Report
on Nuclear and Radiation Safety
in Ukraine
2012

Dear readers!

We offer to your attention the Annual Report on Nuclear and Radiation Safety in Ukraine-2012.

The Report gives you the insights of the legal framework in the nuclear energy field; the main areas of activity of regulatory bodies in this area; activities, which have been performed throughout the reporting period to enhance the level of nuclear and radiation safety in Ukraine.

While preparing the Report for publishing, experts of the State Nuclear Regulatory Inspectorate of Ukraine strived to provide the most complete and objective information to community on the status of nuclear and radiation safety in Ukraine; moreover, we tried to do that for you, dear readers, in the most convenient and easily understood form.

We hope, that with your help, we'll be able to receive the answer to the question of whether or not have we managed to achieve the challenging objective.

We would be grateful for all of your comments, advises and wishes as to the improvement of the of this Report structure.

If, after you have read the Report, there would be more questions from you, do not hesitate to ask them during our telephone hotlines or during the visiting hours for citizens arranged by the management of the State Nuclear Regulatory Inspectorate of Ukraine. The info on the time and place of these arrangements you may find at the web-site of the State Nuclear Regulatory Inspectorate of Ukraine: www.snrc.gov.ua.

Chairperson
of the State Nuclear
Regulatory Inspectorate of Ukraine

Olena Mykolaichuk

Report on Nuclear and Radiation Safety in Ukraine in 2012 was prepared by the editorial board composed of: ***Olena Mykolaichuk*** *– Chairperson of the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU),* ***Ganna Gorashchenkova*** *– Head of the Division for International Cooperation and European Integration,* ***Oleksandr Grygorash*** *– Deputy Director, Department on Nuclear Facilities Safety,* ***Gregory Gromov*** *– Director of State Scientific and Technical Center for Nuclear and Radiation Safety,* ***Tetiana Kilochytska*** *– Head, Unit of Radioactive Waste Management Safety,* ***Taras Kozulko*** *– Assistant to Chairperson on Public Communication Issues,* ***Oksana Maiboroda*** *– NGO «Ecoclub»,* ***Olga Makarovska*** *– Deputy Chairperson of SNRIU,* ***Olga Matarykina*** *– Assistant to Chairperson – Press-secretary,* ***Tetiana Pavlenko*** *– Marzeev Institute of Hygiene and Medical Ecology National Academy of Medical Sciences of Ukraine,* ***Ruslana Tripailo*** *– Deputy Head, Unit of Radiation Safety,* ***Oleksiy Tolkachov*** *– Head of SNRIU Public Council,* ***Mykola Schteinberg*** *– Head of SNRIU Reactor Safety Council.*

The State Nuclear Regulatory Inspectorate of Ukraine would like to pay special tribute for the assistance in preparation and publishing of this Report to the International Atomic Energy Agency, State Enterprise NNEGC «Energoatom», State Concern «Nuclear Fuel», Marzeev Institute of Hygiene and Medical Ecology National Academy of Medical Sciences of Ukraine, Institute for Economics and Forecasting of National Academy of Sciences of Ukraine, and ***Volodymyr Kholosha*** *– Head of State Agency of Ukraine on Exclusion zone management*

List of Abbreviations

ChNPP – Chernobyl NPP
CMU – Cabinet of Ministers of Ukraine
CSM – Concrete storage module
DSFSF – Dry type spent fuel storage facility
DDSC – Double-walled dry shielding case
ETC – Emergency Technical Centre
ENSDF – Engineered near-surface disposal facility
FCM – Fuel-Containing Masses
FA – Fuel Assembly
FE – Fuel Element
FS – Feasibility Study
IAEA – International Atomic Energy Agency
IAMS – Shelter integrated automated monitoring system
ICSRM – Industrial Complex for Solid Radioactive Waste Management
IEC – Information/Emergency Center
INES – International Nuclear Events Scale
IRS – Ionizing Radiation Source
KhNPP – Khmelnitsky NPP
KNRI – Kyiv Nuclear Research Institute of the National Academy of Sciences of Ukraine
LRTP – Liquid Radwaste Treatment Plant
MFA – Ministry of Foreign Affairs
MFE – Ministry for Fuel and Energy
MH – Ministry of Health
MHB – Multi-Place Hermetical Basket
MJU – Ministry of Justice of Ukraine
NASU – National Academy of Sciences of Ukraine
NNEGO «Energoatom» – National Nuclear Energy Generating Company «Energoatom»
NFC – Nuclear-fuel cycle
NI – Nuclear Installations
NM – Nuclear Materials
NNPT – Nuclear Non-Proliferation Treaty
NPP – Nuclear Power Plant
NSC – New Safe Confinement
NSC KIPT – National science center «Kharkov Institute of Physics and Technology»
PE – Public Enterprise
PPS – Physical Protection System
SO – Scheduled Outage
RA – Regulatory Act
RIA – Risk-Informed Approaches
RNPP – Rovno NPP
RW – Radioactive waste
RWDS – Radioactive waste disposal site
SA – State Association
SAR – Safety Analysis Report
SE – Separate Entity
SEIAS – State emergencies informational and analytical system
SFA – Spent Fuel Assembly
SFSF – Storage Facility for Spent Nuclear Fuel
SINEI – Sevastopol Nuclear Energy and Industry Institute
SIP – «Shelter» Implementation Plan
SISP – State Interregional Specialised Plant
SNF – Spent Nuclear Fuel
PSA – Probabilistic Safety Analysis
SRW – Solid Radioactive Waste
SSE – State Specialized Enterprise
SSTC NRC – State Science and technical Center for Nuclear and Radiation Safety
URSS – Ukrainian Radiation Safety Standards
VSC – Ventilated Storage Cask
WWER – Water Cooled Power Reactor
SUNPP – South Ukraine NPP
ZNPP – Zaporizhzhya NPP

Contents

January

16 SNRIU Order №8 approved «Procedure of issuance of permits for the use of lands and basins located in the sanitary protection zone of nuclear facility, facility on radioactive waste management, uranium facility» (NP 306.4.181-2012), later registered in the Ministry of Justice of Ukraine of 10.02.2012 №181/20494.

17-25 Activities on the discharge of irradiation type facilities «UKT» and «UK-250000» at the State Enterprise on radiation treatment of materials «Radma» were carried out (City Kyiv), 180 radiation sources of GIK-7-4 and VII type with general activity $3{,}7*10^{14}$ Bq were removed.

26 Decision of SNRIU Board №1 approved positive conclusion of the State expertise on nuclear and radiation safety of the Feasibility Study of the Fuel Fabrication Plant.

February

9 The Law of Ukraine of 9 February 2013 №4383-VI «On management with spent nuclear fuel as for siting, design and construction of centralized storage facility for spent fuel from NPPs with WWER type reactors» approved the decision on siting, design and construction of CSFSF.

15 Resolution of the Cabinet of Ministers of Ukraine №100 «Issues of siting, design and construction of nuclear accelerator driven facility «Neutron Source» based on sub-critical assembly» approved Feasibility Study for the construction of nuclear facility «Neutron Source» and approved its location on the territory of the industrial site of the NSC Kharkov Institute of Physics and Technology.

5-22 Luxemburg hosted first stage of «stress-tests» peer reviews and was dedicated to the discussion of the National reports of 15 EU countries including Ukraine and Switzerland.

March

2 SNRIU Order №51 approved «Requirements to the management system of operating organization (operator)» (NP 306.1.182-2012), which later were registered in the Ministry of Justice of Ukraine of 21.03. 2012 № 431/20744.

12 SNRIU Order №56 approved «General Provisions of Safety of Nuclear Subcritical Facility» (NP 306.2.183-2012), which later were registered in the Ministry of Justice of Ukraine of 27.04.2012 №640/20953.

13 Decision of SNRIU Board №7 approved the conclusion of the State expertise on nuclear and radiation safety of the Feasibility Study «Construction of power units № 3 and 4 with capacity 2000 MW at Khmelnitsky NPP».

13 Standard of the Enterprise SSE «Centralized Radioactive Waste Management Enterprise» on exemption of radioactive materials from regulatory control was approved, which allowed to start practical activities on the exemption of materials that were generated as a result of dismantling and fragmentation of systems and components of Chernobyl NPP units.

2012 in numbers

March

18-22 Final stage of peer reviews – «Country review» took place in Ukraine in frames of implementation of the ENSREG «stress-tests» for NPPs of EU and partner-countries Ukraine and Switzerland.

23 In frames of implementation of the Memorandum of understanding between the State Nuclear Regulatory Committee of Ukraine and Turkish Atomic Energy Authority (TAEK) for technical cooperation and exchange of information in nuclear regulatory matters Delegation of TAEK visited SNRIU.

27-30 Annual meeting of managers of regulatory authorities of Ukraine and Poland took place in Ukraine. Polish delegation was headed by the President of the National Atomic Energy Agency (NAEA) Mr. Janusz Wlodarski. The meeting took place in frames of implementation of the Agreement between the Government of Ukraine and the Government of the Republic of Poland on early notification of nuclear accidents, exchange of information in the area of nuclear safety and radiation protection of 24 May 1993.

28 Resolution of the Cabinet of Ministers of Ukraine №254 «On Changes to the Resolution of the Cabinet of Ministers of Ukraine of 6 December 2010 №1106» approved NSC Kharkov Institute of Physics and Technology as an operating organization (operator) of nuclear accelerator driven facility «Neutron Source» based on sub-critical assembly.

April

9 SNRIU Order №84 approved «Requirements to the assessment of the nuclear material accountancy and control system» (NP 306.7.184-2012), which later was registered in the Ministry of Justice of Ukraine of 27.04.2012 № 647/20960

17 The plan of activities on assembly and mounting of key metal constructions of east part of New Safe Confinement was approved. Practical activities started as well.

26 ENSREG approved final report on the results of the «stress-tests».

May

15 Ukraine presented National Report on fulfillment of the obligations in connection with the Joint Convention on the Safety of Radioactive Waste Management and on the Safety of Spent Fuel Management during 4th Review Meeting of Countries-Parties to the Joint Convention that took plaice in Vienna in the Headquarters of the IAEA.

June

8.06-1.07 Monitoring of nuclear and radiation safety and security was performed during UEFA Euro 2012.

2012 in numbers

June

27 Resolution of the Cabinet of Ministers of Ukraine № 437-p «Issues of siting, design and construction of Plant on fabrication of nuclear fuel for reactors WWER-1000» approved Feasibility Study «Construction of Fuel Fabrication Plant» and agreed decision on its location on the territory of Smolinsk area in Kirovograd region.

July

4 Resolution of the Cabinet of Ministers of Ukraine №498-p «On approval of Feasibility Study for construction of power units № 3 and 4 at Khmelnitsky NPP» approved Feasibility Study for construction of power units №3 and №4 of KhNPP.

13 A separate permission for commercial operation of the integrated automated control system of Shelter (IACS) was issued.

17 In frames of implementation of the Action Plan on Nuclear Safety Ukraine hosted joint IAEA and International group of experts on civil liability (INLEX) mission regarding issues of functioning of international regime on civil liability for nuclear damage.

18 The license for the construction of the disposal facilities of the first stage of Vector complex was reissued to new operator – SSE «MCEZ» (SSE «Management of Construction in Exclusion Zone»). SSE «MCEZ» was set by the State Exclusion Zone Management Agency as an operator on the stages of siting, design and construction of disposal facilities of the first stage of Vector complex in 2011.

18 A license was issued to the SSE «MCEZ» for the construction of the Centralized facility for long-term storage of the spent high-level radiation sources at the site of the «Vector» Complex.

