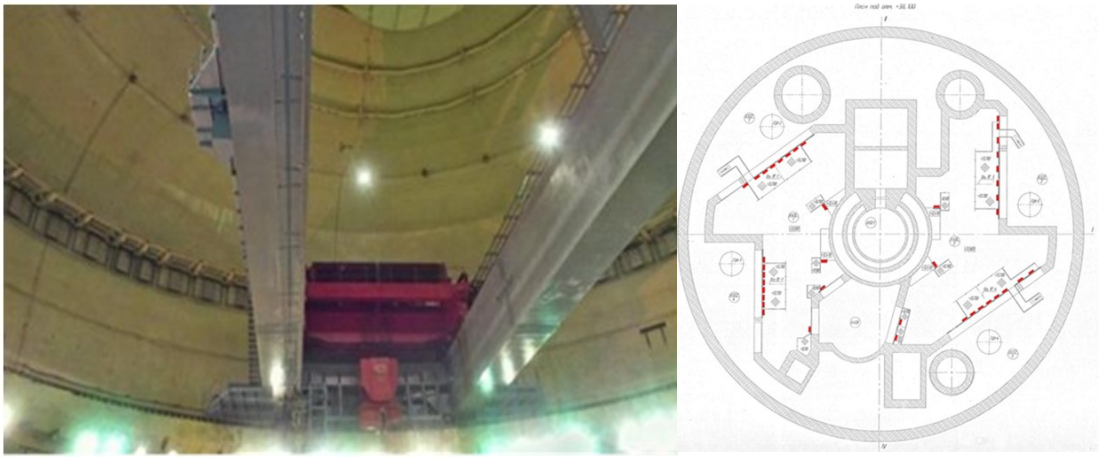


Fig. 3.4 Installation of catalytic hydrogen recombiners

permanent basis using its own resources. The importance of this process can hardly be overestimated as was noted upon review of the National Report of Ukraine at the Seventh Review Meeting under the Convention on Nuclear Safety [14] – continuation of full-scope implementation of the Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs [13], including post-Fukushima measures – is one of the challenges for Ukraine for the near future [24] (see also Section 8). International assistance to strengthen the SNRIU capabilities in licensing and oversight of safety improvement measures is provided within a number of sources (see also Section 9). In the framework of cooperation with the U.S. NRC, the SNRIU obtains supports focusing on:

- continuous development and improvement of methodological basis for nuclear and radiation safety reviews;
- systematic strengthening of SNRIU capabilities in obtaining and effective use of a wide range of codes to support independent assessments of safety justifications submitted by the licensee;
- implementation of novel approaches to oversight activity, primarily by introduction and application of risk-informed approach in inspections at sites of Ukrainian NPPs.

INSC projects financed by the European Commission to develop and strengthen the SNRIU capabilities are another important source of international assistance in this area. The INSC project 'Cooperation with SNRIU in Licensing and Supervision Activities Connected with the Implementation of the Joint Safety Improvement Program at Ukrainian NPP' UK/TS/47 [51] is in its final stage. The main project objective is to support the SNRIU in effective monitoring over implementation of safety improvement measures at Ukrainian NPPs. A number of components under Project INSC [48] to be started in the near future is logical continuation of this project.

3.2.2 Long-Term Operation of NPPs

Thirty-year design-basis life is established for Ukrainian NPPs. Eleven power units were commissioned in the 1980s–1990s. The Government of Ukraine decided to continue operation of NPP units as reflected in the Energy Strategy of Ukraine until 2035 'Safety, Energy Efficiency, Competitiveness' [52] and 'Comprehensive Work Program for Long-Term Operation of Nuclear Power Plant Units' [53]. As of 2017, the design-basis life of seven nuclear power units in Ukraine has been extended. In a period from 2017 to 2020, the design-basis life of other five nuclear power units expires (see Table 3.1).

In accordance with the current legislation, a decision on long-term operation of a power unit is made by the SNRIU based upon conclusions of the state nuclear and regulatory safety review of the

periodic safety review report (PSRR) by amending the license for its operation. Long-term operation may be allowed only if the safety level of the nuclear power unit is not lower than that established by current regulations and rules on nuclear and radiation safety.

For Zaporizhzhya NPP units 1, 2, and 3 and Rivne NPP unit 3, whose design-basis life expires in 2016–2017, Energoatom choses the following option for their lifetime extension in compliance with [54]: “shutdown of the power unit after its design-basis life expires and implementation of organizational and technical measures to continue and recommence operation”. For each of the above-mentioned units, the SNRIU agreed long-term operation programs and licensing plans, according to which Energoatom conducts respective activities and submits associated reports to the SNRIU. The results of these activities serve as the basis for PSRR submitted to the SNRIU for consideration and NRS regulatory review.

In compliance with requirements [54], PSRR is based upon a substantial scope of efforts to prove that the safety level of the nuclear power unit is not lower than that established by current regulations and rules on nuclear and radiation safety.

Table 3.1 Service life of operating units of Ukrainian NPPs

NPP	Unit	Reactor type	Design-basis service lifetime	Extended long-term operation
ZNPP	1	VVER-1000/320	23.12.2015	23.12.2025
	2	VVER-1000/320	19.02.2016	19.12.2026
	3	VVER-1000/320	05.03.2017	05.03.2027
	4	VVER-1000/320	04.04.2018	–
	5	VVER-1000/320	27.05.2020	–
	6	VVER-1000/320	21.10.2026	–
SUNPP	1	VVER-1000/302	02.12.2013	02.12.2023
	2	VVER-1000/338	12.05.2015	31.12.2025
	3	VVER-1000/320	10.02.2020	–
RNPP	1	VVER-440/213	22.12.2010	22.12.2030
	2	VVER-440/213	22.12.2011	22.12.2031
	3	VVER-1000/320	11.12.2017	–
	4	VVER-1000/320	07.06.2035	–
KhNPP	1	VVER-1000/320	13.12.2018	–
	2	VVER-1000/320	07.09.2035	–

The approach complies with IAEA recommendations and best international practices and allows a comprehensive assessment of the power unit safety to make a sound decision on further operation of the power unit, including long-term operation.

The open meetings of the SNRIU Board on 13 September and 3 October 2016 were held to discuss long-term operation of Zaporizhzhya units 1 and 2 based on periodic safety review. Positive findings of the NRS regulatory review for the Periodic Safety Review Reports and comprehensive inspections at Zaporizhzhya units 1 and 2, conducted with SSTC NRS technical support, convinced the SNRIU Board that safe operation of Zaporizhzhya NPP unit 1 is justified until 23 December 2025 and that of Zaporizhzhya NPP unit 2 until 19 February 2026. In accordance with Board decision, the SNRIU amended the licenses for operation of nuclear installations of Zaporizhzhya units 1 and 2. During 2016-2017, efforts for preparation of Zaporizhzhya unit 3 and Rivne unit 3 for long-term operation were continued.

Challenges that occur in regulation of long-term operation of Ukrainian NPP units are dealt with by the SNRIU and SSTC NRS using their own resources and, as in the previous case, through assistance of the U.S. NRC and European Commission (see also Section 9).

3.2.3 Analysis of Operating Experience and Emergency Documentation of Ukrainian NPPs

Article 33 of the Law of Ukraine On Nuclear Energy Use and Radiation Safety [10] states that the operating organization shall provide timely and full information on operational events at nuclear facilities.

The General Safety Provisions for Nuclear Power Plants [55], which establish safety principles and criteria, specify that the operating organization shall inform the SNRIU within established timeframes of all cases of abnormal operation and violation of limits and conditions of safe operation.

For this purpose, the SNRIU developed and implemented a regulatory document to establish the procedure for investigation and accounting of operational events at NPPs [56]. The detailed information on approaches to analysis of operating experience and investigation and accounting of NPP operational events, carried out by the SNRIU and SSTC NRS using their own resources, is provided in the Report [2]. This information is relevant as of 2017.

In 2016, 12 operational events occurred at Ukrainian NPPs (detailed information on the NPP operational events in 2016 is provided in [57]). Fig. 3.5 shows changes in the number of operational events for the last decade and the average number.

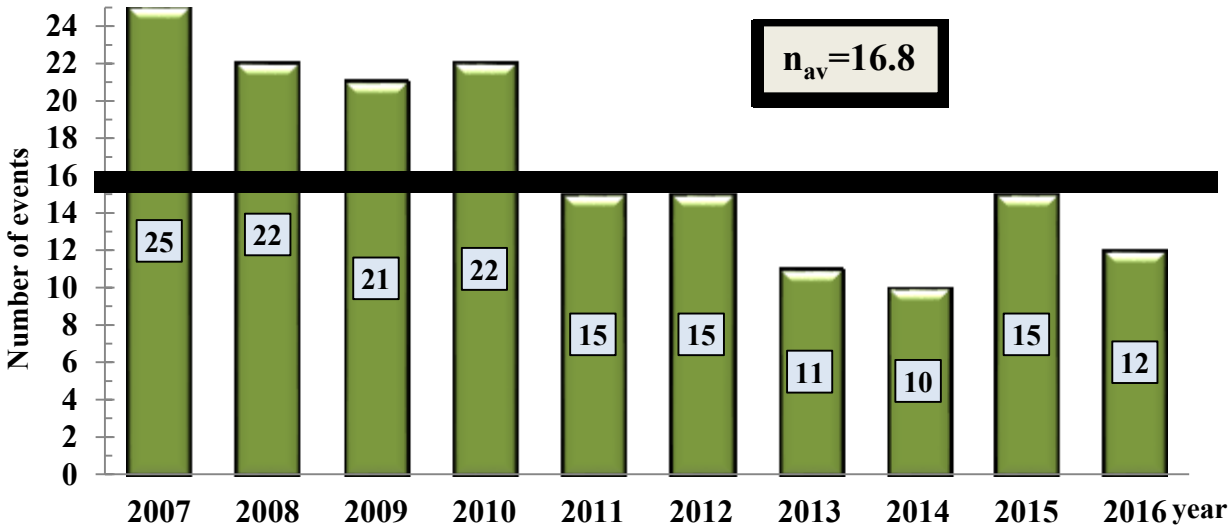


Fig. 3.5 Number of operational events at Ukrainian NPPs in 2007-2016

One of the challenges identified in [2] was the need to ensure systematic and comprehensive analysis of operating experience for Ukrainian NPPs on a permanent basis for effective use of lessons learnt and improvement of operational safety. To solve this issue, under Norwegian

Regulatory Cooperation Program, the project (code: EXPERIENCE) is under way. This project is aimed at developing and implementing a regulatory guideline to assess safety culture and HOF in operating experience analysis of Ukrainian NPPs (operational events, safety performance indicators) to improve effectiveness of regulatory oversight, including planning and conducting of inspections. Under the project, correctness and completeness of the existing safety performance indicators will be also assessed to identify ways for improvements and it is planned to prepare a list of measures to enhance the respective SNRIU oversight capabilities.

Another measure intended to eliminate this threat is one of the components of INSC Project [48] to be started this year with NRPA involvement (see Section 9 for more details).

Ukrainian NPPs use emergency operating documentation developed with the use of novel international approaches. The current system of emergency operating documentation is branched and includes mutual links and connections between different levels of documents (see [2] for more details). The state nuclear and radiation safety review of emergency documentation packages for Ukrainian NPPs, which is conducted by the SNRIU with SSTC NRS technical support, revealed the need to develop general regulatory requirements for NPP emergency documentations, including its elaboration, agreement, updating and application. Another project (code: GUIDLINE), implemented in the area under Norwegian Regulatory Cooperation Program, is intended to develop Requirements for the Structure and Contents of NPP Emergency Documentation (for more detail, see Section 9).

Interaction with Energoatom and engagement of the utility staff in developing respective regulations is an essential part of both projects above. The introductory Workshop within the GUIDELINE project was organized by SNRIU and took place in Kyiv at the beginning of November, 2017. During the workshop, all interested parties (NRPA, SNRIU, SSTC NRS, Energoatom) have got an opportunity to discuss in details the objective of the project, as well as an expected structure and content of the document to be developed. Under the next working meetings, which are planned to be conducted within the GUIDELINE project in 2018 and 2019, the achieved progress will be considered and evaluated, and the planned actions to be taken by SNRIU to implement and enforce the Requirements for the Structure and Contents of NPP Emergency Documentation will be described. The same approach of the interested parties' involvement has been adopted for the EXPERIENCE project.

3.2.4 Nuclear Fuel Diversification

In the framework of the Implementing Agreement between the Government of Ukraine and the Government of the United States of America on Nuclear Fuel Qualification Project for Ukraine signed on 5 June 2000, efforts were started to develop, deliver and qualify alternative nuclear fuel compatible with the Russian-design one.

In July 2013, Energoatom adopted a technical decision on introduction of Westinghouse upgraded robust assemblies (FA-WR) at SUNPP-3. The decision was submitted to the SNRIU for agreement with a package of justification documents for nuclear fuel licensing. In November 2014, a batch consisting of 42 FA-WR was delivered to the SUNPP site. In compliance with the authorization issued by the SNRIU in April 2015, the batch of 42 FA-WR was loaded to the SUNPP-3 core. The next batch of 42 FA-WR was loaded in 2016. According to Energoatom's plans, the SUNPP-3 core is to be completely loaded with Westinghouse fuel in 2018.

On 30 December 2014, Westinghouse and Energoatom signed an agreement for the supply of Westinghouse nuclear fuel (FA-WR) until 2020. In July 2015, Energoatom developed a decision to extend FA-WR trial operation to other units of Ukrainian NPPs. In March 2017, Energoatom developed a work program for implementation of upgraded Westinghouse FA-WR at Ukrainian NPP units for 2017-2018 [58]. The program [58] determines the scope and timeframes for extension of FA-WR operation to Ukrainian NPPs in 2017-2018 and is intended to coordinate activities of all parties involved in safety justification, implementation and operation of upgraded nuclear fuel at

SUNPP and ZNPP. According to the Program [58], time periods for supply of FA-RW ZNPP and SUNPP are planned. In compliance with Program [58], safety justification and analysis of the main technical aspects of FA-RW operation are planned. In particular:

- modification of the in-core instrumentation system SVRK-M to monitor mixed cores. For this purpose, the existing plant instrumentation has been coupled with an additional BEACON module. As of beginning of 2017, trial operation of in-core instrumentation system SVRK-M-BEACON is ongoing at ZNPP-5 in the 27th fuel cycle (see Fig. 3.6);
- development and implementation of the FA-WR inspection and maintenance bench (see Fig. 3.7);
- implementation and application of up-to-date codes for safety justification of cores with FA-WR.

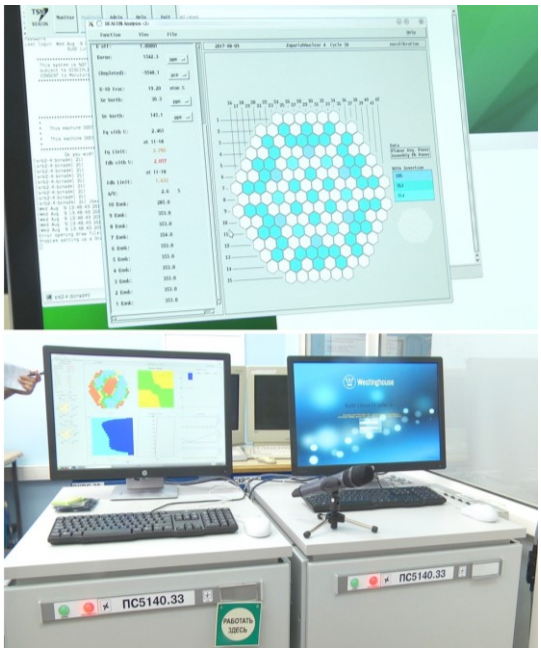


Fig. 3.6 BEACON module installed at ZNPP-5

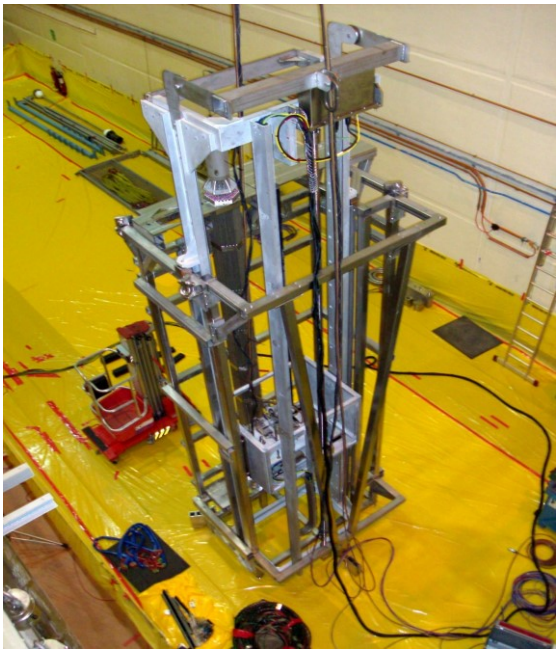


Fig. 3.7 FA-WR inspection and maintenance bench

According to the State Statistics Service, Energoatom imported 41.6% of Westinghouse fuel and 58.4% of the Russian Federation fuel in the first half of 2016. The numbers for the first half of 2017 are 51% and 49%, respectively. Further progress in nuclear fuel diversification is one of the most important issues in Ukraine's energy independence and national security. Current regulatory issues in implementation and further extension of Westinghouse fuel at Ukrainian NPPs are solved by the SNRIU with SSTC NRS technical support. At the same time, one of the SNRIU proposals for INSC Action Program for 2018 [59] (as of autumn 2017, the proposals are under EC review) is harmonization of approaches to licensing in introduction of alternative fuel with the best European practices.

3.2.5 Research Reactors

Ukraine has two research reactors:

- research reactor VVR-M at the Nuclear Research Institute under the National Academy of Sciences of Ukraine in Kyiv (see Fig. 3.8);
- research reactor IR-100 and subcritical uranium-water assembly at the Sevastopol National University of Nuclear Energy and Industry (see Fig. 3.9).

Fig. 3.8 Research reactor VVR-M at the Nuclear Research Institute under the National Academy of Sciences of Ukraine in Kyiv

Fig. 3.9 Research reactor IR-100

Because of the Russian Federation's occupation of the Autonomous Republic of Crimea in 2014, Ukraine lost regulatory control over nuclear facilities such as research reactor IR-100 of the Sevastopol National University of Nuclear Energy and Industry (SUNEI), critical test bench SPh IR-100 and subcritical uranium-water assembly. On 16 June 2014, the SNRIU cancelled License Series EO No. 000131 issued to SUNEI for operation of the nuclear installations: research reactor (IR-100) and subcritical water-uranium assembly. The license for operation of critical test bench SPh IR-100 was revoked earlier.

For long-term operation of the nuclear research reactor VVR-M of the Nuclear Research Institute (Kyiv), the following activities were performed in 2013–2014:

- research of irradiated samples for justification of long-term operation;
- new strength calculations of the reactor vessel (tank) and its components;
- elimination of defects on the pressure side of primary piping (replacement of sections with defects of the primary piping by new ones);
- revision of the section "Analysis of Design-Basis and Beyond Design-Basis Accidents at Research Reactor VVER-M";
- safety reassessment and stress tests, followed by development and implementation of safety improvement measures at the nuclear research reactor (motor pumps and fire hoses were purchased and installed to provide supply of service water from the motor pump to the reactor core, electric cables and electric valves were purchased and installed

to provide power to the reactor systems from the diesel generator in emergency conditions, etc.).

Upon results of these activities and inspection at the end of 2014, the SNRIU allowed long-term operation of the research reactor until 31 December 2023 (SNRIU Board Resolution No. 20 of 29 December 2014 'On Further Operation of Research Reactor VVR-M').

Report [2] identified a threat in this area (see Section 8), which is caused by the deficient regulatory framework that governs individual operational aspects of research reactors. One of the components under the INSC Project [48] is intended to eliminate this threat through the development and improvement of national requirements for periodic safety review of research reactors and investigation and accounting of operational events that occur at them (for more detail, see Section 9).

3.3 Spent Fuel Management Facilities

Currently, two facilities for temporary storage of spent nuclear fuel are operated in Ukraine: wet spent fuel storage facility – ISF-1 at Chornobyl NPP – and dry spent fuel storage facility (DSFSF) at Zaporizhzhya NPP. In addition, two more storage facilities are under construction in Ukraine: DSFSF ISF-2 at Chornobyl NPP and centralized storage facility for VVER spent nuclear fuel (CSFSF) from Ukrainian NPPs.

CSFSF will solve the issue of the long-term storage of spent fuel for three Ukrainian NPPs: RNPP, KhNPP and SUNPP for a long term. For storage of spent nuclear fuel, the Holtec International dry storage technology will be used with a two-barrier system for spent fuel isolation, which is ensured by special engineering systems of a container type. CSFSF commissioning is planned for 2019.

Regarding the Chornobyl NPP and ISF-1, decommissioning of power units 1, 2 and 3 is underway. Nuclear fuel from these power units is now stored in the on-site wet spent fuel storage facility (ISF-1), whose operation license expires on 31 December 2025.

To create an infrastructure for long-term (up to 100 years) storage of spent nuclear fuel from the Chornobyl NPP (21232 fuel assemblies), interim DSFSF (ISF-2) is under construction at the Chornobyl NPP. At present, the ISF-2 design has been approved, PSAR has been agreed, construction work is in progress and technical documentation for equipment manufacturing and supply in accordance with the agreed technical specifications is under development and approval. The respective tests have been conducted on the main ISF-2 equipment (double-wall canister, fuel cutting equipment etc.).

The detailed information on threats in the area of storage and management of radioactive material and waste is provided in Section 6 of this Report.

3.4 Construction of New Nuclear Installations

3.4.1 Construction of Khmelnitsky Units 3 and 4

As of 2017, the construction of Khmelnitsky units 3 and 4 is suspended (see Fig. 3.10).

Fig. 3.10 Khmelnitsky NPP site

Considering political relations between Ukraine and the Russian Federation, the Verkhovna Rada of Ukraine adopted the following Laws of Ukraine (their drafts were agreed by SNRIU) on 16 September 2015:

- On Recognizing Invalidity of the Law of Ukraine On the Siting, Design and Construction of Khmelnitsky NPP Units 3 and 4;
- On Termination of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation on Cooperation in Construction of Khmelnitsky NPP Units 3 and 4.

After approval of the Decision in Principle on Construction of Khmelnitsky NPP Units 3 and 4 on 17 October 2014, Energoatom took measures in 2015-2016 on the construction of KhNPP units 3 and 4 with VVER-1000/320 produced by Skoda JS a.s. (Czech Republic).

At the beginning of 2017, the updated feasibility study for construction of KhNPP units 3 and 4 with VVER-1000/-320 reactors produced by Skoda JS a.s. were submitted to the SNRIU. The state nuclear and radiation safety review concluded that the updated feasibility study for construction of KhNPP units 3 and 4 in general complies with regulations, standards and rules on nuclear and radiation safety, SNRIU requirements and documents of international organizations on new nuclear power units and contains sufficient information for the current stage. Specific technical decisions shall be provided at the design stage and justified in PSAR. Comments of the state nuclear and radiation safety review related to completeness, adequacy and correctness of information presented in the feasibility study are being resolved.

3.4.2 Construction of Neutron Source Based on Subcritical Assembly Driven by Linear Electron Accelerator

The neutron source based on a subcritical assembly driven by a linear electron accelerator (see Fig. 3.11) is under construction at the National Scientific Center 'Kharkiv Institute of Physics and Technology' (KIPT) in accordance with the agreements of the Washington Summit set forth in the Joint Statement of the Presidents of Ukraine and the United States in April 2010 and the Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America [60].

Fig. 3.11 Neutron source

The project is implemented under support of the Argonne National Laboratory, USA.

The neutron source is intended for scientific and applied studies in nuclear physics, radiation materials science, biology, chemistry and production of medical radioisotopes. On 10 October 2010, the SNRIU issued License Series EO No. 001018 to the operating organization for construction and commissioning of the neutron source.