August

6 SNRIU Order №153 approved «Provisions on the list and requirements to the format and content of the documents submitted to obtain a license for performance of separate types of activities in the area of nuclear energy use» (NP 306.1.185-2012), which later was registered in the Ministry of Justice of Ukraine of 29.08.2012 №1453/21765

27-31 In frames of the fulfillment of the obligations under the Convention on Nuclear Safety Ukraine took part in the 2nd Extraordinary meeting of Countries – Parties to the Convention that took place in the IAEA Headquarters. The purpose of the Meeting was to discuss actions taken and planned to consider lessons learnt after Fukushima Daiichi accident and enhancing the efficiency of the Convention on Nuclear Safety.

September

3-5 Radiation monitoring of the Kirovograd city and neighboring territories was carried out with assistance of the mobile radiological laboratory «RanidSonni».

6 The Law of Ukraine №5217-VI «On siting, design and construction of power units № 3 and 4 of Khmelnitsky Nuclear Power Plant» approved decision on siting, design and construction of power units № 3 and 4 of KhNPP

2012 in numbers

September

17-21 Delegation of Ukraine participated in 56th regular session of the IAEA General Assembly that was held in Vienna (Austria).

October

17 Agreement between the Cabinet of Ministers of Ukraine, the Government of Russian Federation and the Government of Hungary on transportation of nuclear materials between Russian Federation and Hungary through the territory of Ukraine was signed in Kyiv.

18 SNRIU Order №188 approved «Procedure of training and knowledge check on nuclear and radiation safety issues of the personnel of operating organization (operator) and legal entities involved as subcontractors by operating organization» (NP 306.1.187-2012), which later was registered in the Ministry of Justice of Ukraine of 31.10.2012 №1817/22129.

19 A Memorandum of cooperation between the State Nuclear Regulatory Inspectorate of Ukraine and Kirovograd Regional State Administration was signed.

16-19 Regional Workshop «Radiation protection and safety of radiation sources – international safety standards» was jointly organized by the IAEA and Ukraine in Kyiv at the Scientific Center of Radiation Medicine of National Academy of Medical Sciences of Ukraine.

2012

November

21 A Plan of activities on the first lift up of metallic construction of the New Safe Confinement was approved.

22 A Memorandum on cooperation between Sate Nuclear Regulatory Inspectorate of Ukraine and Dnipropetrovsk Regional State Administration was signed.

23 9th Meeting of the SNRIU Reactor Safety Council took place. The following issues were considered:

1) Supervisory activity at the stage of assembly works at the power units № 3,4 of the KhNPP

2) Supervisory activity at the stage of assembly works at the Nuclear Fuel Fabrication Plant;

3) Procedure for licensing of nuclear fuel, fabricated in Ukraine.

24 First lift up of the central elements of the east part of the New Safe Confinement was performed.

28 First license for manufacturing of radiation sources in part of cyclotron production of radioactive isotopes for medical applications was issued to the Clinical Hospital «Feofania» of the State Affairs Management Agency.

30 Decision of the SNRIU Board №16 approved positive conclusion of the State expertise on nuclear and radiation safety of the Preliminary Safety Analysis Report of the ISF-2.

in numbers

December

10 In frames of the State Visit of the President of Ukraine to the Republic of India (New Delhi) SNRIU Chairperson Ms. Olena Mykolaichuk and President of the Atomic Energy Board of India Shri S.S. Bajaj signed bilateral Agreement on exchange of technical information and cooperation in the area of nuclear safety and radiation protection.

12 International Workshop «Regulation of «orphan» and sensitive radiation sources. Experience and perspectives of Ukraine» was organized in Kyiv by the State Nuclear Regulatory Inspectorate of Ukraine with the support of the Swedish Radiation Safety Authority (SSM).

17 SNRIU Order №238 approved «List of radiation-dangerous objects in Ukraine that require Design Threat developed for facility» (NP 306.8.188-2013), which later was registered in the Ministry of Justice of Ukraine of 02.01.2013 №21/22553.

27 Decision of SNRIU Board №19 approved conclusion of the State expertise on nuclear and radiation safety of the Preliminary Safety Analysis Report of the accelerator driven facility «Neutron Source» based on sub-critical assembly.

2012

Nuclear safety after Fukushima Daiichi accident

Evolution of regulatory requirements

The System of requirements for the safety of the NPPs, outlined in regulatory documents of former USSR was launched in 60-ies of previous century. The basis of the normative documentation was «General safety provisions for NPPs in the process of design, construction and operation» (OPB-73), which entered into force in 1973. Two years earlier OPB-71 were approved (temporarily), which had the same title but were targeted for the limited purposes use only.

Safety («… safe protection of personnel and population from external and internal exposure, environment – from pollution by radioactive substances within admissible limits, both in cases of long-standing stationary operation and in case of emergency») was supposed to be secured even in the hardly probable emergency conditions, such as break of the flow circuit. In the process of NPP safety analysis all its equipment and systems should be divided into three groups: equipment for normal operation, protective devices and localizing devices.

The basis of safety – high quality of systems of normal operation, protective devices for prevention of normal operation systems failure, localizing devices that constrain the spread of radioactive substances, high qualification of personnel. Important attention is paid to the proper site selection, its distance from settlements, emergency preparedness. Safety should be provided in case of any single failure of normal operation system and lasting absence of information on failure of other device. Along with normal operation systems failure, the failure of one of the independent active protective devices and one independent localization device was reviewed.

It was discussed that NPP should be designed taking into account extreme natural events, for protective and localizing devices «passive» devices were recommended for use. It was required to submit in the design quantitative reliability analysis, analysis of probability of emergency situations, considered in the design.

High reliability of emergency protection systems should be achieved through high quality, parallelism*, inspections and tests, as well as standby power supply**.

Damage limits of fuel elements and related levels of environmental radioactivity should be defined in the design process. Operational regimes were also specified (with sufficient levels of uncertainty), which were supposed to include the damage of fuel elements. Detailed requirements to the design of the reactor core were established and were later transferred to the Rules on Nuclear Safety issued in a year.

Before the development of OPB-73 USSR already operated Biloyarska, Novo-Voronezhska and 1st line of Kola NPPs and several NPPs were under construction (Leningrad, Chernobyl, Kursk, Bilibinsk and Armenian).

In fact, OPB-73 started the history of normative regulation of NPPs safety in our country. Despite lots of differences in terminology, absence of fixed definition of the defense-in-depth protection, other differences from contemporary safety requirements, OPB-73 were applied for the design and successful operation in many countries with power units WWER-1000/302, WWER-1000/338 and WWER-440/213.

It is clear that only construction and operation experience allows to create normative documents that correspond to the modern time requirements. Therefore OPB-73 contained «List of norms and rules» to the «General safety provisions for NPPs in the process of design, construction and operation» with the note that «mentioned in the List norms and rules become effective as far as they are being developed and approved».

** – Parallelism means availability of two channels as minimum.*
*** – It should be mentioned free use of terminology in OPB-73. The document does not contain section «Terms and definitions» that could be explained by lack of attention to that issue and lack of agreed terminology in those years.*

And before that «….. it is allowed to follow norms and rules in force in the energy area» (Article 1.1.2, OPB-73).

Next step in the development of the NPP safety requirements was development of OPB-82 «Main provisions of NPP safety during design, construction and operation». The concept of safety did not change in comparison to the OPR-73, but a lot of innovations were introduced, which improved requirements and made them more specific.

For the first time key terms and definitions were introduced (however the terminology was different from the terminology in use now). Key safety functions were defined: management of fission chain reaction; heat removal from nuclear fuel; containment of radioactive substances within established limits. The term of operating organization was introduced – organization subordinated to the NPP, but its responsibility was limited by the provision of safe operation only*.

Introduced definitions: design accident (established by norms and rules and for which NPP safety is ensured by the design); maximum design accident (design accident with maximum severe initial event, established for each type of reactor) and hypothetical accident that does not have technical measures foreseen in the design to ensure NPP safety. A term maximum hypothetical accident (MHA) was also introduced – hypothetical accident that leads to maximum release of radioactive substances into the environment in case of fuel elements melting and destruction of localizing systems. It was defined that the list of initial events is given in technical safety substantiation and should be agreed with authorities of state supervision.

The term «systems important for safety» is clearly defined (systems of normal operation, damage of failure of which is an initial accident event and safety systems) as well as «safety systems» (systems intended for prevention of accidents and limitation of their consequences).

Requirements to the systems and components important for safety are defined – they should be designed, produced and assembled taking into account possible mechanical, thermal, chem-

** – Which corresponded in those times to the system of interaction in the management of national economy.*

ical and other actions that appear as a result of a design accident and site inherent natural events.

After accident at Chernobyl NPP OPB-82 was amended and the following was introduced: the necessity to carry out analysis of hypothetical accident the results of which should serve a basis for instructions as for actions in emergency situations and emergency plans; the necessity to create training centers; measures to prevent creation of dangerously explosive gas concentrations; means of radiation monitoring in case of hypothetical accident. Sentence about admissibility of positive high-intensity reactivity effect was deleted, which was one of the preconditions of the accident in 1986.

Accident at Chernobyl NPP in 1986 led to the considerable changes in regulation of nuclear safety. «Main provisions of safety of nuclear power plants» were developed and put into force – OPB-88

Section «Terms and definitions» was considerably enlarged. New terms were introduced: management of beyond design accident, pre-commissioning adjustments, physical and commercial commissioning, safety functions, elements, general reason failure, safety culture, commissioning, special norms and rules etc., that to a great extent enlarged definitions area and facilitated interaction in the process of NPP design and operation.

The document clearly defines that NPP safety should be ensured through consistent implementation of principle of defense-in-depth protection based on system of barriers to prevent expansion of ionizing exposure and radioactive substances and system of measures to protect these barriers.

For the design accident initial events and final states should be defined and safety systems are to be foreseen that allow to minimize consequences within the established limits. The term – maximum design accident was excluded.

Term «beyond-design accident» was introduced (terms «hypothetical» and «maximum hypothetical accident» were excluded). It is caused by initial events not considered in the design accidents or characterized by additional ones in comparison with design accident failures, mistakes of personnel that lead to severe damages (melt) of the core.

Also term «severe accident» was introduced (accident with damage of nuclear fuel) and the necessity to analyze scenarios of beyond-design accidents was established in order to define actions to manage such accidents and narrow their consequences. The obligatoriness of probabilistic safety analysis was introduced and targets of acceptability of analysis results and confidence estimation towards technical decisions in NPP design were established.

General requirements to the physical protection, fire safety, communication and notification means an other requirements were developed based on the results of ChNPP accident analysis.

OPB-88 contains classification according to the influence of systems and elements (meaning of «element» was introduced for the first time) on the safety with the purpose to define quality requirements. The term «special norms and rules on nuclear safety to be approved by the nuclear regulatory authority» was introduced. Principle of safety culture was put in practice.

The definition «Operating organization» was brought in compliance with the one used in world practice. The principle of non-delegated responsibility of Operating organization for the NPP safety and allocation of responsibilities between Operating organization and regulatory authority was put as a basis. Strict requirements towards Operating organization to poses a license issued by regulatory authority to perform certain type of activity were fixed.

In 2000 «General provisions of Safety of Nuclear Power Plants (OPB-2000)» were developed and put into force, which did not considerably changed OPB-88. Small corrections were related to the differences in management system and nuclear regulation in the state.

In eight years new version of the General provisions of safety of Nuclear Power Plants, OPBU-2008, was prepared and put into force. This document made changes to the content of NPP safety requirements, the structure of the document was changed with the purpose to outline key safety principles and criteria as in IAEA publication Basic Safety Principles for Nuclear Power Plants (INSAG-12).