In accordance with license conditions, KIPT, as the operating organization, performed installation and construction activities during 2013-2016. In addition, the development and SNRIU agreement of technical specifications for equipment important to safety, as well as operational documentation for the neutron source, were continued.

Within the license, KIPT must obtain three individual permits for:

- first delivery of nuclear fuel for the neutron source to the KIPT industrial site;
- initial start-up of the neutron source;
- trial commercial operation of the neutron source.

The neutron source is a fundamentally new nuclear facility, in which intensity of 235U nuclear fission in the core is driven by an electron accelerator. Neutrons in the facility are obtained through multiplication of an external source in materials of heavy elements (tungsten or natural uranium). The neutron source uses low-enriched uranium with 19.7% 235U. The composition and geometry of the core keep the effective neutron multiplication coefficient not higher than the regulated value (0.98). Therefore, a self-sustained reaction of 235U fission cannot occur in the neutron source core.

The threats recognized by the SNRIU in licensing and safety assessment of the construction and commissioning of the nuclear installation (see Section 8) are resolved with its own resources and through international assistance. The state regulatory review of the neutron source safety case is carried out under support of the Idaho National Laboratory, USA. In the framework of INSC Projects [61] (started in 2015) and [48] with involvement of leading European experts, national regulatory requirements for subcritical facilities and respective computer models are developed (for more detail, see Section 9).

3.4.3 Construction of Nuclear Fuel Fabrication Plant

Construction of the nuclear fuel fabrication plant was planned on the territory of Smolino village in Kirovohrad region.

According to legislation, construction of the nuclear fuel fabrication plant (as well as any other nuclear installation) can be started only if SNRIU issues a license for construction and commissioning of this nuclear installation. In turn, two main conditions for issuing such a license include the SNRIU's approval of the preliminary safety analysis report (PSAR) and approval of the nuclear installation design by the Cabinet of Ministers of Ukraine.

The first condition was met by the operating organization of the nuclear fuel fabrication plant (PSAR for the nuclear fuel fabrication plant was approved according to SNRIU Board Resolution No. 18 dated 4 December 2013), but the second condition still remains to be met despite submission of Expert Report (positive) No. 00-1085-13/PB on review of design documents for construction of the nuclear fuel fabrication plant by the Central Ukrainian Construction Review Service (Ukrderzhbudekspertyza) on 12 December 2013.

On 24 November 2015, in compliance with Article 13 of the Law of Ukraine On Authorizing Activity in Nuclear Energy, the SNRIU refused to issue a license for construction and commissioning of the nuclear fuel fabrication plant. The reason for the refusal was that there were no design for the plant approved according to the established procedure, which shall serve as a basis for issuing a license. The Ministry of Energy and Coal Industry of Ukraine made a statement on rejection of the project for construction of the nuclear fuel fabrication plant together with Russia.

The prospects for construction of the nuclear fuel fabrication plant are uncertain. There are discussions on the possibility and feasibility for construction of the plant under a Westinghouse license.

4 Radioactive material transport

4.1 Review of Ukrainian Legislation on Radioactive Material Transport

Radioactive material transport is a complex activity from organizational and technical viewpoints in the field of nuclear energy, which consists of many stages: preparation, loading, shipment, transport, including transit storage, unloading and acceptance of radioactive material consignments and packages at the final destination point. At the same time, radioactive material must remain under continuous regulatory control when it stays outside nuclear facilities or stationary facilities designed to handle radioactive waste and other radiation sources and is moved at considerable distances.

Fig. 4.1 Railway transport of radioactive material

Therefore, the regulatory and legal framework has been established to ensure safe transport of radioactive material in Ukraine, which includes laws and other regulations on nuclear and radiation safety, including those for safety in transfer of hazardous cargoes. This regulatory framework has a hierarchical structure and consists of three levels:

First level – Laws of Ukraine:

- On Nuclear Energy Use and Radiation Safety [10];
- On Authorizing Activity in Nuclear Energy [11];
- On Transport of Hazardous Cargoes [63].

Second level – Cabinet Resolutions:

- On Approval of the Procedure for Transport of Radioactive Materials through the Territory of Ukraine No. 1373 dated 15 October 2004 [66];
- Some Issues of Radioactive Material Transport No. 1196 dated 03 October 2007 [67], approving the procedure for issuing permits for international shipment of radioactive materials;
- On Approval of the Procedure for State Control of International Transfer of Dual-Use Goods No. 86 dated 28 January 2004 [68].

Third level – regulations approved by the SNRIU and other involved central executive bodies:

- Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials, (PBPRM-2006). Approved by SNRIU Order No. 132 dated 30 August 2006 and registered in the Ministry of Justice of Ukraine on 18 September 2006 by No. 1056/12930 [18];
- Requirements for Quality Assurance Programs for Transport of Radioactive Materials. Approved by SNRIU Order dated 25 July 2006 [70] and registered in the Ministry of Justice of Ukraine on 5 October 2006 by No. 1092/12966;
- Provisions on Planning of Measures and Actions in the Event of Accidents in Radioactive Material Transport (NP 306.6.108-2005) [71]. Approved by SNRIU Order No. 38 dated 7 April 2005 and registered in the Ministry of Justice of Ukraine on 22 April 2005 by No. 431/10711;

- Procedure for Issuing Certificates on Safe Transport of Radioactive Material [72]. Approved by SNRIU Order No. 119 dated 6 September 2007 and registered in the Ministry of Justice of Ukraine on 20 September 2007 by No. 1079/14346;
- Safety Requirements and Conditions (Licensing Terms) for Radioactive Material Transport (NP 306.6.095-2004) [73]. Approved by SNRIU Order No. 141 dated 31 August 2004 and registered in the Ministry of Justice of Ukraine on 9 September 2004 by No. 1125/9724;
- Requirements for the Safety Analysis Report on Radioactive Material Transport (NP 306.6.096-2004) [74]. Approved by SNRIU Order No. 141 dated 31 August 2004 and registered in the Ministry of Justice of Ukraine on 9 September 2004 by No. 1127/9726;
- Procedure for Submitting SNRIU Conclusions in International Shipment of Radioactive Materials (NP 306.6.097-2004) [75]. Approved by SNRIU Order No. 138 dated 26 August 2004 and registered in the Ministry of Justice of Ukraine on 8 September 2004 by No. 1119/9718;
- Reference Material to Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials (PBPRM-2006) [76] Approved by Order of SNRIU Deputy Chairperson dated 20 November 2009;
- Methodological Recommendations on Development of Radiation Protection Program for Radioactive Material Transport [77] Approved by SNRIU Order No. 101 dated 2 August 2010;
- Rules for Road Transport of Hazardous Cargoes. Approved by Ordinance of the Ministry of Internal Affairs of Ukraine No. 822 dated 26 July 2004 [78] and registered in the Ministry of Justice of Ukraine on 20 August 2004 by No. 1040/9639;
- Rules for Transport of Hazardous Cargoes. Approved by Ordinance of the Ministry of Transportation and Communication of Ukraine No. 1430 dated 25 November 2008 [79] and registered in the Ministry of Justice of Ukraine on 26 February 2009 by No. 180/16196.

These regulations identify functions and responsibilities of entities dealing with radioactive material transport and of state management and regulatory bodies, as well as their interaction.

As it is seen from framework list, some regulations are approved by other involved in RM transportation ministries and agencies. To achieve better mutual understanding and effectiveness of accepting regulatory acts, they are considered and agreed by interested ministries, other central authorities before approval by order or resolution. This procedure is approved by legislation and includes technical meetings and conferences of involved authorities' representatives.

Since the main condition for ensuring safety in transport of radioactive material includes the use of approved packages, the consignor is directly responsible for safe transport of radioactive material in accordance with Article 54 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" [10].

According to legislative requirements, Ukraine has implemented appropriate infrastructural measures and established a state system of emergency response and intervention to ensure emergency preparedness of entities dealing with transport of radioactive material.

The regulatory framework includes legal acts that provide for financial compensation to the third parties in case of a nuclear or radiation accident in transport of radioactive material:

First level – Laws of Ukraine:

- On Joining the Vienna Convention on Civil Liability for Nuclear Damage [64];
- On Civil Liability for Nuclear Damage and Its Financial Coverage [65].

Second level: Cabinet Resolution No. 733 dated 1 June 2002 On Approval of the Procedure and Rules for Compulsory Liability Insurance of Entities Dealing with Transport of Hazardous Cargoes in the Event of Adverse Effects in Transport of Hazardous Cargoes [69].

4.2 SNRIU Functions and Tasks in Radioactive Material Transport

4.2.1 General Provisions

The SNRIU is responsible for safety regulation in radioactive material transport according to legislation.

In compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine approved by Cabinet Resolution No. 363 dated 20 August 2014 [16], the SNRIU is responsible for: development and implementation of principles, provisions and guidelines, issues of official permits (licenses for radioactive material transport, permits of international shipment of radioactive material, approval certificates), conduct of regular reviews and assessments, inspections and enforcement measures for safe radioactive material transport.

The SNRIU:

- develops and approves regulations, rules and standards on nuclear and radiation safety for radioactive material transport;
- approves requirements for quality control of radioactive material transport in terms of nuclear and radiation safety;
- approves requirements and conditions (licensing terms) for radioactive material transport;
- determines a list of documents to be submitted to obtain a license for radioactive material transport and requirements for their structure and contents, and procedure for reporting by licensees;
- licenses activities of radioactive material transport;
- issues permits for international shipments of radioactive materials;
- provides conclusions on compliance with requirements of nuclear and radiation safety and physical protection of transport operations in case of export, import, temporary export, temporary import, re-export and transit of radioactive materials that can be used for production of nuclear weapons;
- approves the design of packaging for radioactive materials, transport and special conditions;
- agrees technical conditions for transport packaging;
- performs oversight and inspection of transport operations;
- performs functions of a competent authority responsible for safe radioactive material transport.

To ensure observance of regulations, rules and standards on nuclear and radiation safety for radioactive material transport, SNRIU approves the regulatory act by its order. Then the order and attendant act (except recommendations and internal acts) should be registered in Ministry of Justice whereupon comes into force for all juristic and natural persons in sphere of RM transportation.

4.2.2 Procedures for Obtaining Licenses/Permits

To obtain a license for radioactive material transport, a permit for international shipment of radioactive material and a certificate of approval, the applicant shall submit the application and documents in compliance with established requirements.

Legislation defines the format and requirements for application documents and review procedure, in particular:

- To obtain a license for radioactive material transport:
    - application form, list of documents and requirements for their contents are determined by Order No. 153 dated 6 August 2012 On Approval of Provisions

on the List and Requirements for the Format and Contents of Documents Submitted to Obtain a License for Specific Activities in Nuclear Energy;

- procedure for review of the application, issue a license, amendment of the license is established in the Law of Ukraine On Nuclear Energy Use and Radiation Safety [10];

- To obtain a permit for international shipment of radioactive material:
  - application form and permit form are determined by SNRIU Order No. 198 dated 17 December 2008;
  - procedure for review of the application and issue of a permit is defined by the Procedure for Issuing Permits for International Shipments of Radioactive Material approved by Cabinet Resolution No. 1196 dated 3 October 2007 Some Issues of Radioactive Material Transport [67].
- To obtain certificates of approval for special form radioactive material, low dispersible radioactive material, special conditions, transport and design of packaging:
  - content of the application, list of documents and procedure for review are approved by SNRIU Order No. 119 dated 6 September 2007 Procedure for Issuing Certificates on Safe Radioactive Material Transport.

SNRIU's orders to issue a license and issue permits and certificates and notifications (letters) of rejection of permits and certificates and rejection of license, which are sent to the applicant, are official documents in which the decisions made are recorded.

Fig. 4.2 Radioactive material in packages fixed for transport in a container

The SNRIU may terminate or cancel a license upon conditions defined in Article 16 of Law of Ukraine On Authorizing Activity in Nuclear Energy [11]. Responsibility for violation of laws in the area of nuclear energy and radiation safety is defined in Articles 81 and 82 of the Law of Ukraine On Nuclear Energy Use and Radiation Safety [10] and in Article 17-1 of the Law of Ukraine On Authorizing Activity in Nuclear Energy [11].

4.2.3 State Oversight of Transport Safety

State oversight of compliance with requirements for nuclear and radiation safety is conducted in compliance with the Procedure approved by Cabinet Resolution No. 824 dated 13 November 2013 [30]. According to this document, the SNRIU conducts scheduled inspections envisaged by annual schedules, and unscheduled inspections. The frequency, grounds and procedure of inspections, criteria to assess the degree of risk in radioactive material transport and procedure for finalization of inspection findings are determined in [30]. In case of nonobservance of legal requirements, regulations, license conditions and prescriptions SNRIU should apply enforcement measures – penalties. This is specified by the Code for administrative offences [31].

Fig. 4.3 Inspection of a vehicle with radioactive material at state border checkpoint

4.2.4 Graded Approach in Radioactive Material Transport

The graded approach is one of the fundamental principles of nuclear safety and security set forth in Ukrainian legislation. This principle is widely used in the area of nuclear energy. It is appropriately applied in radioactive material transport, in particular, in:

- classification of radioactive materials;
- use of packaging;
- identification of package category;
- placement of hazard signs and marking.

Fig. 4.4 Equipment for radioactive material transport

4.2.5 Undertaken Efforts and Current Challenges

In the process of regulatory threat assessment (Report [2]), the SNRIU determined the need to revise the Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials PBPRM-2006 [18] to bring them into compliance with the latest IAEA Regulations for the Safe Transport of Radioactive Material No. SSR-6, 2012 Edition, IAEA, Vienna (2012) [80]. At the end of 2016, the project was launched under the Norwegian Regulatory Cooperation Program (code: TRANSPORT), within which revision of PBPRM-2006 [18] is ongoing (for more details see Section 9). During 2017,

the initial stage of the project was completed: current regulations were analyzed and compared with the IAEA standards and Norwegian legislation, gaps in the Ukrainian regulatory framework on safe transport of radioactive materials were identified and discussed with NRPA experts. The first revision of the structure and contents of the document was developed and submitted to NRPA for review, comments were received and acknowledged. Drafting the first revision of the reviewed Rules is in progress and should be completed in 2018. The first revision of the draft will be submitted to the interested authorities for consideration, firstly it will be the Ministry of Interior and Ministry of Infrastructure of Ukraine. After obtaining comments and propositions, they will be accepted or not in the final revision. The conciliation meetings of the involved representatives from the respective authorities are envisaged in line with the legal procedure. In accordance with usual practices, not less than two meetings are required to obtain comments and agree them.

In 2008 the IAEA IRRS mission was held in Ukraine. Based on the mission report [81], the SNRIU was provided with recommendations in the area of radioactive material transport, including suggestions on the need to develop a number of regulations of various levels to establish requirements for compliance with rules for safe transport of radioactive materials:

'S21Suggestion: The SNRCU should develop a guide on quality management systems for the safe transport of radioactive material taking into account the latest advice of the international organizations including the IAEA'.

'S22 Suggestion: The SNRCU should develop a guide (regulation) taking into account the IAEA Safety Guide Compliance Assurance for the Safe Transport of Radioactive Material', No. TS-G-1.5.

All regulatory acts of the third level (see para 4.1) for safe transport of RM were developed in 2002-2007, before publication of IAEA standards [82], [83] directly related to the items of the above suggestions. Consequently, there is a threat of incomplete compliance of the RM transport regulatory framework with international requirements and standards. To eliminate this threat and improve the regulatory framework on safety of radioactive material transport the following efforts should be taken (for more detail, see Section 8):

- Implement recommendations S21 of the IAEA IRRS mission [81] for development of regulatory requirements for compliance with rules for safe transport of radioactive materials;
- Implement recommendations S22 of the IAEA IRRS mission [81] by establishment of requirements for safety analysis of package design, procedure for issuing certificates for safe transport of radioactive materials and other aspects.

Activities to eliminate the identified challenges shall be agreed with ongoing revision of PBPRM-2006 [18] and shall consider the results of Project TRANSPORT.

5 Emergency preparedness and response

5.1 General Principles on Operation of State Civil Protection System

The state policy on emergency preparedness and response to nuclear and radiation accidents is implemented in Ukraine under the Unified State Civil Protection System (USCPS).

The legal basis for USCPS functioning are determined by the Civil Protection Code of Ukraine [86]. The main tasks of the USCPS are to ensure preparedness of the ministries and other central and local executive authorities, local authorities, subordinated forces and means for actions aimed at preventing and responding to emergencies.

The issues on implementing civil protection measures, the composition of governing bodies and civil defense forces, planning of USCPS activities, procedure for implementing tasks and issues on

interaction arrangements are regulated by the Provisions on the USCPS approved by the Cabinet Resolution [87].

The USCPS consists of functional and territorial subsystems and their units, whose interaction and direct management is implemented by the State Emergency Service of Ukraine (SESU) [86], [87].

USCPS functional subsystems are established by the central executive bodies in relevant area of public life. The head of entity that formed such a subsystem is responsible for direct management of the functional subsystem.

Territorial subsystems of the Unified State Civil Protection System and their units are established within the territorial administrative units and operate in the Autonomous Republic of Crimea, regions, Kyiv and Sevastopil [86].

Depending on the scale and features of an emergency predicted or occurred, the USCPS functions in the modes of:

- everyday functioning;
- increased preparedness;
- emergency situation;
- state of emergency [86].

In January 2015, Resolution of the Cabinet of Ministers of Ukraine [88] introduced and maintains the mode of emergency situation in the Donetsk and Luhansk regions. This is due to the need to coordinate the actions of state bodies aimed at protection of the public, territories and property, USCPS functioning to overcome consequences of an emergency at the state level of social and military nature, which was caused by aggravation of the situation in some territories of Ukraine and the threat of terrorist attacks.

The other territory of Ukraine is under the mode of increased preparedness.

5.2 Functional Subsystem for Safety of Nuclear Facilities within USCPS

5.2.1 General Provisions

Within the USCPS, the SNRIU established and supports a functional subsystem for safety of nuclear facilities [89], whose main tasks are to:

- develop, within its competence, regulations on prevention of emergencies and protection of the public and territories against their consequences;
- ensure preparedness of the SNRIU, its subordinate forces and means for actions aimed at preventing and responding to emergencies;
- participate in developing and implementing target and scientific and technical programs aimed at prevention of emergencies;
- prompt notification via mass media of radiation accidents in Ukraine and abroad if transboundary movement of radioactive substances is probable;
- perform functions of a single national communication point in accordance with the Convention on Early Notification of Nuclear Accidents and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency;
- perform functions of a national competent body according to the Convention on Early Notification of Nuclear Accidents;
- international exchange of prompt information on nuclear events within the international nuclear and radiological event scale.

Activities within the functional subsystem for safety of nuclear facilities are regulated by relevant provision [89] and response plan [90], current mode of functioning is established by Order [91].

5.2.2 SNRIU Information and Emergency Center

The SNRIU Information and Emergency Center (IEC) is the executive unit of the functional subsystem for safety of nuclear facilities. The IEC was established within the technical support of the U.S. Nuclear Regulatory Commission under the Lisbon Initiative and the European Union in the framework of TACIS projects in 1997-1998.

It is a combination of specially designed and equipped rooms, where under normal operation, 24-hour duty is maintained, data from Ukrainian NPPs are analyzed, and operation of automated systems is supported.

In the event of IEC activation, workplaces are staffed by predetermined SNRIU and SSTC NRS personnel (several shifts (teams) of experts), who according to functional responsibilities belong to the following groups:

- Executive Team;
- Executive Team Support Group;
- Data Analysis Group;
- Liaison Group;
- Technical Support Group.

Layout of personnel location in IEC rooms is presented in Fig. 5.1.

Since July 2016, under the support of the Threat Reduction Agency of the US Department of Defense, a project for modernization of IEC systems and equipment is underway. In particular, the system of telephone communication, computer equipment and software were updated. Activities to reconstruct the power supply system are in progress.

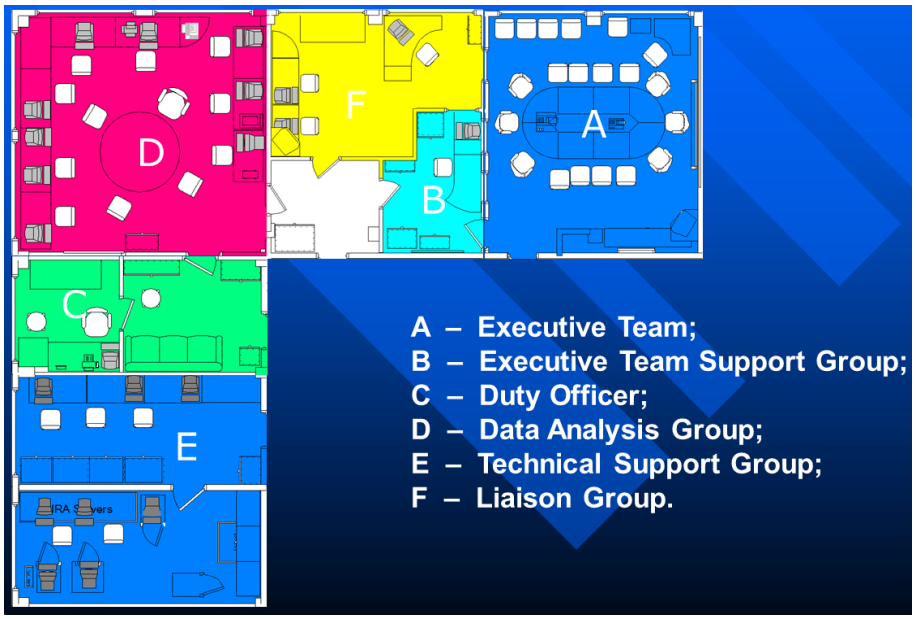


Fig. 5.1 IEC layout

5.2.3 Emergency Training

Personnel included to the IEC undergo special training; participate in emergency training, which are regularly held by the Energoatom Company and IAEA (see Fig. 5.2).

Requirements for emergency training are established by current regulatory documents [55], [92], [109], [118].

In particular, in accordance with the requirements of [55], the operating organization and NPP develop and implement emergency training programs to exercise personnel actions under emergency conditions. The programs are developed in a way to ensure annual inspection for all components of NPP emergency plan and operating organization emergency response plan. According to the schedule developed by the Energoatom Company and approved by the SNRIU, emergency training is held annually at one of the NPPs jointly with the Energoatom.

According to the requirements of [92], training at the state level of the USCPS should be conducted at least once every 5 years. During the recent international ConvEx-3 emergency exercises conducted by the IAEA on 21-22 June 2017 (with participation of Norway, NRPA) under the Paks NPP accident scenario in Hungary, the SNRIU IEC was fully activated for accomplishing the tasks to inform the public, the Cabinet of Ministers of Ukraine, and certain central executive bodies. The information exchange with the operating organization (Energoatom) and Rivne NPP was implemented.

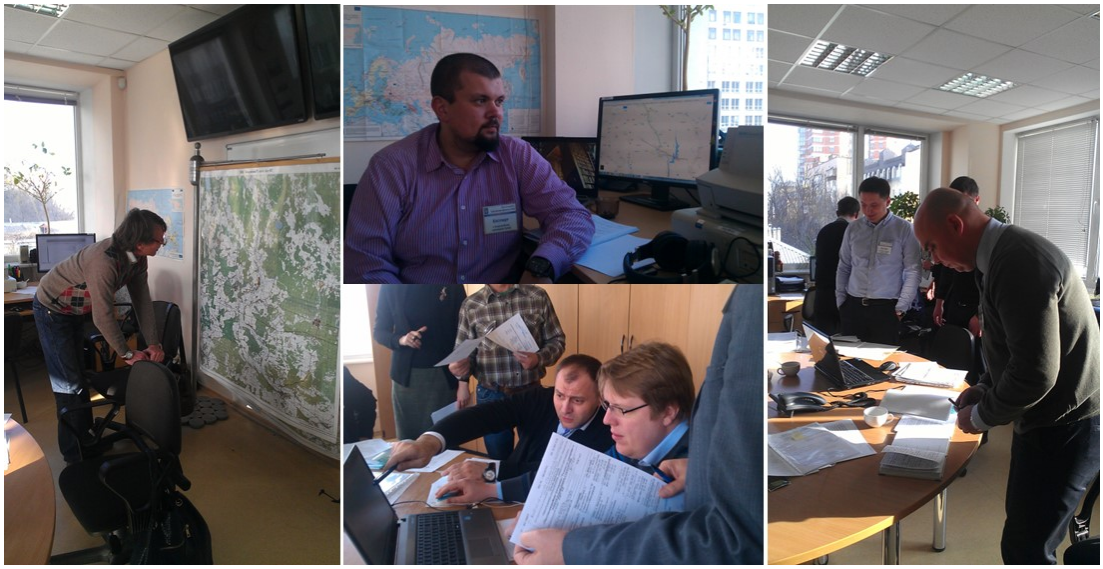


Fig. 5.2 Activities of the IEC Data Analysis Group during emergency training

In early September 2017, during the Ukrainian-American force-on-force training, the SNRIU partially activated the IEC to check communication with the interagency executive team and Special Government Commission established by the Cabinet of Ministers of Ukraine (see Fig. 5.3).