Three Mile Island and Chernobyl NPP accidents made considerable impact on the development of the nuclear energy and caused considerable reconsideration of the safety requirements and it seemed that all possibilities of severe accidents were taken into account, But in 2011 accident at NPP Fukushima Daiichi showed one more weak aspect – practical impossibility to foresee in advance combination of initial events and sequence of their development, especially where the influence of the human factor is huge.

Accidents at Chernobyl NPP and NPP Fukushima Daiichi followed the scenario that was not considered in the design not because it could not be foreseen but because the reasons of future Chernobyl NPP accident were known many years before the accident and nobody did believe that it could happen. The same could be said about the NPP Fukushima Daiichi accident. The knowledge of the situation that could happen does not give confidence that all preventive measures will be taken. Low probability of the event does not give a guarantee that it will not happen («any probability could happen endless number of times»).

It is clear that namely human at all stages of NPP life cycle, from the design to decommissioning, is the most unpredictable part in NPP safety provision. The reason of all known severe accidents in a varying degree was human factor, although it revealed itself at different times, sometimes long before the accident. Therefore all possible initial events and their combinations, accidents scenario should be considered in the design, the design should also contain developed additional technical measures to safety systems to manage accidents in case when accident scale goes beyond the limits established for the safety systems. This understanding became crucial for the further upgrade of NPP safety requirements.

There are two principles of removal of accidents from the review in the design. First – deterministic – when internal characteristics of reactor self-protection allow to remove accident from the review simple because such accident could not happen. Another principle – probabilistic – states that it is necessary to seek probability not to exceed the limit of emergency release higher than 10^{-7} per reactor per year*. In case if this requirement is not fulfilled additional technical measures to manage the accident must be applied in order to minimize the consequences.

The process of improvement of requirements towards NPP safety provision, which is underway now is directed at:

** – According to the contemporary science and technique*

- *Improvement of efficiency of the barriers of defense-in-depth protection, provision of their independence and reliability in case of different initial events;*
- *Secured provision of NPP with electric power and removal of residual nuclear fuel heat during all time necessary to restore external infrastructure in case if it is destroyed as a result of natural or man-caused event;*
- *Provision of reliability of last barrier, hermetic containment of the reactor facility in the most severe or less probabilistic circumstances, including accidents with severe damage of the core, in order to prevent release of radioactive substances beyond NPP area.*

It should be noted that both regulatory authorities and operating organizations in the world came to a consensus as regards main safety criteria. It is necessary to avoid in case of any accident the release of radioactive substances beyond NPP area exceeding the established limits that will be followed by corresponding emergency response actions (sheltering or evacuation) and will limit in time and access area intervention measures. Of course, specific criteria will differ from country to country and depending from characteristics of NPP and the site where it is located. Now the process of improvement of NPP safety requirements based on mentioned approaches is underway everywhere.

Among new innovations there is a decision as regards consideration of potential changes in natural conditions of the site, which is planned to be compensated through increase of NPP characteristics reserve towards external events, such as earthquake.

The basis of philosophy and NPP safety practice – defense-in-depth NPP protection – remains inviolable. Moreover, severe accidents that happened in the past, showed that deviation from strategy of defense-in-depth protection leads to the unpredictable events, negative consequences for the safety. Therefore there are no reasons to speak about considerable review of concept or NPP safety requirements. Systematic improvement of requirements based on the gained experience of positive and negative aspects of NPP design and operation is underway.

Accident at Fukushima Daiichi NPP became a benchmark for safety reassessment of all NPPs in operation and revision of requirements for NPPs under construction or planned for construction.

SNRIU submitted for the review by the National Security and Defense Council an issue on safety enhancement at NPPs of Ukraine in the light of Fukushima Daiichi NPP accident. This issue was reviewed on 8th of April 2011 and the Decision of the Council was put into force by the Decree of the President of Ukraine on 12th of May 2011. This Decision foresees the introduction of additional measures to improve safety of power units at Ukrainian NPPs under circumstances of design and beyond design accidents and revision of normative documents on nuclear and radiation safety.

For Ukrainian nuclear power units in operation safety improvement is performed in frames of «Complex (joint) program on the improvement of safety level at power units of nuclear power plants».

For new power units a design should include concept of safety provision for all range of events including severe accidents, provision of necessary safety margins and continuous performance of safety functions based on application of independence principle and passive safety systems in accordance with modern requirements and international recommendations (in particular: IAEA Action Plan on Nuclear Safety, recommendations of Western European Nuclear Regulators Association (WENRA), Action Plan of European Nuclear Safety Regulators Group (ENSREG).

Accident at NPP Fukushima Daiichi stipulated the necessity to improve requirements towards NPP safety in case of extreme initial events and their combinations, guarantee of safety function performance under total blackout and loss of ultimate heat sink as well as management of severe accidents. There are topical issues remaining to be solved such as introduction of additional criteria and regulatory safety requirements that should be applied in the design of new power units (power units 3 and 4 at Khmelnitsky NPP).

SNRIU together with SSTC NRS performed comprehensive analysis of norms, rules and standards on nuclear and radiation safety taking into account lessons learnt from Fukushima Daiichi accident and developed proposals on improvement of legislation in force taking into account international experience. Based on the results of the analysis the works on the revision of the following documents are underway:

- *Requirements to the systems of emergency cooling and heat removal from nuclear rector to ultimate heat sink;*
- *Requirements to the quakeproof design and assessment of seismic safety of NPP power units;*
- *Requirements to the management with fresh and spent nuclear fuel of NPPs;*
- *Requirements to the localizing safety systems.*

The revision of basic normative document on nuclear and radiation safety НП 306.2.141-2008 «General provisions of safety of NPP» (OPB AS) started according to the following directions:

1. *Revision of approach towards management of severe accidents, review and introduction of acceptability criteria.*
2. *Review and introduction of severe safety margins towards enlarged scale of potential extreme natural and man-caused impacts/ combination of impacts.*
3. *Provision of continued performance of safety functions under conditions of total blackout and loss of ultimate heat sink.*

Management of severe accidents

Based on sad experience of severe accidents that occurred at NPPs at least three times during last 50 years and despite taken safety measures and systematic activity to enhance safety it should be noted that now it is impossible to predict and completely exclude possibility of severe accidents in future.

Taking this into account the design for new NPPs should demonstrate that severe accidents do not lead to radiological consequences that require evacuation of population.

The design should foresee the complex of measures on management of severe accidents, directed towards implementation of established criteria. Analysis of severe accidents should embrace full scope of reactor facility conditions and all potential sources of danger.

Safety margins

Safety margins in relation to the external impacts, which were laid during the design of NPPs of Ukraine are based on the existing knowledge and climate situation at that time in Ukraine. Current situation, connected with progressing climate change in the world and appearance of new kinds of extreme natural impacts not typical for the territory of Ukraine requires considerable revision and definition of new criteria for safety margins.

Existing margins according to seismic impacts, flooding, extreme temperature impacts, should be revised towards their considerable increase. Established safety margins should take into account forecast of climate development for the period not less than announced in the design power unit life time.

Provision of safety functions performance

One of the key lesson learnt after events at NPP Fukushima Daiichi is requirement to foresee in the design technical measures to provide for continuous performance of fundamental safety functions in case of total blackout and loss of ultimate heat sink.

During the design of safety systems the priority should be given to the systems that function based on passive principle and do not require interference of personnel and do not depend from other sources of energy and information.

20 November 2012 SNRIU Board Meeting took place. The issue «Safety criteria and requirements towards construction of new NPP power units in the light of accident at NPP Fukushima Daiichi» was considered and SSTC proposals concerning introduction of new requirements were approved.

In accordance with SNRIU Board Decision SNRIU and SSTC NRS experts organized on 25th of December 2012 professional discussions of WENRA document «Design safety of new NPP» and SSTC proposals concerning enhancement of NPP safety requirements. The main purpose of this discussion was to inform operating organization and discuss with experts key innovations in part of enhancement of safety requirements to NPPs under construction and planned for construction.

Stress-tests and their results

After Fukushima Daiichi NPP accident the majority of countries that operate NPPs carried out full scope safety reassessments of operating NPPs (stress-tests).

Ukraine joined initiative of the European Commission and ENSREG to carry out stress-tests at nuclear power plants and corresponding peer reviews in EU member-countries and EU neighboring countries. In 2012 all activity was concentrated on peer reviews of the stress-tests results and implementation of the «post Fukushima» measures on safety enhancement.

Stress-tests at NPPs of Ukraine

According to the WENRA approaches «stress-tests» – is a targeted reassessment of safety margins of nuclear power plants in the light of the events at NPP Fukushima Daiichi where detailed analysis of extreme natural events and their combinations that impact the performance of safety functions and can lead to severe accident should be performed.

The scope, methodology and period of implementation of the stress-tests at Ukrainian NPPs were approved based on technical specifications developed by ENSREG with the support of WENRA. For operating NPP power units targeted reassessment was performed for nuclear fuel in the reactor core, cooling pool and fresh fuel storage. For Zaporizhzhya NPP reassessment was performed for Dry Type Spent Fuel Storage Facility (DSFSF).

For Chernobyl NPP facilities stress-tests were performed for cooling pools of power units №1-3 of ChNPP and Spent Nuclear Fuel Storage Facility (ISF-1).

During the stress-tests deterministic approach was applied, where consecutive refusal of defense-in-depth protection levels is postulated despite probability of such refusals. All operational conditions of power units were analyzed, special attention was paid to the operational conditions most adverse to the consequences of impacts or safety functions refusals. The possibility of simultaneous impact on all nuclear facilities located at NPP site was considered.

Under the stress-tests the following was analyzed:

- *External extreme natural impacts (earthquake, flooding, fire, tornado, extreme high/ low temperatures, precipitation, strong winds);*
- *Loss of power supply and/or ultimate heat sink;*
- *Management of severe accidents.*

Operating organizations NNEGC «Energoatom» and SSE «Chernobyl NPP» in accordance with deadlines established by ENSREG carried out in 2011 stress-tests for NPP power units in operation and ChNPP facilities and presented their results for the review by SNRIU.

Main results of the stress-tests

As a result of the stress-tests for operating NPPs in Ukraine the following was concluded:

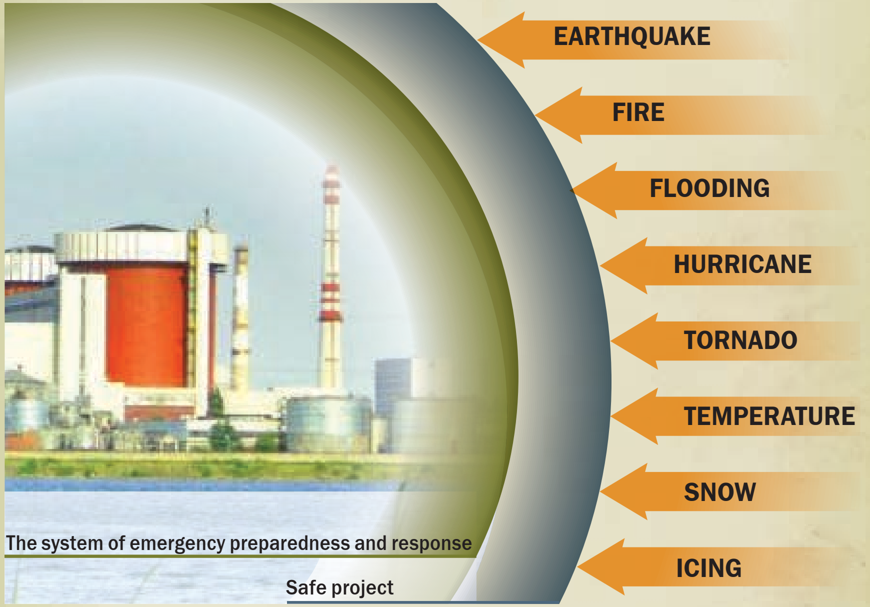
- *Sequence of accidents that took place at NPP Fukushima Daiichi is practically impossible for NPPs of Ukraine. Safety enhancement measures implemented during past 10-15 years at NPP power units to a great extent minimized possibility of core damage and emergency release of radioactive substances into the environment;*
- *No new critical external natural impacts and their combinations were revealed in addition to those considered in the NPP design and analyzed in Safety analysis reports of NPP power units.*

1) Based on the results of analysis of earthquake impact it was concluded that operating NPPs of Ukraine are designed with application of conservative principle and are robust to the design seismic impacts and have certain safety margins as well.