Fig. 5.3 The SNRIU participates in joint training of response to state-level emergency (5-7 September 2017)

In addition to the personnel involved in the IEC activities, for participation in the training, SNRIU delegated observers and representatives to work in the interagency executive team and in the Government Commission. Training scenario assumed to exercise the interaction of central executive authorities in responding to an emergency at the state level associated with a conditional accident at the Zaporizhzhya NPP. The response agencies deployed in Kyiv interacted with the emergency facility and SESU territorial bodies in the Zaporizhzhya, Dnipropetrovsk and Kherson regions. In addition to the SESU and SNRIU, the training involved representatives of the Ministry of Internal Affairs of Ukraine, National Police of Ukraine, Ministry of Defense of Ukraine, Ministry of Health of Ukraine, Ministry of Infrastructure of Ukraine, State Service of Ukraine for Food Safety and Consumer Protection, State Agency for Water Resources of Ukraine, State Committee for Television and Radio Broadcasting of Ukraine, State Agency of Ukraine on Exclusion Zone Management (SAEZ). These large-scale training was conducted under the financial support of the U.S. Defense Department's Defense Threat Reduction Agency.

Emergency training at all USCPS levels is still an effective tool to maintain skills of the personnel involved in the emergency response and emergency preparedness in general.

5.2.4 Automated IEC Systems

The IEC is equipped with automated systems that in real time allow assessment of NPP process parameters, calculation of accident radiation consequences for the environment and the public, monitoring the state of facility physical protection systems.

Fig. 5.4 – Fig. 5.7 present displays of the automated systems installed and operated in the IEC.

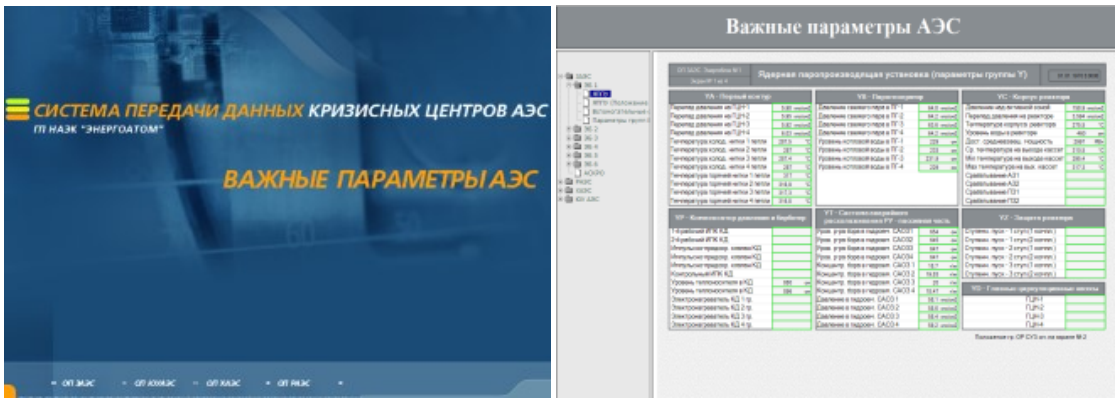


Fig. 5.4 System for transmission of NPP process parameters

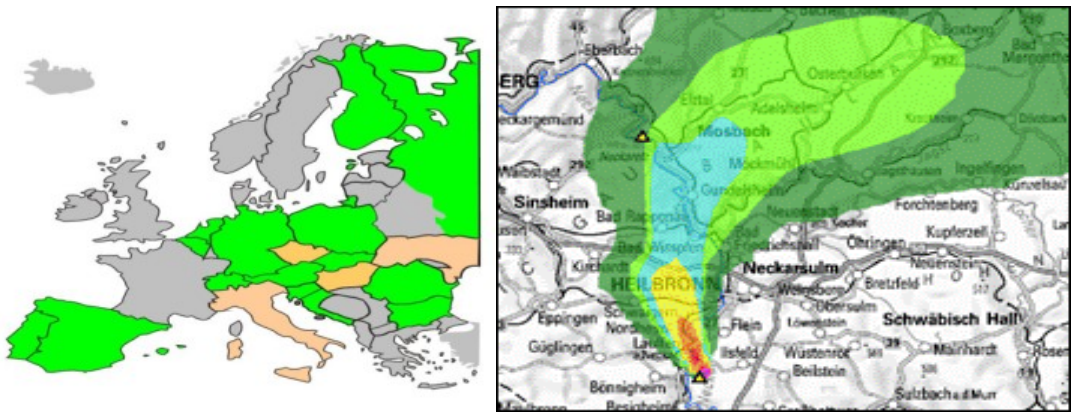


Fig. 5.5 RODOS decision support system

Fig. 5.6 InterRAS international radiological assessment system

Fig. 5.7 Central station for monitoring of engineered features of physical protection systems of facilities using radiation sources and radioactive waste management facilities

The RODOS decision support system was implemented in Ukraine under EU technical support projects for the SNRIU, Energoatom Company, NPPs, Ukrainian Hydrometeorological Center, SESU, and SAEZ. In July 2016, interaction of all RODOS subsystems installed in these organizations was tested.

During the emergency training including IAEA international training, the RODOS system is successfully used in the IEC to perform real-time calculations of radiation situation assessment based on actual weather data. In particular, the use and verification of RODOS models was shown during the participation of Ukraine in the international ConvEx-3 exercises conducted by the IAEA on 21-22 June 2017.

The system for monitoring of engineered features of physical protection systems of facilities using radiation sources and radioactive waste management facilities was established under the support of the U.S. Department of Energy within the Global Threat Reduction Initiative. The system allows remote monitoring of the physical protection of the facilities for radiation source production and use, radioactive waste storage by special enterprises of the Corporation ‘Radon’, in medical institutions using radiation technologies.

The central station of the system for monitoring of engineered features of physical protection systems of facilities using radiation sources and radioactive waste management facilities was installed and put into operation in the IEC in 2016. Sites of 17 medical institutions and two ‘Radon’ SISP equipped with detectors and communication equipment are already connected to the central station in the IEC. Design and mounting activities are in progress for 13 medical institutions. Improved systems of the physical protection for three ‘Radon’ SISP are under trial operation.

Therefore, the systems of communication, information exchange and monitoring of nuclear and radiation safety and security of state oversight facilities are established, operated and maintained in continuous preparedness for response in the SNRIU IEC.

However, there is an urgent need to ensure activity of the central station for monitoring of engineered features of physical protection systems of facilities using radiation sources and radioactive waste management facilities installed at the SNRIU: it is required to establish a unit of on-duty officers, train staff, ensure equipment maintenance, arrange and fund communication lines, etc. Simultaneously, a legal framework should be established and implemented to ensure financing, maintaining and regulating the central monitoring station, including the procedures of information sharing.

According to the Law [25], the State Physical Protection System (see para 2.3.1 of this Report) should:

- establish and ensure functioning of a unified system of secure communication between public authorities and legal entities, whose powers include physical protection functions;
- perform state oversight and monitoring of physical protection state;
- arrange activities on information exchange on physical protection state and its storage.

Such subsystems are established and respective tasks are fulfilled for NPPs. The above central monitoring station will help in reducing the relevant threat for radiation sources and radioactive waste management facilities (for more details see Section 8).

5.3 Radiation Monitoring Using RanidSONNI Mobile Laboratory

Radiation monitoring using the RanidSONNI mobile laboratory is an instrument of the SNRIU and SSTC NRS to respond to emergencies with a threat of radiation exposure or events of public interest or public concern.

Examples of the recent involvement of RanidSONNI mobile laboratory are as follows:

- support of efforts under the project to manage consequences of former USSR military facilities, in particular *'Vakulenchuk'* facility in Zhytomyr region within the Implementation Agreement with NATO in 2016-2017 (see Fig. 5.8), demonstrate results of the site remediation and safety along the route of radioactive waste transport to a protected and controlled storage in *'Radon'* SISP;
- participation in in the pilot project *'STOP_Radon'* with the support of the Swedish regulatory authority;
- monitoring of air in Kyiv and its premises during the forest fires in Chornobyl exclusion zone;
- response to cases of revealed illicit trafficking of radioactive materials, etc.

Fig. 5.8 Radiation survey of remediated Vakulenchuk site, January 2017

In 2017, unauthorized activities in the area of clay pit in Kropyvnytsky (Kirovohrad region) resulted in the destruction of a disposal system for several dozens of metal containers with soil and metal structures contaminated by ^{137}Cs after liquidation of the radiation accident that occurred in 1988. The event gained a significant resonance in the mass media. It was qualified as a radiation accident due to the loss of institutional control and revealed illicit trafficking of radioactive materials. RanidSONNI mobile laboratory was used for radiation survey along the route, gamma survey of the event site and adjacent territories with relevant mapping (see Fig. 5.9). It was applied to provide regional SNRIU inspections and local authorities with recommendations on further actions to ensure radiation safety and security.

Fig. 5.9 Radiation survey in the Kirovohrad region, July 2017

Forest fires that occur from time to time in Chornobyl exclusion zone lead to a rise of radioactive substances in the air together with combustion products, causing concern of people in Kyiv located within a 100 km distance from the places of ignition. In 2015-2017, SSTC NRS experts measured airborne activity using the RanidSONNI mobile laboratory, performed calculations in the RODOS system with real weather conditions (see Fig. 5.10).

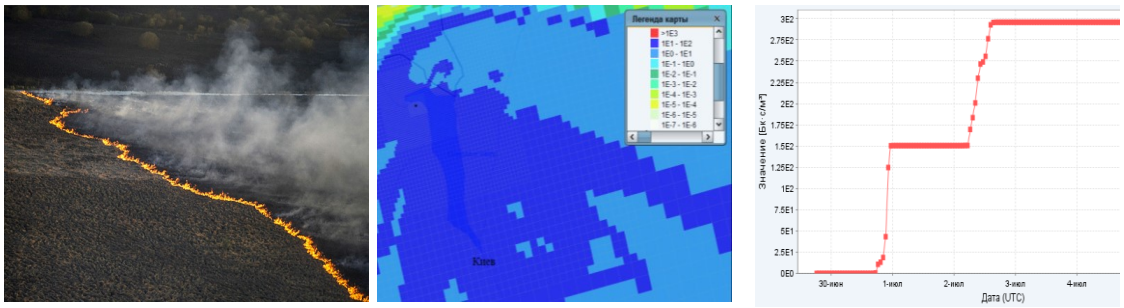


Fig. 5.10 Results of assessments using RODOS air transport models and results of airborne activity measurements in Kyiv during fire in Chornobyl exclusion zone in 2015

In July 2017, the RanidSONNI mobile laboratory revealed an abnormal increase of natural background near the pump room with groundwater in Novohrad-Volynsky during an information tour for the public of settled areas located within the area of Chornobyl accident “western trace”. The spectrometry of selected samples confirmed the presence of thorium and uranium series natural radionuclides.

The Report [2] noted the problem of lacking proper conditions for maintenance of high-quality equipment of the RanidSONNI mobile laboratory (for more details see Section 8). This issue remain open today. Besides, there is an urgent need to create SNRIU and SSTC NRS laboratories for stationary measurements for immediate response and support of oversight measures.

5.4 INES Application

According to international practices, events and situations in nuclear and radiation safety area of public interest are assessed applying the International Nuclear and Radiological Event Scale (INES).

Ukraine became a member of INES activities immediately after creating conditions for INES functioning in 1990. The legal framework for activities within INES in Ukraine includes the documents [16], [107], [108], according to which only NPP events are classified.

If INES was initially used to classify only NPP events, then after review of international guidelines on its use, the scale covers any other events related to transport, storage and use of radioactive materials and radiation sources.

In order to address INES use for the classification of all events in Ukraine defined in the INES User’s Manual 2008 Editions, the SNRIU proposes to initiate relevant consultation meetings with representatives of the Ministry of Energy and Coal of Ukraine, Ministry of Health, State Emergency Service and the public. The following issues shall be discussed: whether available mechanisms for licensees to inform the regulatory authority on events that are not related to NPP events are enough; who shall be responsible for the classification of these events – the national coordinator of the INES or licensee; whether it is appropriate to establish an interdepartmental agency on the classification of events within INES; whether there is a need to develop additional regulatory documents on event classification in Ukraine, etc. After such discussions, a decision may be made on the need to develop a regulatory document on the full use of INES in Ukraine, which can be considered as one of the measures to harmonize Ukrainian regulatory framework with world practice (for more detail, see Section 8).

Such a decision would contribute to the conduct of workshops for representatives of Ukrainian interested parties on the regulatory aspects of INES use in European countries.

5.5 Harmonization of Legislative and Regulatory Framework on Emergency Preparedness and Response with EU Directives and IAEA Safety Standards

Information on the current regulations on emergency preparedness and response to nuclear and radiological events and which are the basis for SNRIU activities in this area was provided in the Report [2]. According to results of performed threat assessment, the experts defined the need "*…for a comprehensive analysis of the national legislation regarding the arrangement/specification of requirements for emergency preparedness and response to nuclear and radiation accident*". The first step in this process is project (code: PREPAREDNESS) launched by NRPA, SNRIU and SSTC NRS under Norwegian Regulatory Cooperation Program. The purpose of this Project is to revise the existing National Radiation Emergency Response Plan [92] to meet requirements of [93], [96], [105] (see Section 9). The State Emergency Service of Ukraine and the State Enterprise 'National Nuclear Energy Generating Company *Energoatom'* will be involved in the development of this document as expert organizations. Effectiveness of such an involvement is supposed to be provided, among other, by organizing and conducting specific working meetings, where each interested party can point out a respective question and discuss it with others. The first such meeting (introductory workshop) will be organized by SNRIU in the frames of the project PREPAREDNESS in spring 2018. Under another similar meeting, a draft document will be presented for representatives of Ukrainian interested parties and SNRIU staff members. After finalization, the document is expected to be approved by the SNRIU, the State Service of Ukraine for Emergencies, Ministry of Energy and Coal Industry of Ukraine, Ministry of Health of Ukraine, Ministry of Ecology and Natural Resources of Ukraine, State Service of Ukraine for Food Safety and Consumer Protection. It is planned to register a new version of the National Radiation Emergency Response Plan in the Ministry of Justice of Ukraine and after its registration, provisions of the document will became mandatory. Since the provisions of the document [92] are the basis for planning response of other functional and territorial subsystems of USCPS, and since they are considered in other regulatory documents, after approval of a new revision of [92], it will be necessary (for more detail, see Section 8) to:

- revise documents [89], [90], [108], [109], [110], other interdepartmental documents;
- establish regulatory requirements for NPP emergency plans, objects of other categories of emergency preparedness according to the classification of GSR Part 7 [104] in relevant SNRIU regulations;
- develop a radiation protection strategy in accordance with the requirements of GSR Part 7 [104].

5.6 Implementation of HERCA-WENRA Joint Approach

The purpose of the HERCA-WENRA joint approach is to:

- coordinate and agree response actions between neighboring countries in the early phase of the accident;
- develop mechanisms for better transboundary coordination of protective measures regardless of the accident cause and scenario progression;
- use simplified procedures to select protective measures at the initial stage of a low probability severe accident in the conditions of insufficient information.

The HERCA-WENRA approach is based on the principles of mutual trust and exchange of technical information. The preparatory stage is aimed at neighboring countries to understand available national emergency measures by development (or improvement of already existing) bilateral and multilateral agreements. At an early stage of the accident, one shall ensure prompt exchange of information and introduction of the "follow my lead" principle. This means that the same protective measures shall be performed in the neighboring countries that are implemented in the country in which the accident occurred. At the later stages of the accident, one shall develop a joint situational report to determine the principles of further coordination of protective measures.

The HERCA-WENRA approach envisages the existence of a general strategy of extension, if it is necessary to implement protective measures, such as evacuation, shelter of the public and blockage of thyroid glands, as well as limited use of agricultural products at a distance of up to 100 km.

The implementation of the HERCA-WENRA approach in Ukraine is included into SNRIU proposals to the INSC Action Program for 2018 [59] (as of autumn 2017, proposals are under EC review).

6 Radioactive waste management and decommissioning

The Report [2] analyzed safety of radioactive waste management and decommissioning of nuclear installations in Ukraine. The analysis generally covered all activities of the industrial side and associated regulation process.

The analysis identified general threats of safety regulation of radioactive waste management and decommissioning as presented in Report [2] (see also Section 8). In order to eliminate the identified threats, an appropriate system of regulations needs to be developed, including:

- Regulations of the first (higher) level such as:
    - General Safety Provisions for Predisposal Management of Radioactive Waste;
    - General Safety Provisions for Disposal of Radioactive Waste;
    - General Safety Provisions for Decommissioning of Nuclear Facilities.
- Regulations of the second level that should detail requirements of higher-level regulations regarding:
    - individual stages of radioactive waste management and individual types of radioactive waste management facilities;
    - decommissioning of different types of nuclear installations;
    - performance of safety assessments, development of licensing documents.
- As of mid-2017, with NRPA financial and expert support (for more details see Section **Feil! Fant ikke referansekilden.**):
    - respective high-level regulations have been developed or their development is in process;
    - development of requirements for the structure and contents of licensing documents for decommissioning of nuclear installations has been started.

Under support of the European Commission within project INSC U3.01/12 (UK/TS/48) [93], development and revision of requirements for the structure and contents of the safety analysis reports for radioactive waste processing and disposal facilities are underway.

All respective Ministries and governmental agencies (Ministry of Health of Ukraine, State Agency of Ukraine on Exclusion Zone Management, Ministry of Ecology and Natural Resources of Ukraine, Ministry of Energy and Coal Industry of Ukraine) took part in the development and approval of the regulations listed above in accordance with the general legal procedure (providing comments to the draft documents, participating in the target working meetings).

The Report [2] addresses safety regulation of radioactive waste management and decommissioning in a general way. Individual specific issues were not considered. This Section reviews the following important specific aspects:

- management of accident-origin and legacy radwaste;

- management of disused sealed radiation sources (DSRS) declared as radwaste;
- release of radioactive materials from regulatory control.

The Section provides also the current information on decommissioning of Chornobyl NPP units 1–3, Shelter and spent nuclear fuel storage facilities that exist or are under construction in Ukraine. Review of the above aspects is based on the analysis presented in [2] and is continuation of this analysis.

6.1 Regulation of Safety in Management of Accident-Origin and Legacy Radioactive Waste

6.1.1 Regulation of Safety in Management of Accident-Origin Radwaste in the Chornobyl Exclusion Zone

A large amount of emergency radioactive waste was generated after the Chornobyl accident in 1986. This radioactive waste was mainly confined in the acute accident phase and is now located at facilities in the Chornobyl exclusion zone:

- Buriakivka, Pidlisny and ChNPP Stage III radioactive waste disposal sites (RWDS);
- radioactive waste interim confinement sites (RICS) – about 1000 trenches/pits around ChNPP.

The Buriakivka RWDS (Fig. 6.1) is a near-surface disposal facility for low- and intermediate-level waste; radwaste retrieval from the Buriakivka RWDS is not envisaged.

The Pidlisny RWDS and ChNPP Stage III RWDS (Fig. 6.2) mainly contain intermediate-level and high-level waste. These RWDS are planned to be kept in safe state over a long-term period (considering that the Chornobyl exclusion zone acts as an access-control barrier). However, radwaste must be retrieved from these RWDS after a long-term period to be processed and disposed. The safety assessment of these RWDS was carried out within the framework of the INSC industrial project [94]. The assessment results and respective recommendations for measures to maintain and improve the RWDS safety are presented in the Report [95].

Fig. 6.1 Buriakivka RWDS

Fig. 6.2 Pidlisny RWDS (on the left) and ChNPP Stage III (on the right)

It is planned that some part of low-level waste from RICS (trenches/pits) (Fig. 6.3) will be retrieved and other part will remain in place.

Fig. 6.3 Radioactive waste interim confinement sites (RICS)

More detailed information on these sites with accident-origin radwaste can be found in [2].

The SNRIU with involvement of Riskaudit/SSTC NRS and financial support of the European Commission under Projects INSC U3.01/08 (UK/TS/39) [96] and INSC U3.01/10 (UK/TS/46) [97] developed guidelines to govern the management of accident-origin radwaste in the Chornobyl exclusion zone:

- Guideline for Common Impact of the Vektor Site with Multiple Facilities for Radioactive Waste processing, Storage, and Disposal;
- Guideline for Safety Assessment of Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone.

At present, the industrial side used the “Guideline for Safety Assessment of Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone” within INSC Project U4.01/10 C+D+F [98] to assess safety of the RICS in the Chornobyl exclusion zone. This assessment resulted in ranking of certain RICS by degree of hazard and determined recommendations concerning actions to maintain RICS safety and safety of radioactive waste retrieval from certain RICS.

Within INSC Project U4.01/10 C+D+F [98], the industrial site performed a comprehensive safety assessment of radioactive waste storage/disposal in the Chornobyl exclusion zone using the “Guideline for Common Impact of the Vektor Site with Multiple Facilities for Radioactive Waste processing, Storage, and Disposal”.

Therefore, safety assessment of emergency radioactive waste management in RWDS/RICS of the Chornobyl exclusion zone is regulated by special guidelines developed by the SNRIU involving Riskaudit/SSTC NRS with the financial support of the European Commission (see also Section 9).

6.1.2 Regulation of Safety in Management of Legacy Radwaste

Legacy radioactive waste is mainly located in RWDS on sites of 'Radon' regional specialized plants (Fig. 6.4). There are also burials with radioactive waste at military facilities of the former USSR (Fig. 6.5).

Fig. 6.4 Typical storage facility on sites of 'Radon' regional specialized plants

Fig. 6.5 Legacy burial with radwaste at military facilities of the former USSR

Legacy radioactive waste from 'Radon' RWDS is planned to be gradually retrieved (depending on the state and degree of hazard of certain SISP). This also applies to burials with radioactive waste at military facilities of the former USSR.

The SNRIU with involvement of Riskaudit/SSTC NRS and financial support of the European Commission under Project INSC U3.01/08 (UK/TS/39) [96] developed a guideline to govern the management of legacy radwaste at 'Radon' RWDS "Guideline for Safety Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities".

The Guideline was used in safety review of 'Radon' RWDS with legacy radioactive waste. First review stages have been completed. Their results were considered by the SNRIU with the support of Riskaudit/SSTC NRS within Projects INSC U3.01/08 (UK/TS/39) [96] and INSC U3.01/10 (UK/TS/46) [97].

The industrial side with the NATO support liquidated 'Vakulenchuk' burial at the military site of the former USSR (see also para. 5.3 of this Report). The abovementioned Guideline for Safety

Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities was used in the project implementation.

Therefore, safety assessment of legacy radioactive waste management at 'Radon' RWDS and in radwaste burials at military facilities of the former USSR is regulated by the special Guideline developed by the SNRIU involving Riskaudit/SSTC NRS with the financial support of the European Commission (see also Section 9).

Fig. 6.6 View of open radioactive material disposal site

As showed the incident in Kropyvnytsky in July 2017, there are threats in Ukraine related to the existence of unknown radioactive material disposal sites of the former USSR. Namely, excavation activities revealed disposal of low-level materials arranged in 1988, after radiation accident related to the damage of capsule with powder cesium-137. The presence of man-made radionuclide cesium-137 was established in places where high dose levels were detected. Fig. 6.6 (information from the Internet) presents the remaining containers with disposed radioactive materials.

The incident is an example of a situation with abandoned sources when administrative control is not ensured.

The Guideline for Safety Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities and regulatory experience in remediation of the Vakulenchuk military burial can be used to solve issues on the management of radioactive materials of the burial near Kropyvnytsky.

6.1.3 Regulation of Safety in Management of Accident-Origin Radwaste at the Shelter

The Shelter is a special facility containing accident-origin radioactive waste (Fig. 6.7), which was installed in 1986 above destroyed ChNPP unit 4. The Shelter is a confining structure with individual systems (dust suppression, introduction of neutron-absorbing solutions, monitoring, etc.).

Fig. 6.7 Shelter, 1986

6.1.3.1 Shelter Safety Improvement and Transformation

Since 1997, the Shelter Implementation Plan has been implemented. This plan envisages the implementation of priority measures on the Shelter stabilization and safety improvement, as well as long-term measures. The Shelter Implementation Plan was approved by Ukraine and the community of countries under the auspices of G-7. These countries have allocated funds to fulfill the Shelter Implementation Plan. At present, implementation of priority measures is almost completed. Besides, the main project of the Shelter Implementation Plan, namely NSC construction over the sarcophagus, is underway (Fig. 6.8).

The main NSC functions are to:

- ensure protection of personnel, the public and the environment against hazards related to the Shelter;
- ensure conditions for dismantling of unstable Shelter structures and management of relevant radioactive waste, for future retrieval of fuel-containing materials and other radioactive waste.

Fig. 6.8 New Safe Confinement (NSC)

The operational period of the main protective structure NSC is at least 100 years. The safe state of the Shelter inside NSC shall be maintained in this period during the active Shelter transformation (removal of structures, fuel-containing materials, etc.) and between these stages when the Shelter is in passive state.

The Shelter Implementation Plan establishes the following safety functions: reduce probability of structure collapse (stabilization); mitigate consequences of sudden collapse; improve nuclear safety; improve safety of personnel and environmental protection; improve the strategy of long-term measures.

The Shelter Implementation Plan is intended to reduce the probability of Shelter collapse by its strengthening (increase in Shelter stability). The minimum amount of measures to stabilize the most unstable Shelter structures has been implemented considering difficult access to certain Shelter rooms and significant doses of personnel exposure during the performance of stabilization activities.

The probability of Shelter collapse before the stabilization was approximately estimated as 10^{-1}/year, and after the implementation of urgency stabilization measures it was estimated as 10^{-3}/year. The risk of potential exposure resulting from Shelter collapse still remains higher than the rated limits. The safety level reached by urgent stabilization (as an intermediate level of gradual increase of Shelter safety) was approved for 15 years, that is by 2023.

In order to mitigate consequences of a sudden collapse of Shelter structures, the experts upgraded the dust suppression system that ensures the creation of dust-fixing film in the under-roof space of the Shelter; the dust suppression area was significantly extended and film characteristics were improved (in particular, its thickness and strength were significantly improved). This made it possible to reduce significantly the estimated dust release in case of structure collapse.

Subcriticality of fuel-containing materials is to be ensured by the criticality risk assessment, creation of a new system for monitoring the state fuel-containing materials and implementation of measures on reducing criticality risks. The assessment of criticality risks is based on available studies of fuel-containing materials. Besides, the study of water in the Shelter was conducted: possible ways of its income, transfer, outcome, characteristics, etc. In the available Shelter state, water is not accumulated in fuel-containing materials due to leakiness of the rooms. A conclusion was made that these risks are low for the available state of fuel-containing materials and the Shelter. Consequences of criticality if it occurs are assessed as local. Solutions with neutron absorbing materials are periodically introduced into the under-roof space. Monitoring of radiation parameters of fuel-containing materials was ensured.

Within the Shelter Implementation Plan, projects on fire protection systems of the Shelter were implemented. Shelter physical protection system was updated.

The Integrated Automated Monitoring System intended for automated monitoring of the Shelter state was implemented. This system includes systems for monitoring radiation parameters of fuel-containing materials, radiation monitoring, monitoring of building structure state, seismic control.

The implementation of the long-term measures strategy envisages: the development and implementation of NSC project; the development of the strategy for retrieval of fuel-containing materials.

The NSC project is divided into startup stages:

- NSC startup stage I (protective structure with process life-support systems and necessary infrastructure);
- NSC startup stage (infrastructure for dismantling of unstable structures).
- The construction of NSC startup stage I is planned to be completed in 2017.

The main functional purpose of the NSC protective structure is to prevent spreading of radioactive substances from the Shelter ensuring protection of personnel, the public and environment; prevention of atmospheric precipitations income inside NSC; ensuring process space and conditions to place systems and components to transform the Shelter into the environmental safe system. The protective building is designed to prevent spreading of radioactive structures to the environment, in particular, in case of extreme natural events.

The system of main cranes is envisaged for the dismantling of unstable structures.

The design of NSC startup stage I envisages the process building located near western wall of the protective building and partially inside the building. Except the process building (on NSC sire outside the protective building), there are other buildings. Under NSC, there are buildings, sites and

areas for primary management of dismantled structures, movement of transport and personnel, etc.

The integrated system for monitoring and control of NSC is intended for control of process equipment and control of operational parameters and main characteristics of NSC.

The design of NSC startup stage I envisages other life support systems: ventilation, power supply, internal transport, communication and notification, access control, dust suppression, fire protection, water supply, sewage system, etc.

Project studies were conducted within implementation of NSC startup stage II. The detailed project has not been yet started. The development and implementation of NSC startup stage II shall be performed without delays to ensure dismantling the most unstable Shelter structures until 2023.

The development of the strategy for the retrieval of fuel-containing materials is postponed. Certain issues on safety of fuel-containing materials are insufficiently studied. One of the important issues is to predict behavior of fuel-containing materials and boundary duration of possible staying of accumulated fuel-containing materials under NSC. Periods for the retrieval of fuel-containing materials and, correspondently, the retrieval strategy significantly depend on this.

6.1.3.2 Regulatory Control of Shelter Safety

In 1997, the nuclear regulatory authority of Ukraine (now the SNRIU) and other regulatory authorities faced the problem of ensuring proper safety regulation during the Action Plan implementation, when there was no relevant experience in the world. This difficult task is being successfully implemented involving a large number of TSOs. Comprehensive TSO cooperation at an international level (between TSOs of Ukraine, Germany, France, USA) is one of key aspects of efficient support received by the SNRIU.

The SNRIU identified the following three fundamental safety principles of for the Shelter Implementation Plan:

1. Radiation safety and ALARA principle
2. Use of proven technologies and advanced international experience
3. Implementation of the quality management system by the licensee.

These principles contributed to the development of safety fundamentals such as: structural integrity, accident prevention, ensuring of preparedness to emergencies and mitigation of accident consequences, nuclear safety (prevention of criticality), radiation protection of personnel, the public and the environment, radioactive waste management, management of quality and safety culture. The Guideline on Use of these Principles for Safety Regulation of the Shelter Implementation Plan was developed as well.

The SNRIU and other regulatory authorities together defined the following specific safety criteria for NSC that correspond with the defined regulatory approaches, namely:

1. Permissible design levels (releases, discharges, permissible levels at working places)
2. Design criteria to limit potential exposure, regulatory requirements for extreme events, such as tornado and earthquake
3. Criteria for classification of contaminated soils and other materials during excavation activities.

The above regulatory framework was developed for the period of the projects within the Shelter Implementation Plan. At present, measures under the Shelter Implementation Plan are under completion. The regulatory framework needs to be updated for further safe operation of NSC (including Shelter transformation). In particular, the validity period of the following regulatory documents is expiring:

- Fundamental Safety Principles under the Shelter Implementation Plan (NP 306.1.102-2004) [99].
- Guideline on Using Safety Fundamentals in Regulatory Activity under the Shelter Implementation Plan (RD 306.1.128-2006) [100].

The SNRIU plans to issue a license for the operation of the NSC, considering the NSC (including the Shelter) as a facility intended to manage emergency radioactive waste. Under the Norwegian Regulatory Cooperation Program the regulatory document 'General Safety Provisions for Predisposal Management of Radioactive Waste' [5] (for more details see Section 9) was developed under the code: WASTE project, which applies to this facility.

Considering the uniqueness of the NSC (including the Shelter), it is necessary to develop a regulation based on the document [5] to establish special requirements and safety rules for NSC (including the Shelter) and activities on this facility (see Section 8).

The NSC design defines safety criteria and requirements directly for NSC, when the Shelter is considered as a facility in general with boundary conditions of Shelter impact on the environment being a part of NSC (for example, boundary conditions for radiation fields, for air contamination in NSC main volume, for temperature and humidity regime). Criteria and conditions for the safe state of Shelter components in its position under the NSC at present are not defined. Such conditions shall be defined. The following conditions and criteria, whose definition is the current challenge for the SNRIU (see Section 8), is the subject under regulatory authority consideration in regulation of NSC operation (including the Shelter):

- safe state of Shelter structures;
- safe state of fuel-containing materials and solid radioactive waste;
- safe state of accumulated liquid radioactive waste in the Shelter;
- limited contamination of Shelter air;
- explosion and fire safety of the Shelter;
- predicted safe state of the Shelter.

Therefore, there is a deficit in regulation of activities on NSC safe operation, including deficit of requirements for maintaining safe state of the Shelter during its "storage and transformation" under NSC, peculiarities of ensuring personnel activity safety, etc. This threat shall be resolved in 2018–2019.

6.2 Regulation of Safety in Management of Disused Sealed Radiation Sources Declared as Radwaste

Ukraine has accumulated a huge amount of disused sealed radiation sources (DSRS) - about 50000). They include various DSRS by radiation types (gamma-, beta- and alpha-, neutron), by activities. The DSRS are being accounted, but there are many legacy sources that have no certificates. The majority of sources is stored at 'Radon' specialized plants. Batches of DSRS were placed in containers. At the same time, there are legacy sources mixed with legacy radioactive waste (in particular, there is a mixture of DSRS and radioactive waste in legacy 'Radon' RWDS).

The Centralized Long-Term Storage Facility for Radiation Sources (CLTSF) (Fig. 6.9) was constructed on Vektor site with support of the Department of Energy and Climate Change of Great Britain. The CLTSF is a key facility of the system for safe management of DSRS in Ukraine. Long-term storage of packages with DSRS is envisaged at this facility (50 years).

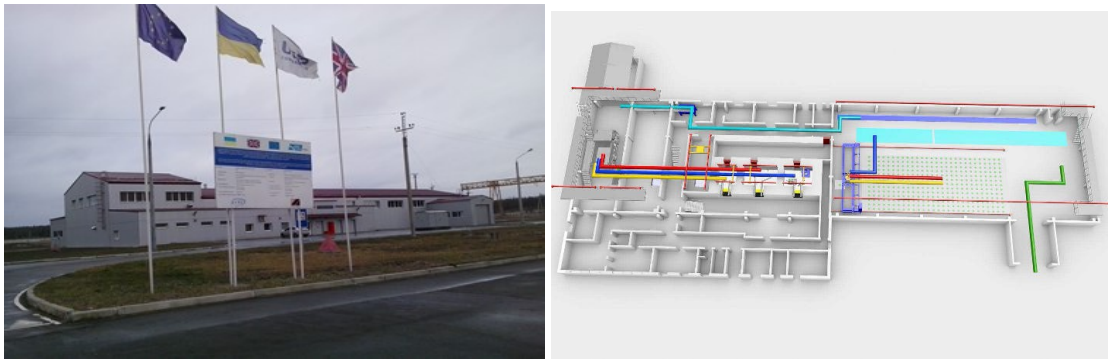


Fig. 6.9 CLTSF and process layout

DSRS processing is envisaged in the CLTSF (DRS preparation for storage) by five process flows:

- Flow 1: radioisotope thermoelectric generators (β-source): placement for storage without processing;
- Flow 2: units of gamma sources (γ-source): preliminary preparation and processing in hot cells;
- Flow 3: neutron sources: processing in hot cells;
- Flow 4: other DRS with higher activity: processing in hot cells;
- Flow 5: other DRS with lower activity: processing in a glove box.

Identification and characterization of DSRS, their sorting, placing in packages is performed in the CLTSF in the hot cells and in glove box.

As of the beginning of autumn 2017, commissioning (hot tests) of the CLTSF is under performance.

Regulation of the activities on DSRS safe management is ensured only by the regulatory documents establishing safety requirements for “ordinary” radioactive waste. There are no specific requirements for DSRS safe management.

The experience of CLTSF licensing has shown the need to establish special requirements. In particular, the following open important safety issues were identified (see Section 8): establishing requirements for the preparation of DRS batches by DSRS suppliers. At ‘Radon’ enterprises, DSRS accounting and storage is conducted in accordance with the previous practice (the regulatory requirements of the former USSR, which are not currently in force in Ukraine). For example, different DRS may be in one container. When preparing DSRS batches for supply to the CLTSF, the issues arose on ensuring DSRS identification for certain process flow (for example, prevention of high-level DSRS entry into a radiation protection box). There are also open issues of safe DSRS supply when reliable information on DSRS is not available:

- Characterization and criteria for DSRS sorting. In the CLTSF, DSRS sorting is provided taking into account further disposal of DSRS packages (after completion of their long-term storage) in a storage facility of a certain type (for example, near-surface or geological).
- As a rule, permissible specific activity of radioactive waste is used as acceptance criteria for disposal. At the same time, activity is determined for DRS and specific activity is not presented (in addition, this indicator directly for DRS active part is too high, without taking into account the capsule and other structures).
- Issues on radiation criteria for DRS disposal is ambiguously addressed also in the IAEA documents.
- Detection of damaged DRS and damage criteria (in particular, leaking criteria) in view of the safety of preparing DRS batch for storage, as well as acceptability/unacceptability of the placement of damaged and not damaged DRS in one package for a long-term storage.

- Reliability of DRS identification and sorting, in particular prevention of erroneous placing DRS with exceeded permissible activity in a package. Such errors are quite probable taking into account enormous amount of DRS.
- Reliable monitoring of DRS flows and their accounting during DRS preparation for storage and in storage. There are no specific requirements for such control and accounting, for reliability of data storage and databases, etc.
- Coordination of actions and data exchange between DRS suppliers and Operator of the CLTSF. Supply of DRS taking into account functioning of all process flows, information exchange on DRS characteristics, investigation of cases with discrepancies of the data in the certificates of DRS suppliers and results of characterization in the CLTSF. These issues should be regulated.
- Special requirements for packages of DRS long-term storage are not established but should be established.

The high-level document 'General Safety Provisions on Predisposal Radioactive Waste Management' developed under the earlier mentioned code: WASTE project with NRPA support [5] (for more details see Section 9) is also applicable to the management of DRS declared as radioactive waste. Based on the provisions of this document, it is proposed to develop a document 'Requirements and Rules for Management of Spent Radiation Sources', which, in particular will regulate the above-mentioned open issues (see Section 8). Within the development of such a regulatory document, it is advisable to study the international experience on DRS management (including legacy DRS).

Currently, there is a lack of regulation on safe management of spent radiation sources declared as radioactive waste including:

- criteria of DRS acceptance for processing,
- DRS characterization and sorting for further storage/disposal,
- management of damaged and unidentified DRS,
- reliable control over DRS flows and their accounting,
- requirements for DRS packages and control of their state during long-term storage, coordination and data exchange between DRS suppliers and Operator of the storage facility, etc.

This threat requires an immediate action.

6.3 Release of Radioactive Materials from Regulatory Control

In Ukraine, release of radioactive materials from regulatory control (RM release) is regulated by document NP 306.4.159-2010 "Procedure for Release of Radioactive Materials from Regulatory Control in the Framework of Practices" [101]. Today, RM release is conducted in relatively small scope in Ukraine, but in the future, it is planned to significantly expand this activity. In particular, this is associated with the decommissioning of ChNPP, at which under support of the European Commission, a facility for RM release with high capacity is constructed. According to the experience of using NP 306.4.159-2010 [101], it was found that this document:

- has certain drawbacks;
- establishes requirements that are not detailed enough;
- does not cover certain issues important to safety.

On 27 December 2016, under participation of the SNRIU, a meeting was held with interested organizations improving the requirements and procedures for RM release. It was decided during the meeting that, among other improvement measures, it was necessary to review document [101]. Based on the results of implementing certain activities within INSC U3.01/10 project

(UK/TS/46) [97], it was also found that document [103] needs correction and amendments. There are, in particular the following open issues:

- Criteria of RM release: only dose criteria and radionuclide specific activity criteria are established. It is indicated that the entity establishes derivative criteria after agreement with the regulatory authorities. Specific methodological and procedural requirements for the development of derivative criteria are not established and should be established. In Western European countries, there is also the practice of establishing derivative criteria by regulatory authorities.
- Requirements for preparing a RM batch for the procedure of measuring radiation characteristics of the batch (requirements for RM origin, RM batch homogeneity, procedures for batch preparing, etc.) are not established.
- Requirements for the procedure of measuring RM batch radiation characteristic.
- Special requirements for the quality assurance system of RM release, in particular, requirements for responsibility of officials (for preparing RM batch, for its radiation characterization, procedure of transferring released RM to another legal entity, etc.) are not established.
- Requirements for prevention of unauthorized access to RM batch are not established.
- Requirements for prevention of repeated contamination of RM batch for which a decision was made on the release from regulatory control are not established.
- Special requirements for the procedure of RM release within the exclusion zone are not established. RMs are released within the Chornobyl exclusion zone; at the same time, the Chornobyl exclusion zone itself is under regulatory control. It is necessary to establish a procedure under which a regulatory decision on RM release comes into force only after the removal of RM batch outside the Chornobyl exclusion zone and with the prevention of repeated RM contamination.
- Requirements for inspecting RM release activities are not established.
- Requirements for making regulatory decisions on RM release.

Document NP 306.4.159-2010 'Procedure for Release of Radioactive Materials from Regulatory Control in the Framework of Practices' [101] needs revision to solve the above-mentioned open safety issues, since at present there are some drawbacks in the regulation of radioactive material release from regulatory control. This hazard requires urgent action (see Section 8).

6.4 Decommissioning

ChNPP conducts ChNPP decommissioning activities in accordance with SNRIU License Series EO No. 000040 by successive implementation of the following decommissioning stages: termination of operation, final closure and temporary shutdown, safe storage and dismantling.

ChNPP completed the operation termination stage during which ChNPP units were released from nuclear fuel.

ChNPP obtained the SNRIU permit to implement the following decommissioning stage: final shutdown and preservation.

During the stage of final shutdown and preservation, it is envisaged, in particular to:

- dismount and process technological channels and control and protection system channels of ChNPP units;
- perform temporary shutdown of reactors and confine temporary shutdown areas;
- reconstruct covers of central halls and dismount lifting mechanisms.

According to NP 306.2.141-2008 'General Safety Provisions for Nuclear Power Plants' [55] after complete removal of nuclear fuel from the power unit, further decommissioning of the ChNPP units

is carried out based on the general safety provisions established for radioactive waste management facilities.

Currently, the regulation 'General Safety Provisions for Predisposal Management of Radioactive Waste' is put into force [5]. This document was developed under the Norwegian Regulatory Cooperation Program with NRPA support.

In 2016, the project (code: DECOMISSIONING) was implemented under this Program to develop two regulatory documents: 'General Safety Provisions for Decommissioning of Nuclear Facilities' and 'Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities (for more details see Section 9). The documents are planned to be drafted in their final form in mid-2018.

6.5 Management of Spent Nuclear Fuel

The strategy accepted in Ukraine envisages storage of spent nuclear fuel for 100 years in intermediate dry storage facilities.

Currently, DSFSF is operated at Zaporizhzhya NPP (Fig. 6.10) and ISF-1 at Chornobyl NPP, ISF-2 is under construction (Fig. 6.11), and construction of CSFSF has been started.

Fig. 6.10 DSFSF at Zaporizhzhya NPP

Fig. 6.11 ISF-2 at Chornobyl NPP

The main regulatory requirements for spent fuel storage facilities are established in 'General Safety Provisions for Interim Dry Storage Facilities for Spent Nuclear Fuel' NP 306.2.105-2004 [102].

Document 'Recommendations on the Structure and Contents of the Safety Analysis Report for Spent Nuclear Fuel Storage Facility' RD 306.8.02/2.067-2003 [103] establishes recommendations on developing the safety analysis report on spent fuel storage facilities.

These regulatory documents were put into force 10 years ago and played an important positive role first in designing ISF at ChNPP. In design of ISF at ChNPP and CSFSF, relevant US experience was applied. Currently, regulatory document 'General Safety Provisions for Interim Dry Storage Facilities for Spent Nuclear Fuel' NP 306.2.105-2004 [102] is reviewed under U.S. NRC support (for more detail, see Section 9).

7 Radiation safety

Principles for radiation safety regulation for use of radiation sources in industry, medicine, research and training are described in the Report [2]. This Section focuses attention on analysis of changes in the legislation and state regulation system for radiation safety during the last two years and more detailed description of hazards that are relevant in mid-2017 and need to be considered.

7.1 Radiation safety regulation of the use of radiation sources

In Ukraine, the use of radiation sources in industry, agriculture, medicine, education and scientific studies is subject to state regulation in nuclear energy use (Article 27 of the Law of Ukraine On Nuclear Energy Use and Radiation Safety) [10]. It is based on the graded approach to safety requirements depending on the potential nuclear and radiation hazard for a specific activity with specific facilities (sources).

The principle of graded approach is also applied in authorizing activities: a system and procedure for licensing, state registration of radiation sources [111], oversight and enforcement is implemented, criteria and procedure for release of radiation sources from regulatory control or licensing are approved [112].

One of the SNRIU priority tasks in the rule-making activity is the implementation of the Directive 2013/59/Euratom [7] establishing basic safety standards for protection against the hazard caused by radiation, which are partly already introduced in the national legislation. This Directive is aimed primarily at establishing basic safety standards for radiation protection of the public and persons exposed to occupational and medical exposures. Implementation of the Directive will provide an up-to-date level of radiation safety in Ukraine by adopting new safety standards and improving the state regulation system. However, there are challenges that either are not fully covered by national regulations or are not currently regulated at all. First, it concerns the limitation of radiation exposure by medical sources for personnel and population (see Fig. 7.1).

Fig. 7.1 Medical sources

In order to cope with the mentioned challenge, regulations were elaborated in the framework of cooperation between the SNRIU and NRPA in 2015-2016 under the Norwegian Regulatory Cooperation Program (the project code: MEDICINE), namely 'General Safety Rules for Medical Radiation Sources' [4] and 'Radiation Safety Rules of Using Radiation Sources in Brachytherapy' [6]. Representatives of the Ministry of Health, governmental medical institutions and professional medical societies were actively involved in development these regulations. Such an involvement was organized by SNRIU under the project MEDICINE by means of targeted workshops conducting. For example, in August 2016 the workshop dedicated to presenting the final versions of [4], [6], was organized by SNRIU and conducted by SSTC NRS for all interested parties listed above (Fig. 7.2).