Equipment and pipelines, necessary to perform main safety functions are robust to the design seismic impacts. Main equipment, pipelines and safety systems of reactor facilities have safety margins. Activities on qualification of the NPP power units' equipment to seismic impacts are underway. In the process of qualification according to the IAEA recommendations peak ground acceleration was established at the conservative level – 0,1g.

Based on the analysis of flooding impact, including potential damage of hydraulic facilities as a result of earthquake it was defined that there are no risks of such kind of negative impacts for operating NPPs in Ukraine. NPP site levels have margins in relation to the potential growth of water level as a result of extreme flooding in the area of NPP location.

Figure 3.1. Evaluation of NPP resistance towards extreme natural impacts



According to the results of analysis of potential tornado impacts at the territory of Ukraine it was defined that tornados do not pose danger to the NPP buildings and constructions both directly and through impact of flying objects.

Results of other natural impacts analysis (external fire, extreme high/low temperatures, strong winds, snow, and combination of external extreme impacts) confirm robustness of NPP power units towards mentioned impacts.

2) In part of provision of reliable power supply it was concluded that for each NPP power unit in Ukraine the design foresees three independent channels of reliable power supply. Each channel includes diesel-generator and rechargeable cells. Each channel, taking into account configuration and consumer capacity, is capable to provide emergency reactor cooling.

Independence of three channels is achieved through total physical separation of channels including separate power supply and management. Moreover the design of each NPP foresees general unit system of reliable power supply that includes two channels with independent diesel-generators and rechargeable cells that support the operation of important equipment of one or more power units. In addition all NPPs have alternative possibility of power supply for own needs through connection to other (s) power unit (s) at the site, thermal power station, hydropower plant, storage plant located in the NPP area, high-voltage line VL-330, VL-750.

In order to provide long-term heat removal from reactors at Ukrainian NPP power units the following modernization measures were taken:

- *For NPPs with reactor facility WWER-440 (RNPP 1 and 2) additional independent emergency water feeding system for steam generators was installed (see figure 3.2);*

- *For NPPs with reactor facility WWER-1000 (ZNPP 1-6, RNPP 3 and 4, KhNPP 1 and 2, SUNPP 1-3) long terms feeding of demineralized water tanks and steam generators in emergency mode of primary circuit cooling with the loss of power supply for own needs was provided using fire hoses and mobile pumping (fire machines) (shown on figure 3.3).*

3) As regards management of beyond design accidents it should be noted that NPP power units have symptom-oriented emergency instructions in place. Actions of personnel in accordance with the instructions are directed to prevent accidents with severe damage of reactor core. Emergency plans are in place in the operating organization and nuclear power plants. Now NNEGC «Energoatom» is developing program on analysis of severe accidents and Guidelines on management of severe accidents at NPP power units.

The results of implementation of targeted reassessment of safety of operating NPPs were discussed at the SNRIU Board Meeting on 24-25 November 2011, which were also discussed in advance at the open meetings of the Reactor Safety Council and Public Council of the SNRIU.

Based on the results of the discussions SNRIU Board confirmed conclusions of the operating organization concerning

Figure 3.2. Additional independent system of emergency feeding to the steam generators at power units №1, 2 of RNPP

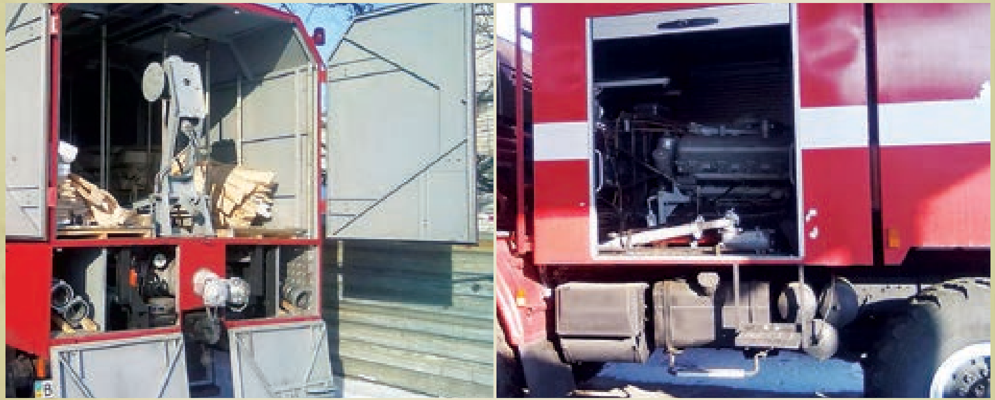
practical impossibility for Ukrainian NPPs to witness the sequence of events that took place at NPP Fukushima Daiichi and confirmed the fact that Safety analysis reports of NPP power units analyzed all possible external extreme natural impacts and their combinations.

The same as for the operating power units, safety reassessment was carried out for facilities of SSE «Chernobyl NPP». The results of assessment were discussed during SNRIU Board Meeting on 3 November 2011. It was stated that SSE «Chernobyl NPP» based on the results of the stress-test properly defined dangerous impacts, areas of future enhancement of safety of nuclear facilities and efficiency of emergency preparedness and response system was confirmed, which could in a most efficient way be used under circumstances of extreme natural impacts at the industrial site.

Peer reviews

Based on the reports of NNEGC «Energoatom» and SSE «Chernobyl NPP» SNRIU prepared National Report of Ukraine in accordance with the structure and content proposed by ENSREG. On 30 December 2011 National Report of Ukraine was submitted to the European Commission for further peer reviews. Organizational scheme of peer reviews is given on figure 3.4.

Figure 3.3. Mobile pumping (fire machines) to supply water to the steam generators in emergency modes in case of loss of power supply for own needs



Peer reviews of the National Report of Ukraine passed in 2 stages:

- *4-9 February 2012, Luxemburg – thematic review of National Report;*
- *18-22 March 2012, review mission to Ukraine including site visit to South Ukraine NPP.*

Statistic information about number of questions put by Ukrainian experts to national reports of other countries and number of questions received by Ukraine is given in figures 3.5 and 3.6. This data show the activity of Ukraine in thematic reviews of national reports.

In total 8 experts took part in the review mission at the SUNPP representing Great Britain (group head), France, Czech Republic, Italy, Bulgaria, Hungary and 2 EC experts. Three Ukrainian experts were included into groups that conducted peer reviews of stress-tests of Bulgaria, Spain, Romania, Finland and Czech Republic.

Based on the results of the peer review experts stated that National Report was developed in accordance with the requirements of ENSREG and contains enough evidence of NPP correspondence to the design criteria in terms of all external natural impacts.

In the peer review reports of ENSREG and final documents of EC Ukraine received following key recommendations:

- *Introduce on a systematic basis measure to enhance NPP seismic stability in order to secure timely implementation of the Comprehensive (Integrated) Safety Improvement Program – C(I)SIP);*
- *Foresee measures on feeding of the primary circuit, steam generators and cooling pool in case of total blackout and loss of the ultimate heat sink. Perform detailed analysis of of mobile equipment use;*
- *In part of severe accidents management – show achievement of key functions necessary to manage severe accidents (management of hydrogen concentrations, reliability of pressure reduction in the primary circuit, protection of reactor facility continement from overpressure, evaluation of persistence of main and auxiliary control panel in case of severe accidents etc.).*

It should be noted that recommendations to Ukraine correlate with general conclusions based on the results of the peer reviews in EU countries.

In general, the results of the stress-tests, State expertise on nuclear and radiation safety and peer reviews confirmed importance of measures to enhance safety of NPPs that already were included in the C(I)SIP and defined new areas for measures to provide for implementation of safety functions under circumstances of extreme impacts, possible multiple failures of equipment and management of severe accidents.

Steps after the stress-tests

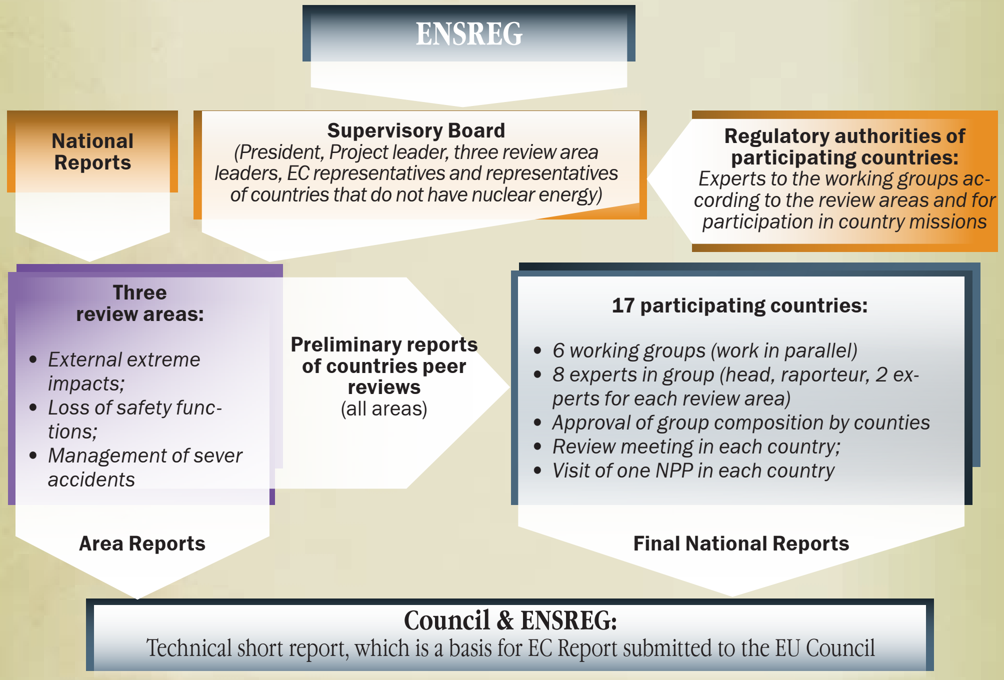
During 2012 NNEGC «Energoatom» performed implementation of measures defined as a result of the stress-tests. Within the C(I)SIP the following complexes of measures were underlined as «post Fukushima» ones:

- *Complex of measures to improve NPP robustness to seismic impacts;*

- *Complex of measures to provide for heat removal from the core and cooling pools under circumstances of total blackout and loss of ultimate heat sink;*
- *Complex of measures to manage severe accidents.*

The results of implementation of «post Fukusima» measures were reviewed at the SNRIU Board Meeting on 20 November

Figure 3.4. Organization of peer reviews



17 participating countries – 15 EU member countries, which operate NPP, Ukraine and Switzerland