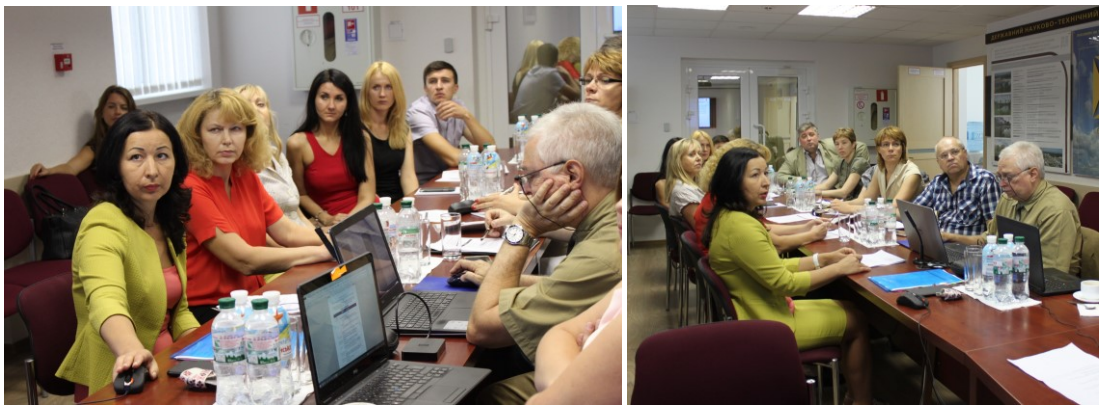


Fig. 7.2 The Workshop on presenting of the final versions of "General Safety Rules for Medical Radiation Sources" and "Radiation Safety Rules of Using Radiation Sources in Brachytherapy", August 2016, Kyiv

The main features of new regulations were discussed in details by all participants along with directions of further enforcement actions, which are expected to be implemented by respective authorities after the regulations will be put in force. NRPA representatives also took part in the workshop in question and participated in the discussions.

Other challenges related to the lack of regulatory requirements are: content of natural radionuclides in waste from industrial enterprises and technologies, decrease of radon exposure levels, etc., no individual dosimetric control and control of premises at such enterprises, and no dose assessment and optimization of exposure for both the public and personnel.

Today, these aspects arouse increased interest, since they are beyond the usual regulatory scope and concern not only practices with established rules and requirements, but also the area of activity that affects each person, for example, medical exposure.

The new radiological protection system divides exposure situations into planned, existing and emergency exposure scenarios.

The modern classification is based on a new concept of source. Today, the International Commission on Radiological Protection (ICRP) understands the source as both a single radiation source and process operations or complex production processes.

The definition of source depends on the context of assessing an exposure situation, selection of a protection strategy, and agreement of this system acceptability with the SNRIU.

These are challenges that should form a basis to develop SNRIU rule-making activity plans and determine the priorities of state regulation in this area. Therefore, the main areas of SNRIU rule-making activity for 2018-2019 may be the following (see also Section 8):

- continue activities on bringing national regulations and rules on radiation safety in compliance with current international safety standards and EU legislation;

- increase the level of radiation protection for personnel and the public by implementing basic safety requirements for management of radiation sources based on current IAEA standards and EU legislation;
- optimize personnel exposure by establishing the dose constrains and a unified state system for accounting and control of individual occupational exposure doses;
- implement criteria and systems for recognizing radiation protection experts;
- improve the safe management system for radiation sources prior to their transfer to specialized radioactive waste management enterprises;
- implement radiation protection programs for personnel of plants with natural content of radionuclides (iron ore, coal mines, etc.) and aircraft crews;
- develop and implement an action plan to reduce public exposure to radon and products of its decay, minimize long-term risks of radon spread in residential and non-residential buildings, in workplaces from any source of radon penetration from soil, building materials or water;
- develop safety standards for radiation sources used for inspection purposes and for non-medical imaging [113].

Ukraine is one of the first countries that joined the Code of Conduct on the Safety and Security of Radioactive Sources (IAEA, 2003) [117] in 2003. To date, most of the Code provisions are already implemented into the legislative and regulatory system. As part of implementing the Code, the National Program for Establishing a Register of Radiation Sources and Ensuring Safe Storage of Spent, High-Level Radiation Sources was fulfilled. To implement the Code provisions, the State System for Licensing and Control of Radiation Sources was substantially improved: seven regional state inspectorates were established and started their activities since 2006. The activities of regional inspectorates have a significant impact on the level of radiation safety and physical protection in the country. A number of measures were taken to improve licensing and oversight activities, as well as measures to recommence control over radiation sources beyond the regulatory control (for example, plan for searching orphan radiation sources). Many of these measures serve dual purposes (for example: the National Program for Establishing a Register of Radiation Sources and Ensuring Safe Storage of Spent, High-Level Radiation Sources contributed to transfer of disused radioactive sources to a safe state and prevention of access to high-level radiation sources for committing unlawful actions.

As of mid-2017, in Ukraine, there are 3620 owners of registered radiation sources using 23565 radiation sources including 8736 radioactive sources and 14829 installations generating radiation.

7.2 Radiation Protection of Personnel and Dosimetry Services

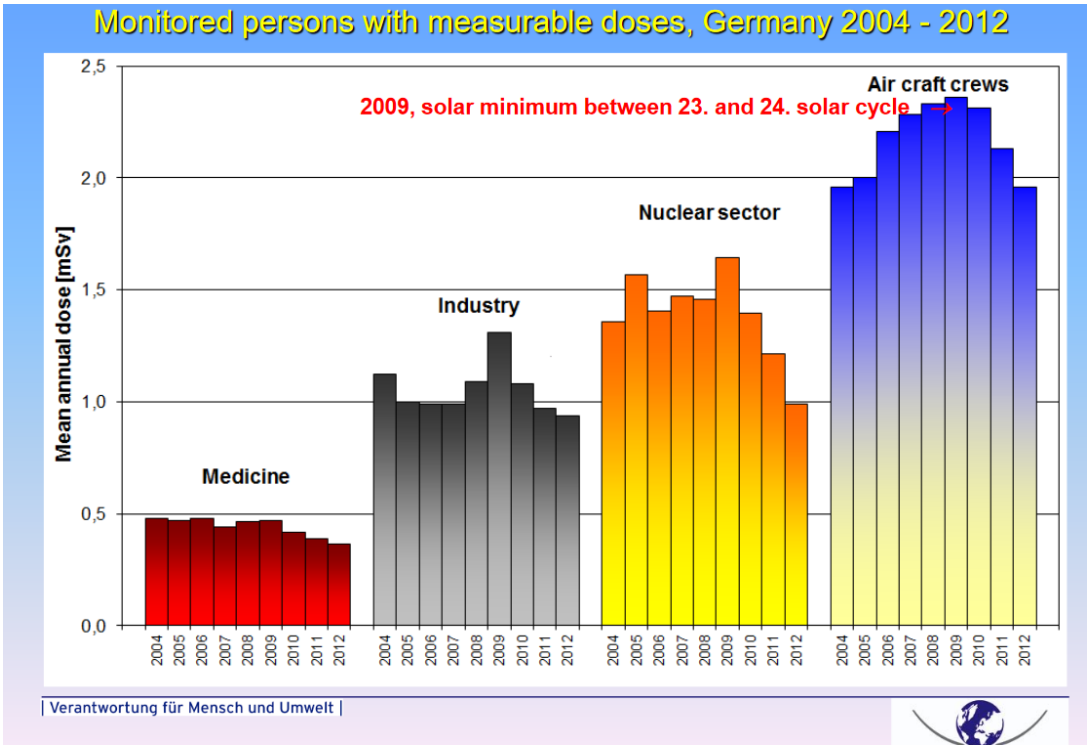
In Ukraine, the Law of Ukraine On Human Protection against Ionizing Radiation [12] and Radiation Safety Standards (1997) [118] establishes the basic principles of radiation protection: justification, limitation and optimization that fully complies with the international practice and the requirements of Directive [7]. However, meeting these principles is complicated by the need to control effective exposure dose of radiation, which in its turn requires developing special methodologies and using complex and expensive technical means (whole body counter, dosimeters for individual organs and types of radiation).

In other spheres of national economy where radiation sources are used, even implementation of the justification and limitation principles entails difficulties associated with the lack of appropriate methodological framework and monitoring means. In fact, external exposure dose of the entire body is monitored neglecting the exposure of individual organs and tissues. This situation is mainly caused by the lack of relevant branch regulatory documents that oblige the licensee to monitor effective exposure dose of personnel in accordance with its definition, i.e. considering all its components. When the internal component of exposure is meant, this mainly concerns personnel

of the uranium mining and processing industry, where effective dose component due to internal lung exposure is determinative. For personnel working with sealed radioactive sources (Fig. 7.3) or with hot cells, internal exposure contribution to the effective dose is not critical but exposure of the limbs and/or eye lens becomes critical.

Fig. 7.3 Industrial radioactive sources

In compliance with international safety standards for radiation protection and safety of radiation sources (GSR Part 3, paras 19 - 24 [116]), regulatory authorities are responsible for establishing and keeping national dose registers. Licensees are responsible for dose control, radiation monitoring of workplaces, making a list of persons subject to individual dosimetric control, storage of data on individual dosimetric control of personnel. TSOs should also be established, whose competence includes consulting, technical and methodological support of defining individual doses of occupational exposure.



National registers of occupational doses should also include registering exposure doses for personnel at plants with natural radionuclide content, exposure of aircraft crews, etc. At the same time, to determine individual exposure doses for such category of persons it is recommended to take into account not only professional occupation but also living conditions. International studies show (see Fig. 7.4) that occupational exposures doses of such workers may be 2-2.5 mSv/year [127].

It should be noted that appropriate regulatory control of occupational exposure in Ukraine is currently implemented only for personnel of nuclear sector and medical personnel, personnel of the economic sectors where material containing natural radionuclides is used and flight personnel remain beyond the regulatory control.

According to international and EU standards, an authorizing principle (licensing) and accreditation of laboratories in compliance with ISO/IEC 17025 “Basic Requirements for Testing and Calibration of Laboratories” [119] should be implemented in the country.

In Ukraine, the activities on implementing the international safety standards and European legislation to ensure control and registration of individual occupational exposure doses were initiated. For this purpose in 2015 – 2016, the following was developed and provided:

- draft Cabinet Resolution “On Establishing the State System for Accounting and Control of Occupational Doses” was developed;
- appropriate amendments to certain laws of Ukraine in nuclear energy use were made;
- information on measuring laboratories and first inter-calibration was collected and analyzed;
- action plan aimed at optimization of personnel doses, improvement of their working conditions by ensuring radiation protection was developed.
- It is planned that for dose registration and accounting, an adapted RAIS platform will be used to ensure the registration of radiation sources.

Thus, the register of individual exposure doses should apply to the control and registration of external and internal radiation doses, control of exposure doses for aircraft crews and workers at

plants with natural content of radionuclides. Another challenging issue is the certification of measuring laboratories and periodic external calibrations.

Therefore, the most priority area is related to extending the concept of occupational exposure for all segments of the workers at the legislative level, regardless of the sector of employment, but only from the current radiation impact at workplace. This may be implemented only after amending the legislative framework in Ukraine by introducing such a concept as the "existing exposure situation" in compliance with the international standards and EU Directives. This should be done by adapting the regulatory framework of Ukraine to the requirements of the EU legislation. According to the mentioned above, the following main challenges remain urgent:

- improve the national legislation by reviewing the Radiation Safety Standards of Ukraine on implementing such concepts as the situation of exposure (current, planned and emergency);
- develop Provisions on the Unified State System for the Accounting of Exposure Doses in Planned Exposure Situations;
- develop the national interface for the exchange of dosimetric information of the established quality between the producers (laboratory of individual dosimetric control), depositary (register) and licensees – users of data on individual doses.

7.3 Remediation of Legacy Sites and Radiation Sources, Including Uranium Mining and Processing Enterprises

The uranium mining industry in Ukraine exists for more than half a century. Uranium ore was mined for the first time in 1944-1946. As indicated in Section *Radiation Safety* of Report [2]: "In Ukraine, in terms of remediation measures, the most priority is the territory of former Prydniprovsk Chemical Plant (PChP) (Fig. 7.4), which is a legacy site from the former USSR. Para. 6.1 of this Report specifies hazards for the public working in the PChP territory due to its uncertain status.

Fig. 7.4 Prydniprovsk Chemical Plant

Tailing pits of the plant on the territory and near Kamyansky contain approximately 40 million tons of solid radioactive waste, as well as contaminated disassembled and buried structures of PChP: dismantled blast furnace, where uranium ore was molten, bunkers for uranium ore and contaminated railway tracks. For comparison, the mass of waste contained within the Chornobyl sarcophagus is approximately 2.5 million tons.

Analysis of the situation regarding remediation of orphan sites in the territory of former uranium mining and uranium processing enterprises shown that the problem is concentrated mainly in outdated regulatory framework for the whole uranium mining and uranium processing industry, as well as for legacy sites that are subject to the law on the extraction and processing of uranium ores.

The SNRIU defined that the priority measures to improve the situation in this area should include development of two high-level regulatory documents:

- Requirements for Administrative Control of Uranium Sites within Restricted Clearance from Regulatory Control [3].
- General Radiation Safety Provisions for Mining and/or Processing of Uranium Ore.

With NRPA support, under the Norwegian Regulatory Cooperation Program, these documents were developed under project code: URAN. Document [3] was officially put into force. The other document has been agreed in accordance with the established procedure and is under state registration in the Ministry of Justice of Ukraine. Interested parties (Ministry of Energy and Coal Industry, Ministry of Health, Ministry of Ecology and Natural Recourses) were involved into the process of mentioned regulations' development through providing of comments to the drafts of the documents. The same approach was realized for NRPA experts' involvement. All such comments were considered in details during the set of working meetings, and were reflected by SNRIU in the final versions of the documents.

Development of these documents is the first step in solving the issues related to deficiencies of the Ukrainian regulatory framework as regards remediation measures on the territory of legacy uranium facilities. The issues of regulatory framework deficiencies may be finally settled only after the revision of the Radiation Safety Standards of Ukraine [118] in accordance with the requirements of Directive 2013/59/Euratom [7].

7.4 Management of Naturally Occurring Radioactive Materials

As noted in the Report [2], exposure to naturally occurring radionuclides is not under SNRIU regulatory control and is subject only to the institutional control. The requirements themselves for limiting exposure to technologically enhanced naturally occurring sources are presented in the Radiation Safety Standards of Ukraine [118] and the Basic Health and Radiation Safety Rules [120].

Sometimes radiation risks related to exposure to naturally occurring radionuclides are quite significant. For example, during the survey of the radiation situation in villages and cities of the Zhytomyr region in the summer of 2017, SSTC NRS experts revealed a place with an increased dose rate (up to 5 μSv/h) in Novohrad-Volynsky around a well with drinking water near a kindergarten (Fig. 7.5). Spectrometric studies of soil samples taken around the well showed that the main dose forming were naturally occurring radium isotopes and thorium radionuclides. Investigations are under way on this fact. It may be assumed that a pulp pumped from the deep ground layer during maintenance of the well was a carrier of radioactivity around the well.

Fig. 7.5 Drinking water well near a kindergarten with a dose rate of 5 μSv/h on the ground

In view of the abovementioned, it may be stated that the exposure to naturally occurring radionuclides may pose a hazard for the public and requires the SNRIU to:

- perform in-depth analysis of radiation risks at the enterprises, which in their activities face higher levels of naturally occurring radiation to identify relevant occupational and social risks;

- determine jointly with the Ministry of Health of Ukraine the signs and criteria by which radiation from naturally occurring sources belong to planned exposure situations or existing exposure situations;
- develop general safety provisions for the activities with naturally occurring sources in both planned and existing exposure situations.

In term of reducing the risks of exposure associated with radon, it may be stated that the measures presented in the Report [2] remain relevant for today. Namely, the development of the state program, within which the following areas would be implemented:

- amend the Ukrainian legislation including the Radiation Safety Standards [118] and other departmental regulatory documents on radon exposure rules at workplaces and in residential building;
- develop a procedure for monitoring of compliance with these rules;
- establish a radon measuring center (control of workplaces and residential buildings);
- form a state database on radon activity in houses and at workplaces;
- develop a system to take radon prevention measures and construction standards for their implementation.

The main components of these plans are to:

- review the legislation and implement the international standards and European legislation on radiation exposure control;
- perform measurements and draw up radon maps to determine territories with the highest radon concentrations. For example, in Ukraine, such areas may include the territories adjacent to uranium facilities, iron ore and coal mines, etc.
- enhance technical capabilities of the country in measuring radon concentrations, improving methodologies for such measurements, implementing corrective measures, etc.;
- improve skills of radon experts, laboratories, informing the public, implement appropriate training programs.

The regulation of exposure to naturally occurring sources is aimed first of all at optimizing exposure and radiation monitoring, rather than implementing regulatory control over these facilities.

The above measures will allow implementing the mechanisms to monitor radon exposure levels at workplaces and residential premises, in particular: measurement of radon concentrations in premises and workplaces, drawing up appropriate maps, taking compensatory measures aimed at reducing radon concentrations, keeping relevant cadasters of the places with the highest radon concentrations.

In Ukraine, radon concentrations were measured in 2011-2012 in the Kirovohrad region under the Stop-Radon Program in the framework of the Swedish-Ukrainian cooperation project ‘Reduction of Risks Caused by Exposure to Radon Gas and Natural Radiation’ funded by the Swedish International Development Agency (SIDA). Within the Stop-Radon Program, radon concentrations were measured in more than 1000 children institutions and schools, and corrective measures were taken in certain institutions. Due to the lack of financing, cancellation of the building standards, as well as destruction of the monitoring system, this program was stopped.

It should be noted that radon exposure control is a specific area for state regulation in all countries. If for all other regulatory areas, tools such as rule-making, licensing and oversight are mandatory, in this area the regulatory authority may apply rule-making and oversight.

All functions of the interested ministries and departments, radon laboratories, local executive authorities, uranium enterprises, coal and iron ore mines should be aimed at reducing radon concentrations to the relevant reference levels established by the legislation.

Further areas of the rule-making activities after adopting the Law of Ukraine On Amending Some Laws of Ukraine on Nuclear and Radiation Safety' are to develop a national action plan for radon. In development of the document, all competent ministries and departments: Ministry of Health of Ukraine, Ministry of Ecology and Natural Resources of Ukraine, Ministry of Regional Development of Ukraine, Ministry of Education and Science of Ukraine, National Academy of Sciences of Ukraine, etc. should be involved. After that, in the next step will be to ensure that all measures of this Plan are implemented (see Section 8).

8 Main identified threats and proposals for their elimination

This Section contains a list of threats and challenges that currently exist and negatively affect activities of the SNRIU as a central executive body for state regulation of nuclear and radiation safety. For each threat, the Section further provides:

- brief description with references to previous sections of this Report with detailed information on the threat;
- risks caused by the threat;
- ways for elimination or minimization of the threat;
- priority of measures to be taken to eliminate the threat.

Challenges and threats were identified in all analysis areas as follows:

1. Organization and general principles for activities of the regulatory authority (including physical protection)
2. Safety of nuclear installations
3. Radioactive material transport
4. Emergency preparedness and response
5. Radioactive waste management and decommissioning
6. Radiation safety.

A number of threats presented below were identified in the Report [2]. For these threats, the Section provides information on current efforts for their elimination made by the SNRIU and SSTC NRS with their own resources and (or) through international assistance. For the other threats and challenges, which are new compared to the Report [2], the Section outlines prospects for their elimination using internal resources and international assistance.

8.1 Organization and General Principles for Activities of the Regulatory Authority

8.1.1 SNRIU independence

In the deregulation of the economic activity that has been underway in Ukraine in the last years, amendments to various laws of Ukraine were made. These amendments to some extent are related to state regulation of safety in nuclear energy (for more detail, see para. 2.2 of this Report). This threat was identified in the Report [2] and still remains relevant and even more urgent. The SNRIU acts in compliance with the Plan for Implementation of Council Directive 2014/87/Euratom [9] to eliminate this threat. In spite of the SNRIU's efforts and support of the European Commission and other partners of international cooperation (EBRD, IAEA, G-7) towards full independence of the regulatory authority, this issue remains unsolved.

This threat causes the risk of losing the economic, political and financial independence of the regulatory authority in fulfilling its functions and competence fully in line with national regulations in the area of nuclear energy and international agreements. To overcome this threat, further multifaceted international assistance is needed. Elimination of this threat has the highest priority.

8.1.2 Need for extension and improvement of the regulatory framework for nuclear security

Activities of the SNRIU as a competent body under the State Physical Protection System are mainly aimed at maintaining the physical protection regime as one of the most important components of the nuclear security regime. Current regulatory documents of Ukraine on the physical protection in general comply with up-to-date approaches to safety regulation (see para. 2.3 of this Report). At the same time, in order to further expand and improve the regulatory framework for the security of nuclear installations, nuclear materials, radioactive waste and other radiation sources and apply a systematic approach to ensuring nuclear safety, it is advisable to study in detail the Euratom's nuclear safety and nuclear security regulations, as well as the IAEA standards on the main components and establishment of the nuclear security regime. The scope of such analysis should at least cover documents [32] - [43]. Based on comprehensive study of the above documents and comparison of their provisions with the relevant regulatory framework in Ukraine, it will be required to determine a list of national regulatory documents on specific issues of physical protection and nuclear security requiring revision or development and justify the priority of individual actions in this area. This new task of highest priority is aimed at strengthening the national legislative and regulatory framework by establishing the main components of nuclear security and identifying areas of further activities to govern this issue in Ukraine.

8.1.3 Need for support of the SNRIU in harmonization of national regulatory requirements on nuclear and radiation safety with WENRA reference levels

Harmonization of national regulatory requirements on nuclear and radiation safety with the WENRA reference levels is one of the SNRIU's activities of highest priority (see para. 2.3.4 of the Report), in which the SNRIU and SSTC NRS employ their own resources. The main source of international assistance for the SNRIU over the next years in this area is the INSC Project [48] Component "Strengthening and alignment of Ukrainian nuclear safety regulations in line with the EU experience, best practice and Euratom acquis". To eliminate this threat (which is new as compared to the Report [2]), the Ukrainian regulatory framework will be strengthened within the above component in implementation of EC Directives and WENRA reference levels through assistance in the improvement/development of new national requirements based on experience in the WENRA topical peer review and activity of WENRA working groups.

8.2 Safety of Nuclear Installations

8.2.1 Need for support of licensing process and safety assessment for implementation of C(I)SIP measures

In NPP operation, there is a need to implement safety improvement measures to incorporate lessons from operating experience, results of periodic safety review and (or) requirements of the regulatory authority to bring the level of NPP safety into compliance with current requirements. Any modification important for nuclear installation safety can be implemented by the operator only upon agreement with the SNRIU. As pointed out in para. 3.2.1 of this Report, safety improvement measures are implemented at Ukrainian NPPs under C(I)SIP [13] agreed with the SNRIU according to the procedure established in [50]. After the Fukushima-Daiichi accident, the Program [13] was extended with additional measures upon extraordinary in-depth safety reassessment for Ukrainian NPPs (stress tests). Technical assessment of C(I)SIP measures and licensing of modifications at NPP systems important to safety are conducted by the SNRIU employing its own resources with involvement of SSTC NRS. The challenges associated with the need to strengthen respective SNRIU capabilities (which are new as compared to Report [2]) are dealt with through international assistance, primarily the US NRC and European Commission (see Section 9). Involvement of this

assistance is also planned for the near future. Hence, there is a number of components under the new INSC Project [48]:

- assistance to SNRIU in enhancing and ensuring robustness of models for severe accident analysis based on EU up-to-date experience and Fukushima-Daiichi lessons,
- strengthening of Ukrainian nuclear safety regulatory capabilities in the external hazard assessment area,
- assessment of licensing and other operator activities,

which are aimed at dealing with the identified challenges of the highest priority.

8.2.2 Need for effective support of the oversight function using operating experience for Ukrainian NPPs

Operating experience is a reliable source of input data to reveal deficiencies that directly affect safety. The full use of this data source allows effective oversight of compliance with standards and rules on nuclear and radiation safety. In addition this is a source to render a probabilistic safety assessment more reliable. Since 2014, the SNRIU and SSTC NRS carry out the operating experience analysis of NPPs in Ukraine and in the world using their own resources (see para. 3.2.3 of the Report) because of the lack of funding from state budget. To overcome challenges in oversight activities using operating experience for Ukrainian NPPs is one of the SNRIU's tasks of highest priority, which involves international assistance. The SNRIU capabilities are strengthened and developed in this area under completed and ongoing INSC Projects [122] and [123]. Further successful elimination of respective challenges (which are not new, see Report [2]) will be possible with assistance of the European Commission (Component 'Enhancement of the national regulatory framework and relevant regulatory capabilities in the frames of operational experience feedback system' of the INSC Project [48]) and NRPA (recently started project EXPERIENCE).

8.2.3 Need for unified regulatory requirements for NPP emergency documentation

Energoatom NPPs develop and introduce emergency procedures and guidelines for each operating nuclear power unit (see para. 3.2.3 of the Report). In recent years, the scope of the emergency documents significantly extended. Emergency operating procedures for shutdown states, emergency operating procedures for the spent fuel pool, and severe accident management guidelines for rated power and for low power and shutdown states were implemented. State nuclear and radiation safety review of emergency documentation packages for Ukrainian NPPs, which is conducted by the SNRIU with SSTC NRS technical support, revealed the need to develop general regulatory requirements for NPP emergency documentations, including its elaboration, agreement, updating and application. This threat is not new and was addressed in detail in the Report [2]. Project GUIDELINE, which started this year under NRPA financial and expert support, is intended to eliminate this threat by development of regulatory requirements for the structure and contents of emergency documentation.

8.2.4 Need for improvement of the existing regulatory framework governing operation of research reactors

According to the Report [2], this threat, caused by the inadequate regulatory framework that governs individual operational aspects of research reactors, is of highest priority. This threat is currently planned to be eliminated (see para. 3.2.5 of the Report) through assistance to be provided by the SNRIU under the Component "Strengthening of SNRIU capabilities in licensing of new nuclear installations (except NPPs)" of Project INSC [48] (to be started this year, with NRPA participation) in the development of national requirements for periodic safety review of research reactors and investigation and accounting of operational events that occur at them.

8.2.5 Need for support of the SNRIU in licensing and safety assessment for construction and commissioning of new nuclear installations

In licensing and safety assessment of the construction and commissioning of the neutron source subcritical facility (new type of nuclear installation in Ukraine), the SNRIU faces threats associated with the technical complexity and unique design features of the facility and lack of experience in licensing of accelerator-driven systems and lack of regulatory framework for subcritical systems (see para. 3.4.2 of the Report). This threat, which is of highest priority and is new compared to Report [2], is resolved by the SNRIU and SSTC NRS with involvement of international assistance. In particular, state regulatory review of the neutron source safety case is carried out under support of the Argonne National Laboratory, USA. In the framework of INSC Projects [61] (started in 2015) and [48] (Component A, to be started this year), it is envisaged to use international experience in licensing and commissioning of subcritical systems, improve the existing regulatory framework (in particular, revise NP 306.2.183-2012 [124]) and develop computer models of neutron source components for performance of verifying calculations by the SNRIU and SSTC NRS within state review of the neutron source safety case to minimize further negative impact of this threat.

8.3 Radioactive Material Transport

8.3.1 Need for improvement of legislation for regulation of nuclear and radiation safety in radioactive material transport in compliance with IAEA standards

The first step in eliminating this threat of highest priority identified in Report [2] (see also Section 4 of the Report) is revision of the 'Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials' (PBPRM-2006) [18] to bring them into compliance with the IAEA Standard [80]. The activity is successfully ongoing with NRPA support under Project TRANSPORT. At the same time, the Report [2] identified additional areas and scopes of this activity (see below) to eliminate the threat.

8.3.2 Need for improvement of the regulatory framework for compliance with rules for radioactive material transport

Based on the IAEA IRRS mission [81], the SNRIU was provided with recommendations in the area of radioactive material transport, including suggestions on the need to develop a number of regulations of various levels to establish requirements for compliance with rules for safe transport of radioactive materials taking into account IAEA Standard [82] and Rules [18].

(See report [81]: 'S22 Suggestion: The SNRCU should develop a guide (regulation) taking into account the IAEA Safety Guide 'Compliance Assurance for the Safe Transport of Radioactive Material', No. TS-G-1.5').

These document(s) shall cover and regulate the following aspects:

- requirements for safety analysis of package design;
- procedure for issuing certificates for safe transport of radioactive materials;
- procedure for inspection of the licensee's management systems;
- procedure and scope for inspection of transport documentation and transport operations, manufacture of packaging, maintenance and repair of packaging.

The development of these document(s) is a priority task for the SNRIU and its beginning does not depend directly on the implementation and completion of Project TRANSPORT.

8.3.3 Need for improvement of the regulatory framework for management systems for radioactive material transport

Another recommendation of the IAEA IRRS mission [81] in the area of radioactive material transport included development of a regulation on management system for activities in radioactive material transport: "S21 Suggestion: The SNRCU should develop a guide on quality management systems for the safe transport of radioactive material taking into account the latest advice of the international organizations including the IAEA".

This document is to be developed in compliance with the IAEA Standard "Management System for the Safe Transport of Radioactive Material", IAEA Safety Standards Series No. TS-G-1.4 [83]. Also, the document should be developed on the basis of the agreed first version of Rules [18], which is currently revised under Project TRANSPORT.

8.4 Emergency Preparedness and Response

Status of the threats identified in 2015 Ukrainian Regulatory Threat Assessment Report

The Report [2] identified a series of threats and challenges of various degrees in the area of emergency preparedness and response (which are also mentioned in Section 5 of this Report). The status with elimination of these threats is described below.

8.4.1 Vulnerability of existing IEC in terms of 24-hour communication under the Conventions and access to its information resources

Improvement of the SNRIU emergency response system through creation of a backup IEC was recommended by the NATO Advisory Support Team mission in 2014.

Proposals to establish a backup IEC on SSTC NRS premises were provided in the technical proposal package for the project "Inclusion of the Ukrainian Nuclear Security System into the Global Nuclear Security", which is implemented in Ukraine by the Defense Threat Reduction Agency of the US Department of Defense from 2015 to 2019 under the Global Nuclear Security Program.

After preliminary discussions, proposals on creation of a backup IEC within the current collaborative project of SNRIU and Threat Reduction Agency of the US Department of Defense were postponed indefinitely due to the budget constraints of the Global Nuclear Security Program. However, SNRIU continues to seek funding sources and accumulate technical ideas and solutions to be used in the backup IEC design. This threat remains relevant.

8.4.2 Lack of proper conditions for using the RanidSONNI mobile radiological laboratory as an instrument for independent radiation assessment of the environment for emergency response purposes

The RanidSONNI mobile laboratory is used by SNRIU and its territorial bodies for prompt response to radiation accidents and other events that are of public concern. The conditions in which the laboratory is currently kept and maintained do not ensure its effective use and required preparedness for emergency response.

This issue remains relevant and can be solved by equipping rented or constructed premises for permanent placement, maintenance and proper protection of the RanidSONNI mobile laboratory, as well as creating conditions for a laboratory base of stationary measurements.

Discussions on potential funding sources under international projects, budget funds, etc. are ongoing.

8.4.3 Review and approval of new standard provisions on functional and territorial USCPS subsystem, as well as provisions on notification about a threat or emergencies and communication in the area of civil protection

This threat is in the stage of elimination.

The new revision of standard provisions on functional and territorial USCPS subsystems was approved by Cabinet Resolution No. 101 on 11 March 2015. Revision of a series of regulations in the area of emergency preparedness and response will be initiated upon completion of Project PREPAREDNESS, which is aimed at harmonizing the current Radiation Emergency Response Plan [92] with requirements of international standards.

8.4.4 Recommendations of the NATO Advisory Support Group mission of 2014 to determine the role of RODOS center in the state emergency response system

Cabinet Resolution No. 44-r dated 25 January 2012 approved the Action Plan for development of the Unified Automated Radiation Monitoring System (UARMS) until 2015. The Action Plan provided for development of the UARMS concept, preparation of provisions on UARMS and their approval by a Cabinet Resolution, elaboration of statement of work for UARMS creation, implementation of UARMS technical design and actual operation of UARMS. An interdepartmental meeting was held in August 2012 to present two alternative options for the UARMS concept, but none was accepted as the final one.

Because of the lack of budget funding, efforts to create UARMS were suspended in 2012. Since that time, some administrative reforms and redistribution of roles and responsibilities of the executive power bodies took place in Ukraine. Due to that as well as due to the current political and social-economic situation, the issue of creation of the UARMS lost its priority for the moment. When efforts are renewed, it will be possible to determine the role of RODOS center in the state emergency response system in the UARMS concept. The issue remains relevant.

8.4.5 Improvement of the emergency preparedness and response system for harmonization with IAEA standards, WENRA reference levels, new EU/Euratom Directives and HERCA initiatives to ensure consistency of national procedures for response to remote nuclear or radiological situations

Improvement of the Ukrainian emergency preparedness and response system for harmonization with IAEA standards, WENRA reference levels and new EU/Euratom Directives will be facilitated by efforts under Project PREPAREDNESS, started by NRPA and SNRIU in summer 2017.

Upon completion of Project PREPAREDNESS, revision of a number of regulations on emergency preparedness and response will be initiated.

Implementation of the HERCA-WENRA approaches in Ukraine is included into the SNRIU proposals for INSC Action Program for 2018 [59].

New identified threats/ challenges

This Report identified a number of challenges in the area of emergency preparedness and response that are new compared to the Report [2]. These challenges are listed below (see also Section 5 of the Report).

8.4.6 Lack of administrative procedures for operation of the central station for monitoring of engineered features of physical protection systems for facilities using radiation sources and radioactive waste management facilities

Operation of the central station for monitoring of engineered features of physical protection systems for facilities using radiation sources and radioactive waste management facilities needs to be supported, including provision of material and technical resources, staffing, and testing of procedures for interaction of the SNRIU with law enforcement agencies, whose competences cover response to diversions. This task is of highest priority for the SNRIU (see also para 5.2.4 of this Report).

The general legal framework for operating, maintaining and regulating the central station consists of the Law [25] and subordinated regulatory acts – resolutions of the Cabinet of Ministers of Ukraine No. 1337 on State Physical Protection System of 21 December 2011 and that on State Contingency Plan No.598 of 24 July 2013. These resolutions establish requirements for information exchange, define subjects of the system and enable the duty and operative services in twenty-four-hour regime in specified communication links both in normal and crisis situations. Based on these acts, an order on functioning of central monitoring station should be developed. This document should cover and regulate the following aspects:

- tasks and functions of central station, its place in unified system of communication;
- financial, material and staff provision;

- procedures of interaction and information sharing with subjects of State Physical Protection System in normal, emergency and crisis situations.

In case, when a regulatory act for central station is not developed, there will be a threat of its illegal, unacknowledged and idle operation and may result in a loss of valuable element of physical protection regime (this is also important for emergency preparedness and response).

8.4.7 Events in the area of nuclear and radiation safety that are of public concern but do not relate to NPPs are not currently assessed in Ukraine using INES

The issue is solved by developing a regulatory framework for application of INES in Ukraine to classify all events defined in the INES User Manual 2008 Edition. The development of a special regulation(s) or revision of current documents to introduce provisions on obligations and mechanisms for full-scope application of INES may be initiated following expert and public consultations and considering international experience.

8.4.8 Emergency exercises of state level under USCPS are not conducted on a regular basis

According to the current regulatory framework, emergency exercises of state level under USCPS shall be conducted not less than every five years. Because of complex economic and sociopolitical situation in Ukraine, the last two exercises of national level were conducted with an interval of 15 years: command staff exercises to prepare for Ukrainian–French Oranta-2012 radiological accident response training and Ukrainian–US command staff training on radiation protection in 2017.

The frequency of emergency exercises shall correspond to changes in the legislative and regulatory framework on emergency preparedness and in the structure of central executive bodies resulting from administrative reform. Elimination of this issue is of highest priority to the SNRIU.

8.5 Radioactive Waste Management and Decommissioning

Status with elimination of the threats identified in Report [2]

The Report [2] identified general threats in safety regulation of radioactive waste management and decommissioning. The status with elimination of these threats is described below.

8.5.1 Lack of a comprehensive approach to ensure safety of radwaste management taking into account consistency of individual radwaste management stages up to final disposal. Lack of clear and unambiguous criteria for radwaste sorting in situ taking into account waste classification in accordance with acceptable disposal concept and specific requirements and rules for radwaste management stages

This threat was eliminated by establishing a comprehensive approach to safe radioactive waste management. With NRPA support (Project code: WASTE), the SNRIU and SSTC NRS developed two high-level regulations:

- NP 306.4.213-2017. General Safety Provisions for Predisposal Management of Radioactive Waste [5], which has been put in force according to the established procedure;
- General Safety Provisions for Disposal of Radioactive Waste (document is in the stage of 'external' agreement with relevant executive bodies).

These high-level documents need to be further used as a basis for revision and (or) development of new regulations to establish specific requirements and rules for individual stages of radwaste management and/or specific types of radioactive waste. Section 6 of this Report addresses respective first-priority threats (see also paras.8.5.2, 8.5.3 below).

8.5.2 Lack of regulatory requirements for remediation of interim radwaste confinement sites in the exclusion zone and legacy waste disposal facilities on 'Radon' site taking into account modern approaches to regulation of existing exposure situations determined in IAEA Standard [116]

This threat has been eliminated. The following regulatory documents were developed with financial support of the European Commission [97] involving leading European experts:

- Guideline for Safety Assessment of Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone;
- Guideline for Safety Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities.

These documents have already been used by the industrial side to develop safety assessments and by the regulatory side to conduct reviews and make appropriate decisions (for more detail, see Section **Feil! Fant ikke referansekilden.** of the Report).

8.5.3 Lack of systemized requirements for safety assessment and safety justification of radwaste management facilities and activities. Improvement of regulatory requirements for development of safety justifications

To eliminate this threat, the following regulatory documents are under development as of autumn 2017 with support of the European Commission [93] and involvement of leading European experts:

- Guideline with requirements for the structure and contents of the safety analysis report for radioactive waste treatment facilities;
- Guideline with requirements for the structure and contents of the safety analysis report for radioactive waste disposal facilities.

After completion and implementation of these documents (to be done over the next year), this threat can be considered to be eliminated.

8.5.4 Lack of specific safety requirements for nuclear installations in decommissioning, including safety requirements for nuclear installations after complete removal of nuclear fuel, requirements for management system for decommissioning, particularly taking into account long duration of the decommissioning process, requirements for safety assessment and justification of nuclear installation decommissioning, and structure and contents of licensing documents

To eliminate this threat, the following regulations are under development with NRPA support (Project code: DECOMMISSIONING):

- General Safety Provisions for Decommissioning of Nuclear Facilities;
- Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities.

After completion and implementation of these documents (to be done at the end of 2018), this threat can be considered to be eliminated.

In continuation of the analysis carried out in [2], Section 6 of this Report considers individual issues of safety regulation in radioactive waste management and decommissioning:

8.5.5 Management of accident-origin waste in the new safe confinement over the Shelter of the destroyed ChNPP unit 4

There is a lack of regulatory framework to govern safe operation of NSC, including a lack of requirements for support of the Shelter in safe state in storage and transformation under NSC, safety of personnel activities, etc. This threat needs to be solved in 2018–2019.

It is required to use NP 306.4.213-2017 'General Safety Provisions for Predisposal Management of Radioactive Waste' [5] as a basis to develop a regulation to establish specific safety requirements and rules for NSC (including the Shelter). Elimination of this threat is of the highest priority.

8.5.6 Management of disused sealed radiation sources declared as radioactive waste

There is a lack of regulatory framework to govern safe management of (DSRS) declared as radioactive waste, including criteria for acceptance of DSRS for processing, characterization and sorting with the purpose of further storage/disposal, management of damaged and unidentified

DSRS, reliable control and accounting of DSRS flows, requirements for DSRS packages and their monitoring in long-term storage, coordination and data exchange between DSRS suppliers and storage/disposal facility operator, etc. Elimination of this threat is of highest priority.

It is required to use NP 306.4.213-2017 'General Safety Provisions for Predisposal Management of Radioactive Waste' [5] as a basis for developing a regulation to establish specific safety requirements and rules for management of DSRS declared as radioactive waste. Elimination of this threat is of the highest priority.

8.5.7 Release of radioactive materials from regulatory control

There is a lack of regulatory framework to govern release of radioactive materials from regulatory control including radioactive material release criteria derived from dose criteria, requirements for preparation of radioactive material batches, procedure for measurement of their characteristics, requirements for responsibilities of different entities involved in radioactive material release, arrangement and quality assurance of this activity, special requirements for procedure of radioactive material release from regulatory control in the Chornobyl exclusion zone, and requirements for procedure of inspection and making regulatory decisions on radioactive material release. It is needed to develop a new regulation instead of current NP 306.4.159-2010 'Procedure for Release of Radioactive Materials from Regulatory Control in the Framework of Practices' [101]. Elimination of this threat is of the highest priority.

8.6 Radiation Safety

The Report [2] identified threats in the area of radiation safety that are described below. The status with elimination of these threats is presented and, in a number of cases, additional measures are identified to allow complete elimination of specific threats.

8.6.1 Lack of a regulatory document with modern safety requirements for management of radiation sources in compliance with basic international safety requirements in new EU/Euratom Directives and IAEA documents

In the framework of cooperation between the SNRIU and NRPA (Project code: SOURCE), development of the 'Basic Safety Requirements for the Use of Radiation Sources' was started to implement basic provisions of the new IAEA Standard (GSR Part 3) [116] and EC Directive [7] into the regulatory activity. Successful completion of Project SOURCE will allow eliminating this threat.

8.6.2 Lack of a national system for accounting and control of personnel exposure doses

In 2015-2017, legislation in the area of metrology, occupational safety, etc. was amended. In addition, new central executive bodies that perform specific functions on radiation safety were established. However, development of the national system for accounting and control of personnel exposure doses has not been started. The threat remains in place.

The elimination of this threat requires first-priority measures, such as development of:

- amendments to legislation, particularly to the Law of Ukraine On Human Protection against Ionizing Radiation;
- Cabinet Resolution On Procedure for Accounting and Control of Occupational Exposure;
- methodological recommendations on individual monitoring of occupational exposure;
- requirements for software of the dose register database and its support.

Elimination of this threat is of the highest priority.

8.6.3 Lack of a comprehensive approach to ensuring radiation protection for medical exposure and harmonization with Directive 2013/59/Euratom of 5 December 2013

In the framework of cooperation between the SNRIU and NRPA (Project code: MEDICINE), 'General Safety Rules for Medical Radiation Sources' [4] and 'Radiation Safety Rules of Using Radiation

Sources in Brachytherapy' [6] were developed and implemented in 2015-2017. The development of these high-level regulations is the first step in dealing with this threat.

The next step will be to eliminate the lack of regulatory framework on medical radiation sources, particularly employing new nuclear technologies associated with the production of radiopharmaceuticals to be used for therapy and diagnostics. It is required to use the 'General Safety Rules for Medical Radiation Sources' [4] to develop:

- Rules for safe use of radiation sources in nuclear medicine and
- Rules on radiation safety in diagnostic radiology.
- Considering the regulation 'General Safety Rules for Medical Radiation Sources' [4], the following current regulations shall also be revised:
- Safety Requirements and Conditions (Licensing Terms) for Use of Radiation Sources in Radiation Therapy [128]
- Requirements for Quality Management System for Diagnostic and Therapeutic Procedures Using Radiation Sources [129]
- Radiation Safety Rules for Electron Accelerators [130].

Elimination of this threat is of the highest priority.

8.6.4 Need to improve legislation in the field of state registration of radiation sources

Development of a Cabinet Resolution to amend some Cabinet Resolutions on state registration of radiation sources established by the Procedure for Sate Accounting and Control of Radiation Sources.

Regarding support of software for the State Register of Radiation Sources, the SNRIU cooperates with the Swedish Radiation Safety Authority (SSM). This software is planned to be upgraded in future with transfer to the new version of the RAIS platform developed by the SNRIU.

There is a lack of regulatory framework for registration of radiation sources. The current Procedure for Registration of Radiation Sources needs to be revised to consider operating experience and revealed issues and deficiencies, taking into account lessons learnt and new international standards, and to improve the effectiveness of the Sate Register of Radiation Sources. It is required to develop and approve a Cabinet Resolution on Procedure for State Registration of Radiation Sources.

Elimination of this threat is of the highest priority.

8.6.5 Lack of current radiation safety requirements for remediation of uranium legacy sites, including uranium mining and processing enterprises

The SNRIU determined that development of two high-level regulations was the first-priority measure to improve the situation in this area:

- Requirements for Administrative Control of Uranium Sites within Restricted Clearance from Regulatory Control [3]
- General Radiation Safety Provisions for Mining and/or Processing of Uranium Ore.

With NRPA support, these documents were developed under Project URAN Document [3] was officially put into force. The other document has been agreed according to the established procedure and is currently under state registration at the Ministry of Justice of Ukraine. The development of these regulations is the first step in dealing with issues associated with deficiencies of the Ukrainian regulatory framework relating to remediation measures on the territory of former uranium plants. The issues associated with deficiencies of the regulatory framework can be finally solved only after revision of the Radiation Safety Standards of Ukraine [118] according to Directive 2013/59/Euratom [7].

8.6.6 Lack of a regulatory system for radiation safety and radiation protection of personnel and the public at enterprises managing naturally occurring radioactive material (NORM)

The issues associated with deficiencies of the regulatory framework can be finally solved only after revision of the Radiation Safety Standards of Ukraine [118] according to Directive 2013/59/Euratom [7]. This activity is supposed to be implemented by the Ministry of Health (MoH) with close involving of other authorities, including SNRIU. The issue regarding necessity to revise the regulation [118] has been raised and discussed in details several times during the meetings with MoH representatives which were arranged under NRPA and SNRIU cooperation.

Legislation shall be primarily amended to legalize the definitions of the existing and planned exposure situations. Therefore, it is necessary to develop a regulation Radiation Safety Rules of Personnel and the Public at Enterprises Managing Naturally Occurring Radioactive Material (NORM).

8.6.7 Need to support the state policy to limit the public exposure to radon

Legislation in this area needs to be improved, and a national action plan to identify the problems and decrease radon exposure where is needed as envisaged by international safety standards [116] and Directive 2013/59/Euratom [7] shall be developed and implemented. According to these international safety standards, one of the regulatory authority's functions is to coordinate activities of ministries and departments, inform the public of potential indoor radon exposure and associated health risks, coordinate actions on development and implementation of a national action plan to decrease radon concentration in living and operating rooms, etc. The national plan to decrease radon exposure shall include aspects such as:

- need for a system to ensure quality of radon monitoring in air of residential houses and at workplaces;
- development of databases on radon activity in houses and at workplaces.

8.6.8 Need to improve legislation governing nuclear and radiation safety in compliance with new basic IAEA standards and EU/Euratom Directives

Substantial efforts have been made in the last years to improve legislation for regulation of nuclear and radiation safety in compliance with new basic IAEA standards and EC/Euratom Directives, which is mentioned in the previous sections of this Report. Amendments were developed to the main Laws in nuclear and radiation safety, a set of regulatory and legal acts have been developed and put into force. However, there are areas identified in the Provisions of the Council Directive 2013/59/Euratom [7], which are not in any way governed by the Ukrainian legislation. Such problem issues which fall under the jurisdiction of the SNRIU are as follows:

- develop criteria for recognition of and provisions for a radiation protection officer in accordance with new EU legislation and IAEA standards;
- develop safety standards for radiation sources used for inspection purposes for non-medical imaging (Radiation Sources Used for Inspection Purposes and for Non-Medical Imaging [113]).

It should be noted that the measures under the 'Implementation Plan for Council Directive 2013/59/Euratom'[7] are being revised now. The measures which fall under the SNRIU's responsibility, include the following: development of a provision on an expert in radiation protection and its approval by the Cabinet of Ministers of Ukraine.

9 Overview and status of international projects and efforts to eliminate regulatory threats identified in 2015 Ukrainian Threat Assessment Report

This Section overviews the existing international projects that are underway as of autumn 2017 or planned until 2020 and are aimed at eliminating or minimizing the regulatory threats and challenges identified in the previous sections of this Report.

9.1 Cooperation between SNRIU and NRPA

Cooperation was started at the end of 2014 by signing the Agreement [1] and further development of the Roadmap. Since that time, the SNRIU and SSTC NRS have carried out a number of projects with NRPA financial and expert support, and several projects are currently ongoing. The chronology of the projects is shown in Fig. 9.1 and information on their technical content is provided further.