2012.Based on the results of the discussions it was planned to include into C(I)SIP additional measures in part of severe accidents management, in particular:

- *Validation of computer codes;*
- *Implementation of strategies on localization of melt in reactor pressure vessel and within the limits of containment of reactor facility;*

- *Qualification of equipment involved in severe accidents management, in harsh conditions;*
- *Detailed analysis on the possibility of feeding of the primary circuit in case of an accident with the loss of power supply and/ or ultimate heat sink.*

Figure 3.5. Number of questions posted by Ukraine

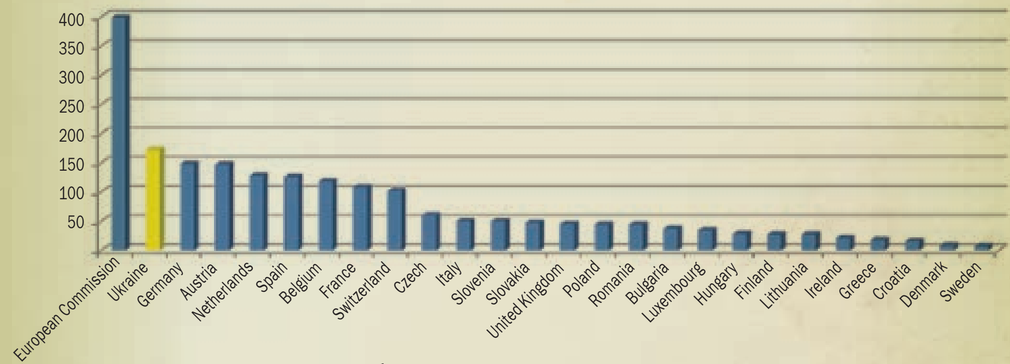
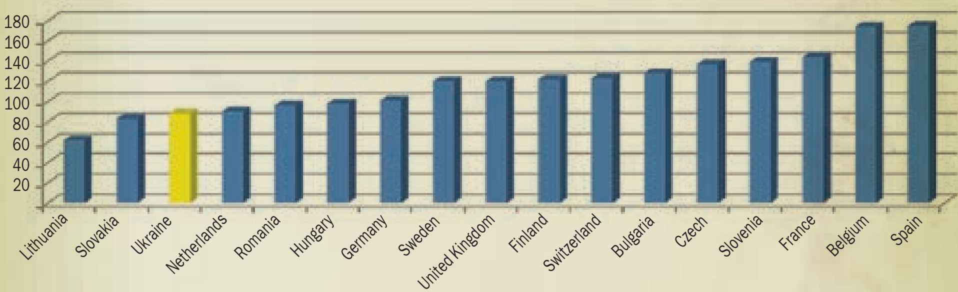


Figure. 3.6. Number of questions posted to Ukraine



SSE «Chernobyl NPP» implements measures after the stress-tests in frames of the agreed by SNRIU «Plan of measures on the enhancement of safety of ChNPP nuclear facilities based on the results of the stress-tests and safety assessment of spent nuclear fuel storage».

Ensuring safe operation of power units at NPPs of Ukraine in the light of lessons learnt from Fukushima Daiichi accident

Tragic events that took place at NPP Fukushima Daiichi on 11th March 2011 pushed all the world to reevaluate its attitude towards safety of NPPs.

In 2011 for all power units of Ukranian NPPs extraordinary safety reassessment was carried out (stress-tests), in frames of which operating organizations (NNEGC «Energoatom» and SSE «Chernobyl NPP») analyzed in details:

- *External extreme events (earthquake, flooding, fire, tornado, extreme high/ low temperatures, heavy precipitations, strong winds, combination of events);*
- *Blackout and/or loss of ultimate heat sink;*
- *Management of severe accidents.*

According to the results of the stress-tests it was defined:

- *Sequence of accidents that took place at NPP Fukushima Daiichi is practically impossible for NPPs of Ukraine. Safety enhancement measures implemented during past 10-15 years at NPP power units to a great extent minimized possibility of core damage and emergency release of radioactive substances into the environment;*

- *No new critical external natural impacts and their combinations were revealed in addition to those considered in the NPP design and analyzed in Safety analysis reports of NPP power units.*

At the same time analysis of events flow at NPP Fukushima Daiichi showed the necessity to revise the scope and priorities for implementation of separate measures and introducing new ones into the C(I)SIP to exclude the repeat of the events occurred at Fukushima NPP. In this regard the following was considered:

- *Introduction of system of hydrogen concentrations control within the containment for beyond-design accidents;*

- *Improvement of reliability of emergency power supply under the conditions of total blackout (mobile diesel-generators);*

- *Additional research of NPP sites seismic robustness and provision of seismic robustness of equipment, pipelines, constructions and buildings important for safety with the use of engineering margins;*

- *Performance of detailed analysis of severe accidents and development of guidelines on severe accidents management, etc.*

All these measures were additionally included into C(I)SIP and taking into account the importance of all measures for the safety the status of this program was advanced and corresponding amounts and sources of financing were defined.

The results of the extraordinary safety reassessment (stress-tests) and the results of the State expertise on nuclear and radiation safety were considered at the enlarged SNRIU Board Meeting (24-25.11.2011).

The meeting of the Board attended representatives of the public organizations, mass media, Secretariat of the Cabinet of Ministers of Ukraine, core committees of the Verhovna Rada of Ukraine, Ministry of Energy and Coal Industry, experts of the Russian Federation, Slovak Republic, Germany, Bulgaria and others.

As a result of discussions the Board Decision was approved. The Decision of the Board contains strict requirements and measures, the implementation of which is a prerequisite for SNRIU decision on NPP long-term operation. Among obligatory requirements there are :

- *Provision of robustness towards earthquake at the level not less than 0,1g – peak ground acceleration (for SUNPP site – 0,12g) of the equipment, pipelines, buildings and constructions necessary for the implementation of critical safety functions *);*

- *Provision of performance of safety function by equipment in «harsh» environment;*

** – Critical safety functions means:*
Safe shutdown of the reactor and maintenance of it in safe condition;
Heat removal from the reactor core and cooling pool;
Prevention of the release of radioactive substances into the environment

- *Introduction at the power units of the emergency pressure relief of gas-vapor mixture from the containment dome;*
- *Implementation of measures on feeding of steam generators and cooling pools under the conditions of long-term NPP blackout and/ or loss of ultimate heat sink;*
- *Introduction of guidelines on beyond-design accidents management (where severe damage of fuel will be covered) and symptom-oriented instructions on elimination of accidents at the reduced capacity level and during planned maintenance, etc.*

Process of safety reassessment of NPP power units and the activity of the operating organization on their long-term operation, in particular power units № 1, 2 of SUNPP and №1, 2 of ZNPP, is under severe supervision of the SNRIU.

At the end of 2013 30 year period of operation of power unit №1 of SUNPP will come to an end. According to the legislation in force the decision on NPP long-term operation is taken by the SNRIU based on the results of the safety reassessment, submitted by the operating organization within Periodic Safety Reassessment Report (PSR).

PSR is prepared after a number of important works is completed, which are related to the:

- *Activities on evaluation of the technical condition of equipment, pipelines, buildings and constructions important for safety and evaluation of their potential operation beyond the designed lifetime taking into account ageing factor;*
- *Removal of deviations from norms and rules on nuclear and radiation safety, which came into force during last several years;*
- *Implementation of measures on safety enhancement in frames of C(I)SIP ;*
- *Qualification of equipment for «harsh» environment and seismic impacts, etc.*

During 2012 the implementation of above mentioned conditions and their corresponding reflection in PSR was examined mostly

for unit №1 of SUNPP. The results of implementation were discussed at the SNRIU Board Meetings (held on 20.04.2012 and 20.12.2012).

The Decisions of the Board state that there are no technical aspects revealed that could indicate impossibility of long-term operation of unit №1 of SUNPP, however several issues were remained open, in particular:

- *Considerations of NPP Fukushima Daiichi lessons;*
- *Development and introduction guidelines on severe accidents management;*

Figure 3.7. Period of operation of Ukrainian NPPs.

NPP	Unit	Reactor type	Date of commercial start-up	Design lifetime expiration date
ZNPP	1	WWER-1000/320	10.12.1984	10.12.2014
	2	WWER-1000/320	22.07.1985	22.07.2015
	3	WWER-1000/320	10.12.1986	10.12.2016
	4	WWER-1000/320	18.12.1987	18.12.2017
	5	WWER-1000/320	14.08.1989	14.08.2019
	6	WWER-1000/320	19.10.1995	19.10.2025
SUNPP	1	WWER-1000/302	31.12.1982	02.12.2013
	2	WWER-1000/338	06.01.1985	06.01.2015
	3	WWER-1000/320	20.09.1989	20.09.2019
RNPP	1	WWER-440/213	22.12.1980	22.12.2010 / 22.12.2030
	2	WWER-440/213	22.12.1981	22.12.2011 / 22.12.2031
	3	WWER-1000/320	21.12.1986	20.12.2016
	4	WWER-1000/320	10.10.2004*	01.04.2034
KhNPP	1	WWER-1000/320	22.12.1987	21.12.2017
	2	WWER-1000/320	07.08.2004*	01.11.2034

- *Prevention of explosive dangerous gas concentrations in the premises of localizing safety systems;*
- *Reduction of impact on containment in case of severe accident;*
- *Qualification of equipment for operation in «harsh» environment and seismic impacts, etc.*

All above mentioned measures are foreseen for implementation in frames of C(I)SIP with statement of exact implementation period, which is not expired.

The same approach is applied by the SNRIU towards all power units of Ukrainian NPPs. The status of implementation of obligatory conditions for long-term operation is checked also for power units №2 of SUNPP and №1 and 2 of ZNPP. For these power units implementation of safety enhancement measures, qualification of equipment, evaluation of technical condition, is underway. The reporting documents are submitted to the SNRIU on a periodic basis to pass State expertise. It should be also mentioned that for ZNPP site tool research of seismic risks is still underway, the result of which along with engineering margins will allow to define seismic level of ZNPP site.

Chernobyl NPP and Exclusion Zone

Chernobyl exclusion area and area for unconditional (obligatory) resettlement (further – Exclusion Zone) – part of territory of Ukraine polluted with radionuclides as a result of Chernobyl disaster, which population was resettled during first years after the accident. At the territory of the Exclusion Zone there is a large number of radioactive waste (RW) and facilities for RW management, Chernobyl NPP under decommissioning together with the Shelter in the process of transformation into the safe system. In the Exclusion Zone a complex infrastructure for spent fuel and RW management is being developed in connection with large number of waste accumulated after ChNPP accident in 1986 and waste that is generating and will be generated in the process of ChNPP decommissioning and Shelter transformation into environmentally safe system. This infrastructure foresees safe management of spent fuel and radioactive waste from the moment of their removal till long-term storage and disposal. In order to provide for implementation of the above mentioned tasks, including creation of RW management infrastructure there are several national programs in force: National Program on Chernobyl NPP decommissioning and Shelter transformation into environmentally safe system and National environmental program on radioactive waste management.

Implementation of actions at the Shelter and creation of new safe confinement

According to the National Program on Chernobyl NPP decommissioning and Shelter transformation into environmentally safe system all activities at the Shelter are directed at its transformation into environmentally safe system.

All transformation activities are included into plans, projects and programs. The most comprehensive among them is international project – Shelter Implementation Plan (SIP). In 2012 a considerable progress was achieved in implementation of the main SIP project – New Safe Confinement (NSC). During last year considerable steps were made towards completion of the projects on integrated automated Shelter monitoring system (IAMS), fire protection system and system of physical protection.