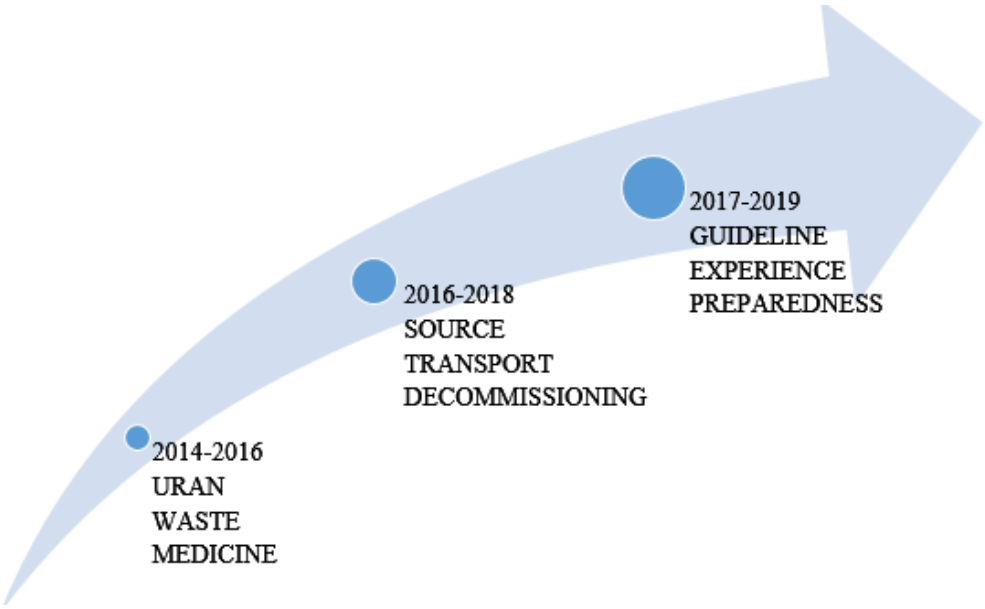


Fig. 9.1 Timeframe for implementation of Roadmap projects

9.1.1 Projects URAN, WASTE, MEDICINE

Projects were aimed at improvement and development of the national regulatory framework in individual areas as follows:

- Project URAN: Support of the SNRIU in amendment of Ukrainian regulatory documents on radiation protection in uranium industry in accordance with IAEA safety standards and Council Directive 2013/59/EURATOM. The project is aimed at eliminating the threats identified in Report [2] (for threat elimination status, see Sections 7 and 8.6). The project objective is to improve the regulatory framework on nuclear and radiation safety in uranium industry. Two high-level regulations have been developed in the project:
    - Requirements for Administrative Control of Uranium Sites within Restricted Clearance from Regulatory Control [3], which establish procedure for planning, conduct, revision and termination of administrative control of uranium sites, which are under restrictive clearance from regulatory control after termination of their activities by shutdown or decommissioning.

- General Radiation Safety Provisions for Mining and/or Processing of Uranium Ore, which establish safety rules for uranium ore mining and processing and for termination of these activities by design, siting, construction, upgrading, operation, decommissioning and partial closure of uranium mining and processing plants.

Document [3] was officially put into force. The other document has been agreed according to the established procedure and is currently under state registration at the Ministry of Justice of Ukraine.

- Project WASTE: Development of general safety provisions for radioactive waste management in Ukraine. The project is aimed at eliminating the threats identified in Report [2] (for threat elimination status, see Sections 6 and 8.5). The project objective is to improve the regulatory framework on nuclear and radiation safety in radioactive waste management. Two high-level regulations have been developed in the project:
  - General Safety Provisions for Predisposal Management of Radioactive Waste [5], which establish safety criteria and general requirements for nuclear and radiation safety at all stages that precede radioactive waste disposal.
  - General Safety Provisions for Disposal of Radioactive Waste, which establish general requirements for nuclear and radiation safety in radioactive waste disposal to protect personnel, the public and the environment against potential radiation impact in operation of disposal facilities and in long-term post-closure period.

  Document [5] was officially put into force. The other document is under external agreement at relevant executive bodies.
- Project MEDICINE: Support to the SNRIU in amendment of Ukrainian regulatory documents on radiation protection in medicine in accordance with IAEA safety standards and Council Directive 2013/59/EURATOM. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 7 and 8.6). The project objective is to improve the regulatory framework on nuclear and radiation safety in medicine. Two high-level regulations have been developed in the project:
  - General Safety Rules for Medical Radiation Sources [4], which establish safety criteria and requirements for all medical institutions that use radiation sources for medical purposes.
  - Radiation Safety Rules of Using Radiation Sources in Brachytherapy, which identify safety principles and criteria for protection of personnel and patients against radiation risks in brachytherapy [6].

  Documents [4], [6] have officially been put into force.

9.1.2 Projects SOURCE, TRANSPORT, DECOMMISSIONING

- Project SOURCE: Development of Ukrainian regulation on radiation protection in use of radiation sources. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 7 and 8.6). The project objective is to improve the national regulatory framework on radiation protection by development of a high-level regulation to establish systemized radiation safety requirements for the safe use of radiation sources. The initial stage of the project was completed: current regulations were analyzed and gaps in the Ukrainian regulatory framework on radiation safety in use of radiation sources were identified (first revision of the structure and contents of the document was developed and submitted for NRPA for review, comments were received and are being addressed).
- Project TRANSPORT: Revision of the regulatory document 'Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials' [18]. The project is aimed at eliminating the threat identified in Report [2] (for threat elimination status, see Sections 4 and 8.3). The

project objective is to provide an up-to-date regulatory framework for all stages of radioactive material transport (preparation, loading, transfer, shipment, transit storage, unloading and final acceptance of radioactive materials and packages). The initial stage of the project was completed: current regulations were analyzed and gaps in the Ukrainian regulatory framework on safe transport of radioactive materials were identified (first revision of the structure and contents of the document was developed and submitted for NRPA for review, comments were received and are being addressed).

- Project DECOMMISSIONING: Development of high-level regulatory documents for decommissioning safety of nuclear facilities. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 6 and 8.5). The project is aimed at strengthening the regulation in decommissioning of nuclear facilities. Two regulatory documents shall be developed in the project: General Safety Provisions for Decommissioning of Nuclear Facilities and Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities. Further implementation of these documents will increase effectiveness of safety regulation in decommissioning of nuclear facilities in Ukraine and improve the national regulatory framework in this area. The inception project report was prepared, the initial project stage was completed: first revisions of the structure and contents of the document were developed and submitted to NRPA for review, comments were received and are being addressed.

9.1.3 Projects GUIDELINE, EXPERIENCE, PREPAREDNESS

These projects were started in spring 2017:

- Project GUIDELINE: Development of general regulatory requirements for the structure and contents of NPP emergency documentation. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 3 and 8.2). The project objective is to improve the regulatory framework through development of the regulation 'Requirements for the Structure and Contents of Emergency Documentation' to establish requirements for the development, application, review and updating, including regulatory follow-up, of emergency documentation packages for Ukrainian NPPs. The project is in its inception phase.
- Project EXPERIENCE: Development of guideline for assessment of safety culture and human and organizational factors in operating experience analysis. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 3**Feil! Fant ikke referansekilden.** and 8.2). The project is aimed at increasing operational safety of Ukrainian NPPs by prevention of operational events caused by human and organizational factors and more effective application of operating experience. A guideline for assessment of safety culture and human and organizational factors in operating experience analysis for Ukrainian NPPs shall be developed in the project to improve effectiveness in identification of inspection areas, planning of inspections and general regulatory oversight. The project is in its inception phase.
- Project PREPAREDNESS: Enhancing emergency preparedness and response in Ukraine. The project is aimed at eliminating the threats identified in the Report [2] (for threat elimination status, see Sections 5**Feil! Fant ikke referansekilden.** and 8.4). The project objective is to revise the Radiation Emergency Response Plan [92], which is the main regulatory document that identifies emergency response and preparedness measures in Ukraine. This project will promote harmonization of the national legislative and regulatory framework on emergency preparedness and response with current IAEA requirements and Euratom Directives. The project is in its inception phase.

9.1.4 Planning of other activities within cooperation

At working (coordination) meetings that are periodically held in Kyiv or Oslo, the status of projects within cooperation between the SNRIU and NRPA is reviewed, current issues are solved and future activities are planned.

Fig. 9.2 Working meeting between NRPA, SNRIU and SSTC NRS. March 2017, SSTC NRS office, Kyiv

Fig. 9.3 Ukrainian delegation at working meeting between NRPA, SNRIU and SSTC NRS. May 2017, NRPA office, Østerås

One of the common decisions accepted by the SNRIU and NRPA upon two recent meetings was to carry out threat reassessment, whose results are provided in this Report and develop the Roadmap for cooperation between the SNRIU and NRPA for 2018-2020.

9.2 Cooperation between SNRIU and US NRC

Since 2000, cooperation is carried out according to the Memorandums of Meetings between the U.S. NRC and the SNRIU (Memorandum), which define and agree areas of cooperation for a certain period of time and the list of detailed tasks planned for the implementation by the parties: U.S. NRC, SNRIU and SSTC NRS.

In determining the areas of cooperation, one shall consider, on the one hand, available experience and achievements of previous periods, and, on the other hand, current situation in Ukraine and challenges faced by the SNRIU.

The current Memorandum of Meeting for 2016-2017 [125] was signed by managers of the U.S. NRC and the SNRIU in March 2016 during the Annual Regulatory Information Conference (Fig. 9.4).

Fig. 9.4 Signing the Memorandum of Meeting for 2016-2017, Rockville, Maryland, 9 March 2016 (center: Stephen G. Burns, Serhii Bozhko)

The Memorandum [125] defines 13 areas and 43 detailed tasks in the areas and is one of the most extensive documents for the entire period of bilateral cooperation. The detailed tasks cover the following areas:

- systematic strengthening of SNRIU and SSTC NRS capabilities in obtaining and efficient use of a wide range of state-of-the-art computer codes (thermal hydraulics, neutron physics, radiological consequences, etc.) and developing relevant models for independent assessment of safety justifications provided by the licensee;
- support of the SNRIU and SSTC NRS in carrying out a number of urgent tasks (licensing of NPP power uprate; comprehensive use of risk-informed approach to NPP safety regulation, etc.);
- general support and strengthening capacities of SNRIU and its territorial State Inspections to fulfil the assigned functions, develop relevant infrastructure.

Activities undertaken within cooperation under the Memorandum [125] are mainly focused on SNRIU support in overcoming threats and challenges described in Section 3 of this Report. The areas and scope of US NRC and SNRIU cooperation for 2018-2020 will be defined by the end of the current year and the beginning of the next year.

9.3 Coordination of efforts - Information Sharing Initiative (ISI)

Many countries worldwide has been developing bilateral cooperation with Ukraine, many of them provides different type of support to Ukrainian authorities and organisations. Information Sharing Initiative initiated by NRPA and Ministry of Foreign Affairs of Norway aims to bring together key Ukrainian partners and other involved international community to ensure coordination and compatibility at the implementation level. Information Sharing Initiative on nuclear and radiological security cooperation in Ukraine has aim to avoid duplication and provide better coordination between similar types of bilateral activities in Ukraine. The need for sharing information and discussing lessons learned is of high importance.

9.4 Current INSC Projects for Strengthening SNRIU Capabilities

The overall scope and areas of support provided by the European Commission to SNRIU within the Instrument for Nuclear Safety Cooperation (INSC) are described in the recent paper [126] of EC

representatives directly involved in this process. Below there the brief information is presented on the current and planned INSC projects for which SNRIU is the beneficiary.

9.4.1 Support in safe management of radioactive waste

As of autumn 2017, the following INSC projects are conducted in this area:

- UK/TS/46 *Support to SNRIU in the field of radioactive waste management* [97]. Duration of the project is from April 2014 to January 2018. The project objective is to ensure efficient safety regulation of radioactive waste management according to priority issues foreseen by the National Ecological Program of Radioactive Waste Management in Ukraine. The project tasks are aimed at support to regulation of the priority safety issues:
  - national organization and comprehensive radioactive waste management;
  - definition of characteristics, monitoring and control of radioactive waste and clearance of radioactive materials from the regulatory control;
  - assessment of the existing radioactive waste temporary storage sites and temporary radioactive waste storage/disposal facilities located in the Chornobyl exclusion zone;
  - construction of facilities aimed at radioactive waste processing and radioactive waste transport;
  - in the context of long-term storage of high-level long-lived waste;
  - safety of developing the concept for the confinement of high-level long-lived radioactive waste in stable deep geological formations.
- UK/TS/48 *Safe radioactive waste management at Vektor industrial complex in the Chornobyl exclusion zone* [93]. Duration of the project is from June 2015 to June 2018. The project objective is to implement state-of-the-art safety assessment methodologies and best European practices into regulatory activities related to safe radioactive waste management at Vektor industrial complex in the exclusion zone. The project tasks are aimed at providing support to regulation of priority tasks related to:
  - clearance from regulatory control;
  - safe construction and operation of radioactive waste processing facilities;
  - safety of radioactive waste storage and disposal facilities;
  - disposal of high-level and long-lived waste in geological formations.

Within INSC project [48], which will be launched soon, a separate component *Support of the regulatory activity under implementation of the modern safe technologies of radioactive waste management and remediation* (Project UK/TS/56) is envisaged. The project is also aimed at support of the SNRIU in the stated area. Besides, one of SNRIU proposals to the INSC Action Plan for 2018 [59] is also related to this issue.

The ongoing or planned activities within INSC projects listed above are focused on SNRIU support into overcoming threats and challenges described in Section 6 of this Report.

9.4.2 Support in safety regulation of nuclear installations and improvement of regulatory framework on nuclear and radiation safety

As of autumn 2017, the following INSC projects are conducted in this area:

- UK/TS/49 *Licensing of new nuclear subcritical facility – neutron source based on an electron accelerator-driven subcritical assembly* [61]. Duration of the project is from June 2015 to June 2018. The project objective is to strengthen SNRIU activities in licensing of the neutron source based on an electron accelerator-driven subcritical assembly. The project tasks are aimed at support to regulation of priority issues:

- design, construction, licensing and operation of subcritical assemblies driven by linear electron accelerators;
- development of regulatory documents and methodologies in neutron safety area;
- development of computer models for regulatory review;

- UK/TS/50 *Oversight and assessment of nuclear and radiation safety in terms of the licensee management system and human factor* [62]. Duration of the project is from June 2015 to June 2018. The project objective is to strengthen SNRIU capabilities in oversight and assessment of nuclear and radiation safety in the context of licensee management system and human factor. The project tasks are aimed at support to regulation of priority issues, namely:
  - definition of capabilities to improve assessment and oversight of the management system;
  - organization of state regulation and oversight of safety culture depending on activities performed by the licensee;
  - assessment of regulatory requirements for energy company personnel and approval of personnel in Ukraine;
  - assessment and development of recommendations to improve the national training and qualification of licensee personnel on nuclear and radiation safety issues;
  - development of recommendations on the regulation the licensee knowledge management system;
  - development of recommendations for SNRIU on conducting regulatory oversight of suppliers;
  - human factor analysis in nuclear and radiation safety area.

Within INSC project [48], which will be launched soon, a number of the following components is envisaged aimed at support of safety regulation at nuclear installations and improvement of regulatory framework of nuclear and radiation safety:

- UK/TS/51 *Strengthening of SNRIU capabilities in licensing of new nuclear installations (except NPPs)*. The project objective is to improve SNRIU capabilities in licensing of nuclear installations through transfer of practical experience of EU regulatory activities on nuclear safety.
- UK/TS/52 *Assistance to SNRIU in enhancing and ensuring robustness of models for severe accident analysis based on EU up-to-date experience and Fukushima Daiichi lessons*. The project objective is to improve capabilities of the regulatory authority on severe accident analysis based on advanced EU experience and lessons learnt from Fukushima-Daiichi NPP accident.
- UK/TS/53 *Strengthening and alignment of Ukrainian nuclear safety regulations in line with the EU experience, best practice and EURATOM Acquis*. The project objective is to provide support in the strengthening of Ukrainian regulatory framework during implementation of EU Directives and WENRA reference levels.
- UK/TS/54 *Strengthening of Ukrainian nuclear safety regulatory capabilities in the external hazard assessment area*. The project objective is to strengthen capabilities of the Ukrainian regulatory authority in relevant areas related to the assessment of external hazards (natural and man-made).
- UK/TS/55 *Enhancement of the national regulatory framework and relevant regulatory capabilities in the frames of operational experience feedback system*. The project objective is to improve regulatory capabilities within the operational experience feedback system according to state-of-the-art EU experience.

- UK/TS/57 *Assessment of licensing and other operator activities*. The project objective is to strengthen SNRIU capabilities in assessing measures implemented by the operator for Ukrainian NPP safety improvement considering experience in the implementation of similar measures in EU states.

SNRIU proposals to the INSC Action Program for 2018 [59] in this area include projects aimed at receiving support for:

- regulatory consideration of severe accident phenomena;
- implementation of HERCA-WENRA approach;
- licensing of alternative fuel types for Ukrainian NPPs;
- technical assessment of documents of seismic PSA for Ukrainian NPPs;
- improvement of the regulatory framework on ageing management of components and structures of nuclear installations.

The ongoing or planned activities within INSC projects listed above are focused on the support to the SNRIU in overcoming threats and challenges referred to in Sections 2, 3, 5, 7 of this Report.

9.5 Brief Overview of Other Areas of SNRIU International Cooperation

Information on other SNRIU international projects that are ongoing (or have been completed) since 2015 is summarized in Table 9.1. The attributes and areas (relevant Section of this Report) are indicated for each project.

Table 9.1 Some International Projects of SNRIU for 2015–2017

No.	Project title	Donor	Recipient	Beneficiary	Performance period	Reference to a threat(s)
Projects with the US						
1.	Enhancement of safety of the ionizing radiation sources used in Ukraine	US Government through the Department of Energy	SNRIU	SNRIU	01.05.2003- -31.08.2020	Threats identified in Section 7
2.	Modernization of the Information Emergency Centre (IEC) by reference to the up-to date challenges and threats	US Government through the Department of Defense/Defense Threat Reduction Agency	SNRIU	SNRIU	2015-2019	Threats identified in Section 5

No.	Project title	Donor	Recipient	Beneficiary	Performance period	Reference to a threat(s)
3.	Integrated Response Readiness Exercise Project	US Government through the Department of Defense/Defense Threat Reduction Agency	SNRIU Anti terrorist Center at the State Security Service of Ukraine National Nuclear Energy Generating Company Energoatom Khmelnitsky NPP	SNRIU State Security Service of Ukraine Ministry of Energy and Coal Industry of Ukraine	2015-2019	Threats identified in Sections 2.3 and 5
Projects with Germany						
4.	Decommissioning of the irradiating facilities and providing the safe storage of ionizing radiation sources	German Government through BMU	USIE IZOTOP	SNRIU SAEZ	17.05.2010- till now	Threats identified in Section 6
5.	The exchange of scientific and technical experience between Germany and the CIS countries, the Baltic States, Central and Eastern Europe and other regions - workshops and the creation of joint databases in the area of nuclear safety and physical security	German Government through BMU	SNRIU	SNRIU	1993 - till now	Threats identified in Sections 2-7
Projects with the Kingdom of Sweden						
6.	Technical support to SNRIU database for nuclear material accountancy and control (STAR)	Sweden Government through SSM	SNRIU	SNRIU	2012-2017	Threats identified in Section 2.3
7.	Information support of SNRIU	Sweden Government through SSM	SNRIU	SNRIU	2017-2018	Threats identified in Section 2

No.	Project title	Donor	Recipient	Beneficiary	Performance period	Reference to a threat(s)
8.	Nuclear History of Ukraine	Sweden Government through SSM	SNRIU	SNRIU	2015-till now	Threats identified in Section 2
9.	Information support to the State Regulatory Inspectorate of Ukraine: development of the website on nuclear and radiation safety in Ukraine	Swedish MFA through SSM	SNRIU	SNRIU	2011-2013	Threats identified in Section 2
10.	Providing technical assistance for Qualification of the Mechanized In-Service Inspection Systems QMSIS	Swedish MFA through SSM	SNRIU	SNRIU	2012-2015	Threats identified in Section 2
Ukrainian-Swedish-Norwegian Initiative Projects						
11.	Safety requirements for new types of nuclear fuel	Sweden Government through SSM Norway Government through NRPA	SNRIU	SNRIU	2014-2015	Threats identified in Section 3
12.	Tools for probability safety assessment	Sweden Government through SSM Norway Government through NRPA	SNRIU	SNRIU	2014-2015	Threats identified in Section 3
13.	Safety requirements for damaged nuclear fuel	Sweden Government through SSM Norway Government through NRPA	SNRIU	SNRIU	2014-2015	Threats identified in Section 3

No.	Project title	Donor	Recipient	Beneficiary	Performance period	Reference to a threat(s)
14.	Modernization of the radioactive source register	Sweden Government through SSM Norway Government through NRPA	SNRIU	SNRIU	2014-2015	Threats identified in Section 7
IAEA Projects						
15.	Defining Safety Goals and Regulatory Strategies for New Build and NPP Long Term Operation	IAEA	SNRIU	SNRIU	2014-2015	Threats identified in Section 3
16.	Strengthening Capabilities in the Field of Conducting a State Review	IAEA	SNRIU	SNRIU	2016-2017	Threats identified in Section 2
EBRD Projects						
17.	Grant agreement 007, 2009, between the EBRD and the Cabinet of Ministers of Ukraine and the SNRCU	EBRD	SNRIU	SNRIU	2010- till now	Threats identified in Section 6
18.	Grant Agreement (Chornobyl Shelter Fund: Licensing Consultant) between EBRD as Administrator of Grant Funds provided by the Chornobyl Shelter Fund and the NRA of the Ministry of Environmental Protection and Nuclear safety of Ukraine	EBRD	SNRIU	SNRIU	1998-till now	Threats identified in Section 6**Feil! Fant ikke referansekilden.**

9.6 Availability of the international support for the period 2018 – 2020

The table below summarizes the information about the international support aimed at assistance of the SNRIU under mitigation of the threats identified in each specific area, subject of the threat assessment.

Table 9.2 International support to SNRIU for mitigation of the identified threats

SNRIU Partners / Area of threat assessment	NRPA	US NRC	EU (INSC)	Other
Organization and general principles for activities of Regulatory Authority	2018 - 2020		2018 - 2020	
Safety of nuclear installations	2018 - 2020		2018 - 2020	
Radioactive material transportation	2018 - 2020			
Emergency preparedness and response	2018 - 2020		2018 - 2020	
Radioactive waste management and decommissioning	2018 - 2020		2018 - 2020	
Radiation safety	2018 - 2020		2018 - 2020	

Colored sections in the table mean the ongoing projects which are in place in a respective area with a respective partner. Colored sections with dates mean that the respective activities are planned for the next three years. Blanc sections in the table mean that there are no ongoing projects and no activities are planned yet in a respective area. Dates in the blanc section means that the respective proposals for cooperation with certain partners are developed by the SNRIU.

Thus, the on-going bilateral projects between NRPA and SNRIU (see para 9.1) cover majority of the areas, which are subjects of assessment presented in this Report. Proposals for further activities, directed to eliminate some highly prioritized threats (see Section 8) will be presented in the Roadmap of the cooperation for the period 2018 – 2020 and will cover all areas of the threat assessment.

As it was mentioned in para 9.2 of this Report, cooperation between the US NRC and the SNRIU is carried out according to the Memorandums of Meetings. The on-going Memorandum of Meeting for 2016-2017 [125] mainly focuses on the SNRIU support in overcoming threats described in Section 3 of this Report, but at the same time, there are particular tasks dedicated to cope with challenges in other areas listed in Table 9.2. Further directions and scope of US NRC and SNRIU cooperation will be defined at the beginning of the next year.

The INSC projects (see para 9.4), which are currently in progress, consist of a set of components directed to enhance relevant SNRIU capabilities in the areas defined in Table 9.2. The SNRIU proposals to the INSC Action Program for 2018 [59] also relate to similar technical topics.

Cooperation of the SNRIU with other international partners, briefly outlined in Table 9.1 above, also covers all areas of performed threat assessment. It is envisaged that such a cooperation will be continued in the future under mutual agreements of the interested parties.

Finally, it is necessary to point out that the SNRIU permanently takes respective efforts to ensure that any overlapping under planning and implementing of the international activities be avoided. Consideration of this important issue is of course the key element of the procedure for developing project proposals being applied under NRPA and SNRIU cooperation since its beginning. Traditionally, this issue is a subject of the detailed technical discussions between Norwegian and

Ukrainian colleagues before making decisions to launch any specific project. The same approach is applied by SNRIU under planning and implementing the activities with other partners. The effectiveness of this approach was recently verified and assessed positively by auditors under the project [131] arranged by the European Commission.

10 Conclusions

The Ukrainian regulatory threat assessment aimed at a comprehensive analysis of the SNRIU's activities, as a central executive authority entrusted with state regulation of nuclear and radiation safety. This second assessment was made by SNRIU with support of NRPA. The first such assessment in 2015 has provided a solid basis for further bilateral projects which have already been successfully implemented or are in progress now. This Report presents the results of the aforementioned assessment which main objective was to make a detailed analysis of the SNRIU activities considering the current challenges and identifying weak points in regulatory framework, licensing and oversight, with planning of measures for their further elimination or mitigation.

The threat assessment has identified directions for regulatory enhancements in the area of safety of nuclear installations, radioactive materials transport, emergency preparedness and response, radioactive waste management and decommissioning, radiation protection, and nuclear security.

In some cases, activities dedicated to the mentioned regulatory enhancements are currently the part of ongoing bilateral projects between NRPA and SNRIU. Presently, respective efforts of both agencies are focused on elimination of the identified gaps in Ukrainian legislation in the following areas:

- radiation protection in use of radiation sources;
- regulatory framework for all stages of radioactive material transport;
- regulation in decommissioning of nuclear facilities;
- regulatory requirements for NPP emergency documentation;
- assessment of safety culture and human and organizational factors in operating experience analysis;
- regulatory requirements that define emergency response and preparedness measures in Ukraine.

Owing to the comprehensive support of NRPA, Ukrainian experts use an opportunity to consider the best European approaches and standards in the development of relevant regulatory requirements. All stakeholders – such as the Ministry of Health of Ukraine, State Agency of Ukraine on Exclusion Zone Management, Ministry of Ecology and Natural Resources of Ukraine, Ministry of Energy and Coal Industry of Ukraine, other governmental bodies participate both in the development of regulations and in their approval process in accordance with the general procedure (providing comments on a draft, participating in the target working meetings, etc.).

In several cases, mitigation of the identified threats is the objective of ongoing or planned projects of SNRIU with other international partners. Thus, activities undertaken in cooperation with the US NRC are focused on strengthening the SNRIU capacities due to obtaining and efficient use of a wide range of state-of-the-art computer codes; developing relevant models for independent assessment of safety justifications provided by a licensee; and general support to SNRIU and its regional State Inspections to fulfil their functions, and develop relevant infrastructure. The EU INSC projects, on-going and planned by the EC Directorate General for International Co-operation & Development also aim at effective support to and further

development of SNRIU as an independent national nuclear regulator with high professional competence and capacity.

Finally, the completed threat assessment helped SNRIU to identify a number of new challenges to regulatory activities in Ukraine. To cope with them properly SNRIU will request further assistance of NRPA. All those challenges and the SNRIU proposals for their mitigation will be described in the Roadmap of Cooperation between NRPA and SNRIU for 2018-2020. While developing Roadmap and defining contents of the proposed projects, special consideration was given to avoid duplications and/or overlapping of the Roadmap proposals with other SNRIU activities at national and international level, which are on-going or planned. The above Roadmap for 2018-2020, based on the threat assessment results presented in this Report, will systemize further NRPA and SNRIU activities for continuation of efficient cooperation within the areas identified in the Agreement [1].

References

[1] Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and Norwegian Radiation Protection Authority on Cooperation related to Nuclear and Radiation Safety, 18 November 2014, Kyiv.

[2] Ukrainian Regulatory Threat Assessment: Identifying Priorities for Improving Supervision of Nuclear and Radiation Safety. Stralevern Rapport 2016:10, NRPA, 2016.

[3] NP 306.3.209-2017. Requirements for Administrative Control of Uranium Sites within Restricted Clearance from Regulatory Control, approved by SNRIU Order No. 60 of 21 February 2017 and registered in the Ministry of Justice of Ukraine on 15 March 2017 by No. 353/30221.

[4] NP 306.5.211-2017. General Safety Rules for Medical Radiation Sources, approved by Joint Order of SNRIU and Ministry of Health No. 51/151 of 16 February 2017 and registered in the Ministry of Justice of Ukraine on 18 May 2017 by No. 636/30504.

[5] NP 306.4.213-2017. General Safety Provisions for Predisposal Management of Radioactive Waste, approved by SNRIU Order No. 279 of 1 August 2017 and registered in the Ministry of Justice of Ukraine on 22 August 2017 by No. 1045/30913.

[6] NP 306.5.216-2017. Radiation Safety Rules of Using Radiation Sources in Brachytherapy approved by joint Order of the SNRIU and Ministry of Health No. 316/998 of 31 August 2017 and registered in the Ministry of Justice of Ukraine on 8 November 2017 under No. 1362/31230.

[7] Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

[8] Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel.

[9] Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations.

[10] Law of Ukraine On Nuclear Energy Use and Radiation Safety No. 40/95-VR of 8 February 1995.

[11] Law of Ukraine On Authorizing Activity in Nuclear Energy No. 1370-XIV of 11 January 2000.

[12] Law of Ukraine On Human Protection against Ionizing Radiation No. 15/98-VR of 14 January 1998.

[13] Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants, approved by Cabinet Resolution No. 1270 of 7 December 2011.

[14] Convention on Nuclear Safety of 17 June 1994, ratified by Law of Ukraine On Ratification of the Convention on Nuclear Safety No. 736/97-vr of 17 December 1997.

[15] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management of 5 September 1997, ratified by Law of Ukraine On Ratification of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management No. 1688-III of 20 April 2000.

[16] Statute of the State Nuclear Regulatory Inspectorate of Ukraine, approved by Cabinet Resolution No. 363 of 20 August 2014.

[17] Convention on the Physical Protection of Nuclear Material and Nuclear Facilities of 26 October 1979, put in force for Ukraine on 5 August 1993, Verkhovna Rada Resolution No. 3182-XII of 5 May 1993.

[18] Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials (PBPRM-2006), approved by SNRIU Order No 132 of 30 August 2006 and registered in the Ministry of Justice of Ukraine on 18 September 2006 by No. 1056/12930.

[19] Convention on Early Notification of a Nuclear Accident of 26 September 1986, ratified by the Ukrainian SSR Verkhovna Rada Resolution of 30 December 1996.

[20] Provisions on the Board of the State Nuclear Regulatory Inspectorate of Ukraine, approved by SNRIU Order No. 35 of 13 April 2011, with amendments made by SNRIU Order No. 120 of 8 June 2012.

[21] Law of Ukraine On Licensing of Economic Activities No. 222-VIII of 5 July 2017.

[22] Law of Ukraine On Basic Principles of State Supervision over Economic Activities No. 877-V of 1 January 2017.

[23] Memorandum of Understanding of Strategic Energy Partnership between Ukraine and European Union, together with the European Atomic Energy Community, 24 November 2016.

[24] Convention on Nuclear Safety, 7th Review Meeting, Country Review Report for Ukraine, Country Group N° 7, IAEA, Vienna, 2017.

[25] Law of Ukraine On Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources No. 2064-III of 28 December 2015.

[26] Procedure for State Physical Protection System, approved by Cabinet Resolution No. 1337 of 21 December 2011.

[27] Presidential Decree No. 520/14t/2015 of 27 August 2015: On Resolution of the National Security and Defense Council of Ukraine of 20 July 2015 'Design-Basis Threat for Nuclear Installations, Nuclear Materials, Radioactive Waste and Other Radiation Sources in Ukraine'.

[28] List of Radiation Hazardous Facilities in Ukraine Subject to Facility-Level Design-Basis Threat, approved by SNRIU Order No. 238 of 17 December 2012.

[29] Procedure for State Inspection of Physical Protection Systems of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources and Plans of Interaction in the Event of Acts of Nuclear Terrorism, approved by Cabinet Resolution No. 327 of 12 March 2003.

[30] Procedure for State Oversight of Compliance with Nuclear and Radiation Safety Requirements, approved by Cabinet Resolution No. 824 of 13 November 2013.

[31] Code of Ukraine on Administrative Offences: current legislation on 05.09.2017. (Of. text).

[32] Council Decision 2007/513/Euratom of 10 July 2007, approving the accession to the amended Convention on the Physical Protection of Nuclear Material (CPPNM).

[33] Commission Decision 2008/99/EC of 19 December 2007, establishing procedural rules concerning the accession of EURATOM to CPPNM as part of the Occupational Health & Safety Information.

[34] Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources, concerning among other security of sources and countering illicit trafficking of radioactive materials.

[35] Commission Staff Working Document SWD(2013)187 of 27 March 2013, accompanying the Specific Monitoring Report on research activities for nuclear safety and security.

[36] Council Decision 2013/517/CFSP of 21 October 2013 on the Union support for the activities of the International Atomic Energy Agency in the areas of nuclear security and verification.

[37] IAEA Nuclear Security Series No. 20. Objective and Essential Elements of a State's Nuclear Security Regime. Nuclear Security Fundamentals.

[38] IAEA Nuclear Security Series No. 13. Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (also INFCIRC/225/Revision 5).

[39] IAEA Nuclear Security Series No. 14. Nuclear Security Recommendations on Radioactive Material and Associated Facilities.

[40] IAEA Nuclear Security Series No. 15. Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control.

[41] IAEA Nuclear Security Series No. 6. Combating Illicit Trafficking in Nuclear and Other Radioactive Material.

[42] IAEA Nuclear Security Series No. 17. Computer Security at Nuclear Facilities.

[43] IAEA Nuclear Security Series No. 23-G. Security of Nuclear Information.

[44] Declaration of ENSREG, Annex 1 "EU Stress-Test Specifications", 13 May 2011.

[45] WENRA Reactor Safety Reference Levels, RHWG, WENRA, January 2008.

[46] WENRA. Harmonisation of Reactor Safety in WENRA Countries. RHWG, WENRA, January 2006.

[47] Component B (UK/RA/09): Harmonisation of regulatory requirements on nuclear and radiation safety. INSC project U3.01/10 Assistance to State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in regulation on safe radioactive waste management and harmonisation of regulatory requirements on nuclear and radiation safety.

[48] Strengthening of SNRIU Capabilities Relevant to the Regulation of Nuclear Activities and Licensing and Severe Accident Management of Nuclear Installations (U3.01/14 and U3.01/15), EuropeAid/138301/DH/SER/UA.

[49] Concept for Safety Improvement of Operating Nuclear Power Units, approved by Cabinet Resolution No. 515-r of 13 December 2005.

[50] NP 306.2.106-2005. Requirements for Modifications of Nuclear Facilities and Procedure for Their Safety Assessment.

[51] CIS3.01/11 (part Ukraine U3.01/11A) – Cooperation with SNRIU in Licensing and Supervision Activities Connected with the Implementation of the Joint Safety Improvement Program at Ukrainian NPP. Component A (UK/TS/47).

[52] Energy Strategy of Ukraine until 2035 'Safety, Energy Efficiency, Competitiveness', approved by Cabinet Resolution No. 605-r of 18 August 2017.

[53] Comprehensive Work Program for Long-Term Operation of Nuclear Power Plant Units, approved by Cabinet Resolution No. 263-r of 29 April 2004.

[54] NP 306.2.099-2004. General Requirements for Long-Term Operation of Nuclear Power Plant Units Based on Periodic Safety Review.

[55] NP 306.2.141-2008. General Safety Provisions for Nuclear Power Plants.

[56] NP 306.2.100-2004. Provisions on the Procedure for Investigation and Accounting of Operational Events at Nuclear Power Plants. 2011 Revision.

[57] Research and Development Report. Prompt and In-depth Analysis of Operational Events at Ukrainian NPPs for 2016. R&D Report, SSTC NRS Kyiv, 2017.

[58] Work Program for Implementation of Upgraded Westinghouse Fuel (FA-WR) at Ukrainian Nuclear Power Units for 2017-2018, approved by SNRIU Letter No. 15-17/3-1495 of 10 March 2017.

[59] Proposals of the State Nuclear Regulatory Inspectorate of Ukraine to the INSC Action Program 2018. Action Document. SNRIU, 2017.

[60] Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America on Cooperation in Nuclear Safety signed on 26 September 2011.

[61] U3.01/12. Support to the Ukrainian Regulatory Authority. Component B: Licensing of new nuclear subcritical facility - neutron source based on an electron accelerator-driven subcritical assembly (UK/TS/49).

[62] U3.01/12. Oversight and assessment of nuclear and radiation safety in terms of the licensee management system and human factor (UK/TS/50).

[63] Law of Ukraine On Transport of Hazardous Cargoes.

[64] Law of Ukraine On Joining the Vienna Convention on Civil Liability for Nuclear Damage.

[65] Law of Ukraine On Civil Liability for Nuclear Damage and Its Financial Coverage.

[66] Law of Ukraine On Approval of the Procedure for Transport of Radioactive Materials through the Territory of Ukraine No. 1373 of 15 October 2004.

[67] Some Issues of Radioactive Material Transport No. 1196 of 3 October 2007, approving the procedure for issuing permits for international shipment of radioactive materials.

[68] On Approval of the Procedure for State Control of International Transfer of Dual-Use Goods No. 86 of 28 January 2004.

[69] Cabinet Resolution No. 733 of 1 June 2002 On Approval of the Procedure and Rules for Compulsory Liability Insurance of Entities Dealing with Transport of Hazardous Cargoes in the Event of Adverse Effects in Transport of Hazardous Cargoes.

[70] Requirements for Quality Assurance Programs for Transport of Radioactive Materials, approved by SNRIU Order dated 25 July 2006 and registered in the Ministry of Justice of Ukraine on 5 October 2006 by No. 1092/12966.

[71] Provisions on Planning of Measures and Actions in the Event of Accidents in Radioactive Material Transport (NP 306.6.108-2005), approved by SNRIU Order No. 38 dated 7 April 2005 and registered in the Ministry of Justice of Ukraine on 22 April 2005 by No. 431/10711.

[72] Procedure for Issuing Certificates on Safe Transport of Radioactive Material, approved by SNRIU Order No. 119 dated 6 September 2007 and registered in the Ministry of Justice of Ukraine on 20 September 2007 by No. 1079/14346.

[73] Safety Requirements and Conditions (Licensing Terms) for Radioactive Material Transport (NP 306.6.095-2004), approved by SNRIU Order No. 141 dated 31 August 2004 and registered in the Ministry of Justice of Ukraine on 9 September 2004 by No. 1125/9724.

[74] Requirements for the Safety Analysis Report on Radioactive Material Transport (NP 306.6.096-2004), approved by SNRIU Order No. 141 dated 31 August 2004 and registered in the Ministry of Justice of Ukraine on 9 September 2004 by No. 1127/9726.

[75] Procedure for Submitting SNRIU Conclusions in International Shipment of Radioactive Materials (NP 306.6.097-2004), approved by SNRIU Order No. 138 dated 26 August 2004 and registered in the Ministry of Justice of Ukraine on 8 September 2004 by No. 1119/9718.

[76] Reference Material to Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials (PBPRM-2006), approved by Order of SNRIU Deputy Chairperson dated 20 November 2009.

[77] Methodological Recommendations on Development of Radiation Protection Program for Radioactive Material Transport, approved by SNRIU Order No. 101 dated 2 August 2010.

[78] Rules for Road Transport of Hazardous Cargoes, approved by Ordinance of the Ministry of Internal Affairs of Ukraine No. 822 dated 26 July 2004 and registered in the Ministry of Justice of Ukraine on 20 August 2004 by No. 1040/9639.

[79] Rules for Transport of Hazardous Cargoes, approved by Ordinance of the Ministry of Transportation and Communication of Ukraine No. 1430 dated 25 November 2008 and registered in the Ministry of Justice of Ukraine on 26 February 2009 by No. 180/16196.

[80] Regulations for the Safe Transport of Radioactive Material No. SSR-6, 2012 Edition. IAEA. Vienna, 2012.

[81] Report of the Ukrainian Government for the Integrated Regulatory Review Service (IRRS) Mission, IAEA, 2008.

[82] Compliance Assurance for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.5, 2009.

[83] The Management System for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-G-1.4. IAEA. Vienna, 2008.

[84] ISO 9001:2015. Quality Management Systems–Requirements.

[85] Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2.

[86] Civil Protection Code of Ukraine No. 5403-VI of 2 October 2012.

[87] Provisions on the Unified State Civil Protection System, approved by Cabinet Resolution No. 11 of 9 January 2014.

[88] Cabinet Resolution No. 47-r of 26 January 2015 On Establishment of Increased Preparedness and Emergency Situation Modes.

[89] Provisions on Functional Subsystem 'Safety of Nuclear Power Facilities' of the Unified State System for Prevention and Response to Mad-Induced and Natural Emergencies, approved by SNRIU Order No. 16 of 20 January 2009.

[90] Response Plan of the Functional Subsystem 'Safety of Nuclear Power Facilities' of the Unified State System for Prevention and Response to Mad-Induced and Natural Emergencies, approved by SNRIU Order No. 93 of 16 July 2010.

[91] SNRIU Order No. 16 of 6 February 2015 On Establishment of Increased Preparedness and Emergency Situation Modes.

[92] Radiation Emergency Response Plan, approved by Joint Order of the SNRIU and Ministry of Emergencies of Ukraine No. 87/211 of 17 May 2004 and registered in the Ministry of Justice of Ukraine on 10 June 2004 by No. 720/9319, with amendments made by SNRIU Order No. 24/126 of 2 March 2010.

[93] INSC U3.01/12 (UK/TS/48). Safe radioactive waste management at Vektor industrial complex in the Chornobyl exclusion zone.

[94] INSC industrial project U4.01/10-D 'Investigation of Radioactive Waste Burials and Temporary Storage Places in Chernobyl Exclusion Zone'.

[95] INSC industrial project U4.01/10-D Task D6 Report 'Implementation of approved approach for safety assessment of RWDS Podlesny and 'ChNPP 3rd Stage'.

[96] INSC Project U3.01/08 (UK/TS/39). Technical support to the SNRIU and its TSOs to develop their capabilities on the basis of transferred Western European safety principles and practices.

[97] INSC Project U3.01/10 (UK/TS/46). Support to the State Nuclear Regulatory Inspectorate of Ukraine in the field of radioactive waste management.

[98] Project U4.01/10 C+D+F. Support to radioactive waste management in Ukraine.

[99] NP 306.1.102-2004. Fundamental Safety Principles under the Shelter Implementation Plan.

[100] RD 306.1.128-2006. Guideline on Using Safety Fundamentals in Regulatory Activity under the Shelter Implementation Plan.

[101] NP 306.4.159-2010. Procedure for Release of Radioactive Materials from Regulatory Control in the Framework of Practices.

[102] NP 306.2.105-2004. General Safety Provisions for Interim Dry Storage Facilities for Spent Nuclear Fuel.

[103] RD 306.8.02/2.067-2003. Recommendations on the Structure and Contents of the Safety Analysis Report for Spent Nuclear Fuel Storage Facility.

[104] Preparedness and Response for a Nuclear or Radiological Emergency, GSR Part 7, IAEA, 2015.

[105] WENRA Safety Reference Levels for Existing Reactors, 2014.

[106] Cabinet Resolution No. 813 of 2 June 2003 'On Approval of the Procedure for Interaction of Executive Bodies and Legal Entities Using Nuclear Energy in Case of Revealing Illicit Trafficking of Radioactive Materials'.

[107] SNRIU Order No. 165 of 27 October 2014 "On Appointment of National Coordinator for INES Operation".

[108] Provisions on the Procedure for Investigation and Accounting of Operational Events at Nuclear Power Plants, approved by SNRCU Order No. 184 of 1 December 2004 and registered in the Ministry of Justice of Ukraine on 17 December 2004 by No. 1594/10193, with amendments made by SNRIU Order No. 39 of 20 April 2011.

[109] PN-A.0.03.192-15. Standard Emergency Plan of Ukraine.

[110] Provisions on Actions of the On-Site State Nuclear Safety Inspectorate in Case of Emergencies, approved by SNRIU Order No. 145 of 1 December 2003.

[111] Order of the Ministry for Environmental Protection and Nuclear Safety of Ukraine and Ministry of Health of Ukraine No. 15/7 of 18 January 2000, registered in the Ministry of Justice of Ukraine on 16 March 2000 by No. 171/4392 'On Approval of the Procedure for Registration of Radiation Sources and Format of Registration Card'.

[112] Cabinet Resolution No. 1174 of 16 November 2011 'On Approval of Criteria for Release of Radiation Source Use from Licensing'.

[113] Radiation Safety of X-ray Generators and Radiation Sources Used for Inspection Purposes and for Non-Medical Imaging (DS471).

[114] Law of Ukraine On Amending Some Legal Acts on Use of Nuclear Energy.

[115] Law of Ukraine On Licensing of Economic Activities.

[116] GSR Part 3. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. IAEA Safety Standards Series, Vienna, 2015.

[117] Code of Conduct on the Safety and Security of Radioactive Sources, IAEA, 2003.

[118] DGN 6.6.1-6.5.001-98. Radiation Safety Standards of Ukraine (NRBU-97).

[119] ISO/IEC 17025. Basic Requirements for Testing and Calibration of Laboratories.

[120] DSP 6.177-2005-09-02. Basic Health and Radiation Safety Rules of Ukraine (OSPU-2005).

[121] Law of Ukraine On Amending Some Laws of Ukraine on Nuclear and Radiation Safety.

[122] INSC Project U3.03/08. Support to SNRIU in activities related to NPP safe operations of risk-informed approaches (operation and maintenance), integrated NPP safety oversight system, severe accident analysis and management, regulatory issues about reactor pressure vessel operations. Component B (UK/TS/42): Development of the integrated NPP safety oversight system.

[123] INSC Project U3.01/12. Component C (UK/TS50): Oversight and assessment of nuclear and radiation safety in terms of the licensee management system and human factor.

[124] NP 306.2.183-2012. General Safety Provisions for Nuclear Subcritical Facility.

[125] Memorandum of Meeting between the U.S. Nuclear Regulatory Commission and State Nuclear Regulatory Inspectorate of Ukraine, Washington, 2016.

[126] H. Pauwels, P. Daures, Y. J. Stockmann, J. Vegh 'Cooperation between SSTC NRS and the EU in the area of nuclear safety'. Nuclear and Radiation Safety Journal, No. 2(74), 2017.

[127] Aircrew exposure to cosmic rays - Challenges and management - Gerhard Frasch, Federal Office for Radiation Protection (BfS), Germany International Conference on Occupational Radiation Protection, 15. Dec. 2014, IAEA Vienna, Austria.

[128] NP 306.5.140-2008. Safety Requirements and Conditions (Licensing Terms) for Use of Radiation Sources in Radiation Therapy, approved by SNRIU Order No. 193 of 28 December 2007 and registered in the Ministry of Justice of Ukraine on 18 January 2008 by No. 31/14722.

[129] NP 306.5.148-2008. Requirements for Quality Management System for Diagnostic and Therapeutic Procedures Using Radiation Sources, approved by SNRIU Order No. 166 of 3 October 2008 and registered in the Ministry of Justice of Ukraine on 29 October 2008 by No. 1054/15745.

[130] NP 306.5.192-2013. Radiation Safety Rules for Electron Accelerators, approved by SNRIU Order No. 83 of 5 August 2013 and registered in the Ministry of Justice of Ukraine on 21 August 2013 by No. 1442/23974.

[131] Assessment of the EU support to the Nuclear Regulatory Authority of Ukraine FWC BENEFICIARIES 2013 - LOT 4: Energy and Nuclear Safety EuropeAid/132633/C/SER/multi.

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ISSN 1891-5191 (online)
ISSN 0804-4910 (print)