Creation on New Safe Confinement

Confinement – is a protective construction that includes complex of equipment for removal of materials that contain nuclear fuel from destroyed power unit №4 of ChNPP, management with RW and other systems to be used for transformation of this power unit into environmentally safe system and provision of safety of personnel, population and the environment.

Works on the development of the detailed design, construction and commissioning of first NSC start-up complex* (NSC SC-1) are performed by SSE ChNPP Contractor – Novarka Consortium.

For information.

Novarka Consortium implements NSC SC-1 through separate projects divided into 6 Licensing Packages (LP):

- *LP-1: Cleaning, preparation of industrial site (completed);*
- *LP-2:Construction of on-site facilities (completed);*
- *LP-3: Temporary foundations (construction of foundations completed in the assembling area, construction of foundations in transportation area is underway);*
- *LP-4: Dismantling of the ventilation pipe (removed from the scope of Novarka works);*
- *LP-5: First part of NSC SC-1 – NSC arch, arch foundation, lining, crane system (after expertise LP-5 was agreed with restrictions);*
- *LP-6: Second part of NSC SC-1 – NSC project as a whole with supporting systems (in October 2012 comprehensive design expertise was started);.*

In 2011 Novarka completed the development of the first part of detailed design of the NSC SC-1 (LP-5).

** – First NSC start-up complex (NSC SC-1) – a protective building with process support systems and required infrastructure (strategy for further implementation of NSC project).*

SNRIU performed State expertise on nuclear and radiation safety of the LP-5 materials and on 18 November 2011 issued separate written permission for performance of works with restrictions related to the main cranes system.

In April 2012 practical activities on assembly of metal constructions of east part of the NSC arch started. On the 24th November first successful lift-up of the central arch fragments was performed at the 22 meters height. Since total height of the arch constitutes 108 meters two more lift-ups are foreseen of the fragments of east part of arch in accordance with the design, in total – six lift-ups.

Figure 4.1. First lift-up of NSC metallic constructions

Among other activities that were performed at the SSE ChNPP in frames of NSC project testing and assembly of the NSC roofing should be mentioned as well, including test of service area foundation piles, work on removal of out-of service communications in the area of transportation zones foundation settlements, performance of preparatory works for construction of confinement in the Shelter local zone, etc.

Works on the assembly of metal constructions of the arch are performed at the specially equipped platform located within the limits of the Shelter industrial site at the distance of 250 meters west from the Shelter. Special conditions are created at this platform and a set of measures is defined that allows to maintain free regime zone. Such regime gives easy access of personnel to the platform to perform works with minimized means of personal protection, which in its turn improves efficiency and quality of works.

During last year SNRIU along with technical support organization performed technical evaluation of designs, technical specifications for the internal and external lining of the NSC arch, safety important quality control procedures, etc.

In 4th quarter of 2012 SNRIU performed expertise on nuclear and radiation safety of the materials of LP-6 (NSC SC-1 as a whole) and amendments of the LP-5 related to the system of NSC main cranes.

Implementation of other projects at the Shelter in 2012.

Integrated automated Shelter monitoring system (IAMS).

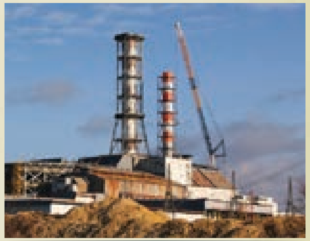
IAMS is targeted to monitor nuclear safety parameters in the place of accumulation of fuel containing materials within the Shelter, which were generated after accident at unit №4 of ChNPP, parameters of radiation situation, condition of Shelter constructions, seismic events within ChNPP site.

On 13 July 2012 SNRIU issued separate permit OD № 000033/4 to perform works on commissioning of the Integrated automated Shelter monitoring system, which will be conducted in two stages: pilot operation and acceptance tests.

New ventilation pipe of the ChNPP second line.

In March 2012 assembly of the new ventilation pipe of the second ChNPP line (NVP) was completed. In July the group of experts revealed capillary cracks at several parts of NVP tower.

Based on the results of inspection at SSE ChNPP all activities at the NVP were stopped except for the works on survey of the technical condition of the NVP, and research on the reasons of



appearance of defects in the construction. SNRIU ordered SSE ChNPP to develop schedule of actions on NVP survey, reveal of causes and control over construction defects, defining of conditions of NVP functioning etc. Implementation of these measures is under control of SNRIU.

Also during 2012 creation of Shelter fire protection system (SFPS) was completed and system of physical protection was put into operation.

Creation of infrastructure for management of radioactive waste and spent nuclear fuel

Implementation of state strategy in the area of radioactive waste management is performed in accordance with Strategy on radioactive waste management in Ukraine, National environmental program on radioactive waste management and National Program on Chernobyl NPP decommissioning and Shelter transformation into environmentally safe system. The Strategy foresees the creation and efficient functioning in Ukraine of the integral system of RW management that will allow to achieve safe management (including disposal) of RW of all types and categories that were accumulated in previous times, still generating in the process of nuclear energy use and will be generated in future. The Strategy includes organizational and technical measures directed at management of so called «post Chernobyl» waste, localized in the Exclusion Zone at the SSE ChNPP site. In the Exclusion Zone at the ChNPP site and at the site of Vector Complex a number of new facilities for RW management are being constructed: for removal of RW from existing temporary storage facilities, sorting, processing and conditioning of RW, new facilities for RW storage, near surface storage facilities for conditioned RW.

Creation of infrastructure for RW management at the site of SSE ChNPP.

Large volume of solid and liquid RW of different activity is accumulated at the Chernobyl NPP since accident in 1986 and as a result of power units operation. At present there approximately 2500 m^3 of solid RW and 19 810 m^3 of liquid RW that are stored in the specialized facilities.

At the site of the ChNPP Liquid Radwaste Treatment Plant (LRTP) and Industrial Complex for Solid Radwaste Management (ICSRM) were constructed within international assistance project and now are under commissioning. The commissioning of these facilities will allow to provide for processing, conditioning of accumulated and generated RW.

The commissioning of **LRTP** will provide for processing of all types of liquid RW from ChNPP (vat residue, ion-exchange resin, etc.) and receive of packages with cemented RW ready for disposal. The design capacity of the plant – processing and conditioning of 29,6 m^3 of liquid RW per day. It is envisaged that during 10 years of operation all accumulated liquid RW at the ChNPP site will be conditioned. During 2012 the minor modification of the design continued. The modernization touched radiation control system, systems of removal and processing of liquid RW, automated system of technological process management.

ICSRM includes:

- ***Solid Radwaste Retrieval Facility***, *designed to remove solid RW from existing ChNPP RW storage facility;*

- ***Solid Radwaste Treatment Plant***, *designed for sorting and processing (fragmentation, incineration, cementing) of ChNPP solid RW. Processed RW will be placed and cemented in ferroconcrete containers 3 m^3 for further disposal. Revealed during sorting process high activity and long lived RW will be placed in special metal barrels and will be transported for interim storage. Design capacity of the plant – sorting and processing of 3500 m^3 of solid RW per year.*

In 2012 commissioning activities were underway at the plant. The purpose of these activities was to adjust equipment for sorting and characterization of solid RW and adjustment of RW processing technological systems.

ICSRM also includes temporary storage facility for low- and medium level long lived and high activity RW intended for interim storage (during 30 years) of long lived and high activity RW.

Now this facility is ready for operation.

However in 2012 RW acceptance and further placement for storage in facility modules was not performed because of the unavailability for commissioning of the Solid Radwaste Treatment Plant.

According to the «Integrated Program on Radwaste Management at ChNPP» in order to provide for proper decommissioning activities the following facilities are under construction:

- *Facility for grinding of long seized RW, special devices, elements of reactor core that worked out the design life-time;*
- *Facility for cleaning of liquid RW from transuranium elements and organic substance;*
- *Complex for production of metal barrel and ferroconcrete containers for RW;*

It is also planned to construct:

- *Facility for characterization of dismantled equipment with the purpose to substantiate release from regulatory control.*

Creation of infrastructure for management with RW at the territory of the Exclusion Zone

Vector Complex.

The site of the Vector Complex is located in the Exclusion Zone at the distance of 17 km south-west direction from Chernobyl NPP.

Vector Complex is a manufacturing complex for decontamination, transportation, processing and disposal of RW. The construction of the Complex started in 1998 and is performed in two stages.

Vector Stage 1 is designed for disposal of RW, generated as a result of Chernobyl NPP accident. Start-up complex of Stage 1 includes storage facility for RW disposal in ferroconcrete containers (SRW-1) and module-type, for disposal of radwaste in bulk (SRW-2) and the required infrastructure facilities.

Operating organization at the stages of site selection, design and construction of storage facilities for RW disposal at the Vector Complex is State Specialized Enterprise «Management of Construction in Exclusion Zone» (SSE MCEZ). SSE MCEZ completes now construction activities at the facilities SRW-1 and SRW-2 and equipment of necessary infrastructure facilities including car wash, radiological laboratory and sanitary inspection room.

At the Vector site there is also an engineered near-surface disposal facility for solid RW (ENSDF) designed for disposal of conditioned Chernobyl NPP radwaste, with the capacity of 55 000 m^3. While plants for processing of Chernobyl NPP RW do not produce packages of conditioned RW activities to maintain systems and equipment at facilities are performed. The possibility of disposal in ENSDF of RW from specialized enterprises UkrDO «Radon» is under consideration now.

Figure 4.2. The site of Vector Complex– main facilities of the Start-up complex of Stage 1 and ENSDF

According to the Feasibility Study of the Stage 2 of Vector Complex, approved by the Resolution of the Cabinet of Ministers of Ukraine, Vector Stage 2 foresees the construction of the complex of facilities for RW management:

- *Centralized near-surface storage facilities for disposal of RW, generated during operation of NPPs of Ukraine and accumulated at the sites of state specialized enterprises on RW management UkrDO «Radon»;*

- *Facility for processing of Chernobyl origin RW and RW from the sites of UkrDO «Radon»;*
- *Facilities for long-term storage of high-activity and long-lived RW, including facilities for long-term storage of vitrified RW that will be returned from Russian Federation after processing of spent nuclear fuel from Ukrainian NPPs;*
- *Centralized facility for long-term storage of spent high-activity radiation sources.*

During 2012:

- *the construction of the Centralized facility for long-term storage of spent high-activity radiation sources (SFLSRS) is underway. This facility should provide for centralized location of all amount of spent radiation sources accumulated up to date at the sites of UkrDO «Radon» and still in the use in medical institutions and industrial enterprises;*
- *the activities on the design of the storage facilities for high-activity and long-lived intermediate activity RW started.*

Existing facilities for RW management at the territory of the Exclusion Zone

During implementation of the primary measures on elimination of the accident at Chernobyl NPP a number of facilities for the disposal and localization of big amount of emergency RW was constructed at the territory of the Exclusion Zone during 1986-1987. These are facilities for RW disposal – the Buryakivka RWDS, the Pidlisny RDWS, ChNPP Stage III RDWS and radwaste interim confinement sites (RICS).

Operation and introduction of measures to maintain safety level of the facilities is performed by the operating organization on RW management at the stage of long-term storage and disposal – SSE «Centralized Enterprise of Radwaste Management» (SSE «CERWM»), taking into account conditions of license issued by the SNRIU, separate permissions, approved design and technical decisions.

Buryakivka RWDS is operated since 1987. Buryakivka RWDS is composed of the 30 near-surface storage modules (trenches) for RW disposal. Main engineering barrier that provides for localization of radionuclides is special clay protective layer of 1 meter thickness. Since the operation start-up of the Buryakivka RWDS approximately 1330,5 thousand tons (665,25 thousand m^3) of Chernobyl origin RW were located in the trenches with total capacity 2,53E^{15} Bq.

Now, in connection with expiration of design service life of the Buryakivka RWDS the possibility of reconstruction of Buryakivka RWDS is under review. The purpose of the reconstruction is to create additional capacities for disposal of low-level RW, which

Figure 4.3. Implementation of conservation activities at the Pidlisny RDWS.

will be generated during future activities at ChNPP, Shelter and Exclusion Zone. In order to substantiate possibility of reconstruction operating organization performs now reassessment of Buryakivka RWDS as it is now and reassessment of potential reconstruction.

Moreover, at the special equipped site at the territory of Buryakivka RWDS there is a contaminated machinery used during elimination of consequences of Chernobyl accident. In 2012 SSE «CERWM» started activities on dismantling and fragmentation of the machinery in accordance with technical decisions agreed by the SNRIU.

Pidlisny RDWS and **ChNPP Stage III RDWS** were constructed during first years of after Chenobyl accident. These facilities contained the most dangerous high-activity and long-lived emergency RW. In future all RW will be removed and re-disposed in geological storage facilities. Before the construction of such geological disposal facility the safety of existing facilities should be maintained. With this purpose in 2012 activities were carried out to protect from degradation and support necessary localizing functions of the engineering barriers of these storage facilities, to create additional barriers and improve monitoring system.

At the territory of the Exclusion Zone there are nine RICS: Yaniv Station, Naftobaza, Pischane Plato, Rudy Lis, Stara Budbaza, Nova Budbaza, Prypyat, Kopachi and Chystogalivka. The total area of RICS is 10 ha. There are trenches and pits with RW on the RICS territory. The estimated number of trenches and pits is 1000. There are no maps showing the location of trenches and pits or data on radwaste placed in them. Therefore activities on investigation of RICS are underway in order to take substantiated decision on their further management (conservation, closure, removal, re-disposal etc.).

The decision on the liquidation of trenches and pits of RICS will be taken first of all for the territories where season flooding may take place and the territories where activities on ChNPP decommissioning and Shelter transformation are carried out. In 2012, in accordance with agreed by SNRIU Technical decisions, the activities on re-disposal of trenches and pits of RICS Nova Budbaza and RICS Naftobaza were carried out.

Management with spent nuclear fuel and radioactive waste at the Chernobyl NPP.

At the site of Chernobyl NPP there is spent nuclear fuel stored in the amount of 21284 spent fuel assemblies (SFA). There is no fresh nuclear fuel at the site of ChNPP.

The majority of SFA's is stored in the cooling pool of Wet Spent Fuel Storage Facility (ISF-1), which was commissioned in 1986. At present operation of ISF-1 is performed according to the license of SNRIU № 000859 issued on 25.06.2008.

The rest spent nuclear fuel is stored in the cooling pools of units №№ 1 and 2 of ChNPP.

There is no spent nuclear fuel at the power unit № 3 of ChNPP and further use of the cooling pool of this unit is not envisaged. Considering the above, SNRIU agreed on 07.12.2012 the Decision of SSE ChNPP «To consider power unit №3 as a facility for radwaste management». Therefore, starting 08.12.2012 unit № 3 of ChNPP is considered as a RW management facility.

According to the results of the stress-tests carried in 2011 for units №№ 1,2,3 and ISF-1 the SSE ChNPP developed and agreed with SNRIU:

- *«Action Plan of safety enhancement of SSE ChNPP nuclear facilities (AP NF ChNPP)»;*
- *«Decision on placing for storage within 5th module of the cooling pool of ISF-1 of spent nuclear fuels (with except for damaged fuel) accumulated during operation period of units №№ 1,2,3».*

In accordance with the last decision all spent nuclear fuel is planned to be located for storage in the cooling pool of the ISF-1 and cooling pools of units №№1,2, will be used as a backup.

Figure 4.4. Facility for ISF-2 spent fuel preparation

On 30.11.2012 SSE ChNPP completed removal of non-damaged spent nuclear fuel from cooling pool of unit №2 to the cooling pool of ISF-1 and started removal of spent nuclear fuel from the cooling pool of unit №1.

The designed life-time of ISF-1 will end in 2025. Therefore new dry-type storage facility (ISF-2) is under construction at the site of ChNPP in order to provide for long-term safe storage of all spent nuclear fuel.

On 30 November 2012 SNRIU Board approved (Decision № 16) the conclusion of the State expertise on nuclear and radiation safety of the Preliminary Safety Analysis Report of ISF-2 and SSE ChNPP received positive expert report of the SE «Ukrderzhbudekspertiza» on 30.11.2012 № 00-1525-12/PB.

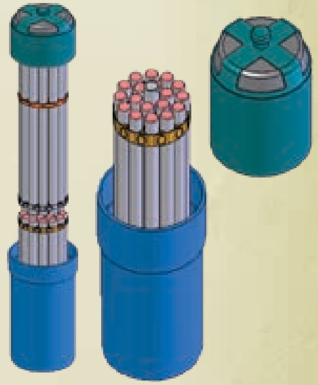


Figure 4.5. Fuel cartridge

On 7 December 2012 the Order of SSE ChNPP №946 approved «Design for completion of ISF-2 construction».

Now SNRIU reviews SSE ChNPP license application for construction and commissioning of ISF-2.

Further process of ISF-2 licensing foresees review and agreement by SNRIU of technical specifications for the equipment important for safety.

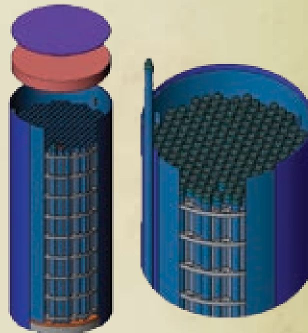


Figure 4.6. Double-walled dry shielding case.

After commissioning of ISF-2, which is planned in 2015, spent nuclear fuel from ISF-1 will be removed to ISF-2.

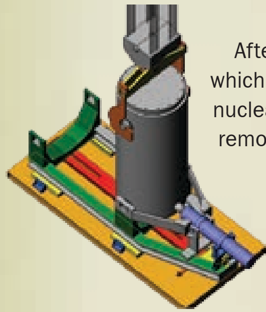


Figure 4.7. Putting of DDSC with spent fuel on platform for transportation to the fuel storage area

ISF-2 design foresees the following procedure of spent nuclear fuel management:

1. First, spent nuclear fuel will come to a facility for preparation of spent fuel for storage, where each fuel assembly will be cut into 2 parts (bunch), each bunch will be put into special fuel cartridge.
2. Later cartridges will be set in double-walled dry shielding case (DDSC) – big double-walled hermetic container from stainless steel for 186 fuel cartridges.
3. DDSC, after filling with fuel cartridges containing SFA butches, will be transferred to the special facility for complete draining of the spent fuel and filling of the case with rare gas – helium.

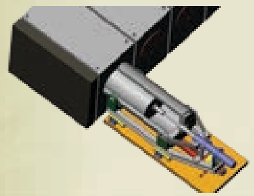


Figure 4.8. Putting of DDSC with spent fuel into CSM

4. *After draining, filling with gas and hermetic check DDSC will be moved to the spent fuel storage area and will be placed in concrete storage module (CSM).*

5. *In CSM the DDSC with spent fuel will be stored during 100 years.*

Figure 4.9. Concrete storage module in the fuel storage area of ISF-2

Moreover ISF-2 design foresees:

- *Possibility to withdraw DDSC out of CSM for technical review and re-packaging (if necessary);*
- *Facilities for treatment with damaged spent nuclear fuel.*

New facilities

Nuclear fuel fabrication plant

Creation of fuel fabrication plant for reactors WWER-1000 is one of the priorities of nuclear energy development, supported by the «Energy Strategy of Ukraine till 2030», State economic program «Nuclear Fuel of Ukraine» and other Governmental decisions approved in connection with Energy Strategy.

Commissioning of the fuel fabrication plant will reduce the dependence of energy fuel of Ukraine from external suppliers of nuclear fuel and will increase energy safety of the country.

In accordance with Article 1 of the Law of Ukraine «On the Use of Nuclear Energy and Radiation Safety» nuclear fuel fabrication plant (further – Plant) is a nuclear facility and as any other nuclear facility requires implementation of all complex of measures on safety assessment and licensing.

Following the Law State Concern «Nuclear fuel» developed Feasibility Study of the Plant (FS) where necessity of construction of this facility was confirmed and the site for plant location was chosen (out of three possible).

For information

In the process of site selection three options were considered: city Slavutich, Kiev region, village Smolino, Kirovograd region and village Zhovti Vody of Dnipropetrovsk region.

Comparative analysis of sites showed that Smolino site and Slavutich site are almost the same and satisfy all safety requirements. At the same time more advantageous is Smolino site, which allows to minimize the distance of fuel assemblies transportation to the NPPs of Ukraine.

On 29.10.2011 in Smolino village public debates were held as regards the Plant location. During these debates population *of village expressed almost unanimous support towards the construction of the Plant.*

SNRIU performed State expertise on nuclear and radiation safety of the FS, and the conclusion was approved by the Decision of SNRIU Board №1 of 26.01.2012.

Figure 5.1. Model of nuclear fuel fabrication plant.

On 27.06.2012 FS and the selected site were approved by the Resolution of the Cabinet of Ministers of Ukraine №437.

According to the FS the construction of the Plant will be performed in two stages:

- *2012 – 2015 – first line – fabrication of fuel elements, fuel assemblies and components;*
- *2016 – 2020 – second line – production of uranium dioxide powder (UO_2) and fuel pallets.*

Design capacity of the Plant – 800 FA/year.
Moreover, during 2012 SNRIU agreed the following documents:

- *«Terms of Reference for the Design of the «Fuel Fabrication Plant»;*
- *«Recommendations to the structure and content of the safety analysis report of the facility on nuclear fuel fabrication»;*
- *«Licensing plan of fuel fabrication plant».*

Next steps will be development of the design and preliminary safety analysis report.

Neutron Source (NSC Kharkov Institute of Physics And Technology)

Nuclear subcritical facility «Accelerator driven facility «Neutron Source» based on sub-critical assembly» (further – Neutron Source) is being created on the basis of National Scientific Center «Kharkov Institute of Physics and Technology» (NSC KIPT) in accordance with agreement reached during Washington Security Summit and outlined in the Joint Statement of the Presidents of Ukraine and USA in April 2010 and Memorandum of understanding between the Government of Ukraine and the Government of the United States of America on cooperation in the area of nuclear security, signed on 26 September 2011. Implementation of the Project Neutron Source is performed under the support of the Argonne National Laboratory of USA.

Neutron Source according to the IAEA terminology is a nuclear subcritical system, driven by accelerator (Sub-critical accelerator driven systems). Ideas to use subcritical assemblies in nuclear energy appeared in mid 50-ies of the last century. But actual application of such systems was restrained by the absence of corresponding capacities for neutron generation. Increase of research activity in the world as regards subcritical assemblies is connected with the development of accelerator physics and techniques, development of nuclear energy and the necessity to carry out research of subcritical systems as well as research in different areas of science and medicine.

Neutron Source is innovative nuclear facility with power production in the core up to 300 kW. Existing facilities in Belgium, China, Belarus are so-called subcritical systems of «zero capacity». At the same time consortium of European countries (Belgium, France, Sweden, Germany) is planning to create subcritical system Myrrha with heat capacity 100 MW, and China is planning to create facility Venus III with heat capacity 60 MW.

Neutron Source of the NSC KIPT is aimed at scientific and applied research in the nuclear physics, radiation metal science, biology, chemistry and for production of medical isotopes.

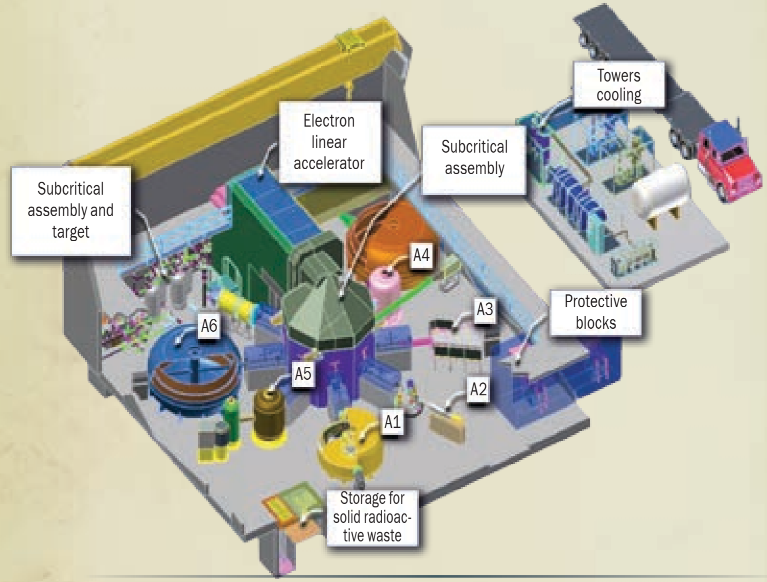


Figure 5.2. Location of main equipment

The principle of gaining the intense neutron flux in the Neutron Source is based on the multiplication of neutrons of external source within the environment containing nuclear material. The geometry of location and mass of nuclear material in use is defined in the following way – efficient neutron multiplication factor ($K_{ef\,max}$, key indicator of condition of nuclear system) was less than 1 at any initial event to exclude possibility of self-sustaining fission chain reaction. For normal conditions of operation, violations of normal operation and design accidents $K_{ef\,max}$ must be less than 0,98.

In Neutron Source to support fission reaction neutron-accelerator target is used (tungsten or uranium), where neutrons are

generated as a result of photonuclear reaction at γ – high-energy radiation ((γ,n) – reaction), that appear during neutron beam stagnation with power 100 MeV.

Neutron Source consist of the following key systems (location of main equipment and layout of the core are shown on Figure 5.2. and 5.3.):

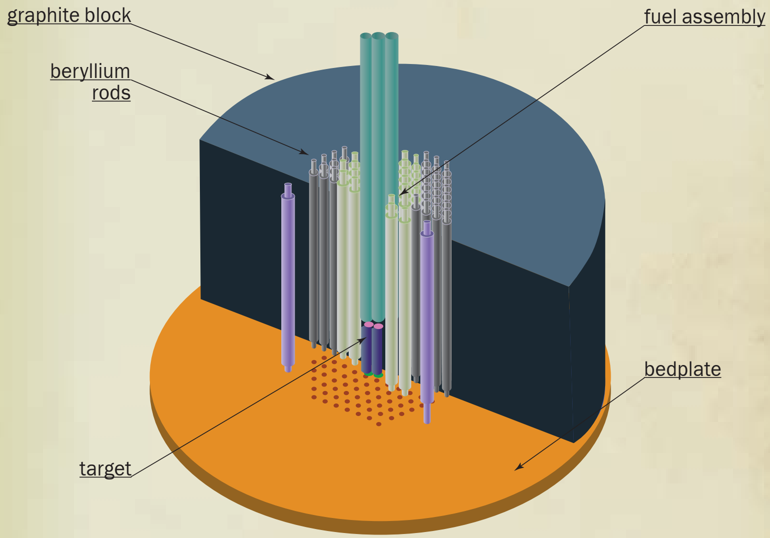


Figure 5.3. Composition of the core

1. Subcritical pool type assembly with key components:
- *The core: nuclear fuel type FA VVR-M2 with enrichment 19,7% of ^{235}U;*
- *reflector: Beryllium/Graphite;*
- *coolant and moderator: demineralized light water.*

2. Neutron-forming target (tungsten or natural uranium);
3. Electron linear accelerator, operating in pulsed mode, and channel transporting the electron beam to the neutron-generator target;
4. Automated system of monitoring and control;
5. The cooling system of the subcritical assembly reactor core;
6. The cooling system of neutron-generator target;
7. Cooling pool for spent nuclear fuel;

8. Storage for solid radioactive waste;
9. Secondary cooling (towers cooling);
10. Experimental feeds and equipment.

At the same time Neutron Source as any other nuclear facility requires implementation of all complex of measures foreseen by the legislation on safety assessment and licensing.

In accordance with Ukrainian legislation:

- *On 6 August 2010 NSC KIPT developed and approved «Declaration of intent to construct research nuclear facility «Neutron Source» at NSC KIPT», which later was published in local papers «Slobodskiy Krai» № 142 of 30.10.2010 and «Uriadoviy Kurier» № 223 of 27.11.2010;*
- *On 30 April 2011 Kharkov city council organized general public hearings of the issue «Construction of Neutron Source at the NSC KIPT»;*
- *On 15 February 2012 Resolution of the Cabinet of Ministers of Ukraine №100 «Issues of siting, design and construction of nuclear facility «Accelerator driven facility «Neutron Source» based on sub-critical assembly» approved Feasibility Study of the Neutron Source construction and approved its siting at the territory of the industrial site of NSC KIPT;*
- *On 28 March 2012 Resolution of the Cabinet of Ministers of Ukraine №254 «On Changes to the Resolution of the Cabinet of Ministers of Ukraine of 6 December 2010 №1106» approved NSC KIPT as an operating organization of the Neutron Source;*
- *On 27 December 2012 the Decision of SNRIU Board №19 approved Conclusion of State expertise on nuclear and radiation safety of the Preliminary Safety Analysis Report of the Neutron Source.*

Power units № 3,4 Of Khmelnitsky NPP

One of the main areas of implementation of the Energy Strategy till 2030 is further development of nuclear energy that foresees, amongst others, timely construction of new capacities in addition to existing or as a replacement of those under decommissioning.

First power units that will be commissioned in frames of implementation of the Energy Strategy are power units № 3 and № 4 of the Khmelnitsky NPP (KhNPP).

Figure 5.4. Units №3 and №4 of KhNPP

The construction of power unit № 3 of KhNPP started in 1985, unit №4 – in 1986. In accordance with the Order of the Ministry of Energy of USSR of 28 December 1979 it was foreseen the constriction of units with reactor facility WWER -1000/V-320.

In connection with moratorium in 1990 the construction of units № 3 and 4 of KhNPP was shutdown and the structures built before already were not properly mothballed.

Decision to renew activities on construction of power units №3 and 4 of KhNPP was taken by the Resolution of the Cabinet of Ministers of Ukraine №281-r of 21 July 2005 «On Preparatory actions for construction of new power units of KhNPP».

In 2008 Ministry of Energy organized a competition to choose the type of reactor facility for completion of power units №3 and 4 of KhNPP and the results of which (WWER-1000/V-392 was chosen) were approved by the Resolution of the Cabinet of Ministers of Ukraine №118 of 18 February 2009 «On primary actions in connection with construction of power units № 3 and 4 of KhNPP».

On 13.03.2012 SNRIU Board Meeting took place, which by its Decision № 7 approved the Conclusion of the State expertise on nuclear and radiation safety of the Feasibility Study «Construction of power units № 3 and 4 with capacity 2000 MW at Khmelnitsky NPP» (FS).

On 04.07.2012 Resolution of the Cabinet of Ministers of Ukraine №498-r approved Feasibility Study for construction of power units № 3 and № 4 of KhNPP.

On 06.09.2012 the Verhovna Rada of Ukraine approved a Law of Ukraine №5217-VI «On Siting, Design and Construction of power units № 3 and 4 of Khmelnitsky NPP».

At present there is still a number of unsolved issues, in particular possibility of using old building constructions of power units № 3, 4 of KhNPP, designed for reactor facility WWER-1000/V-320, for construction of power units with reactor facility type WWER-1000/V-392:

- *Possibility of integration of reactor facility type WWER-1000/V-392 into existing constructions of power unit №3 and 4 of KhNPP;*
- *Possibility of placing in existing constructions of power units № 3 and 4 of auxiliary safety systems and safety important systems;*
- *Capability of the existing constructions of power units № 3 and 4 to withstand additional workload from auxiliary safety systems and safety important systems (including new and modernized) during all designed lifetime.*

Facilities for spent nuclear fuel management

In NPP technological cycle one of the important components is spent nuclear fuel (SNF), generated in process of energy production in nuclear reactors.

Figure 5.5. CSSNF of ZNPP

Period of nuclear fuel utilization within reactors is defined by the seize of permissible burn-up fraction of isotopes that are divided. After reaching of the planned burn-up depth nuclear fuel is unloaded from reactor and is considered as a spent, since it can not be used for production of nuclear energy.

After the upload from the reactor core SNF is reloaded to the reactor cooling pool. In these pools fuel is kept for the period necessary to reduce energy release conditioned by radioactive decay of fission products till admissible values. After storage of SNF in the cooling pool during limited period of time, spent fuel assemblies (SFA) should be removed from power unit and transported for storage (disposal) or processing. This is connected with the fact that storage capacity of the NPP power units cooling pools is limited and there is always should be free space for upload of nuclear fuel from reactor core or periodic inspections of the vessel and vessel internal devices of WWER reactors.

In the process of SNF management the following factors should be taken into account: high level of radioactivity and presence in SNF of valuable component (uranium, plutonium, germanium, erbium, palladium, zirconium etc.), which in perspective could be used in other nuclear cycles (nuclear fuel for fast neutron reactors, MOX-fuel for light-water reactors). Taking into account the above mentioned SNF is not treated as radioactive waste.

Existing condition of nuclear energy in the world shows that under contemporary level of technology development, final conclusions about economical reasonability of either processing or disposal of SNF (final stage of nuclear-fuel cycle – NFC) can not be made. Therefore, Ukraine, as well as the majority of countries that develop nuclear energy, took so-called «deferred decision», which foresees organization of long-term storage of SNF. Mentioned «deferred decision» allows to take decision as for final stage of NFC much later taking into account the development of technology in the world and economic profits for the state.

At present Ukraine operates two storage facilities designed for temporary storage of spent fuel: SNF storage of «wet» type – ISF- 1 at Chernobyl NPP and SNF storage of «dry» type – CSSNF at Zaporizhzhya NPP.

Moreover Ukraine is planning the construction of two more storage facilities: SNF storage facility of «dry» type – ISF-2 at Chernobyl NPP and centralized storage facility for SNF of WWER reactors – CSFSF.

Management of SNF from WWER reactors

The first NPP that met the problem of absence of free space for SNF in power units cooling pools was ZNPP. In order to solve this problem ZNPP started the construction of centralized storage for spent nuclear fuel (CSSNF) in 1996.

CSSNF design was developed with the use of probated technology of «Duke Engineering & Serv ices» (USA). Principle of SNF storage is following: 24 fuel cartridges with low energy release (<1kW) after 5 years of storage in the cooling pools are placed in

special baskets later filled in with helium (rare gas with high heat conduction) and sealed, after the basket is placed in concrete ventilated storage container (VSC). The storage is designed for 380 VSCs, where 9000 fuel cartridges with SNF can be located.

First line of CSSNF with capacity of 100 VSC was commissioned in 2001, and second with capacity of 280 VSC – at the end of 2011.

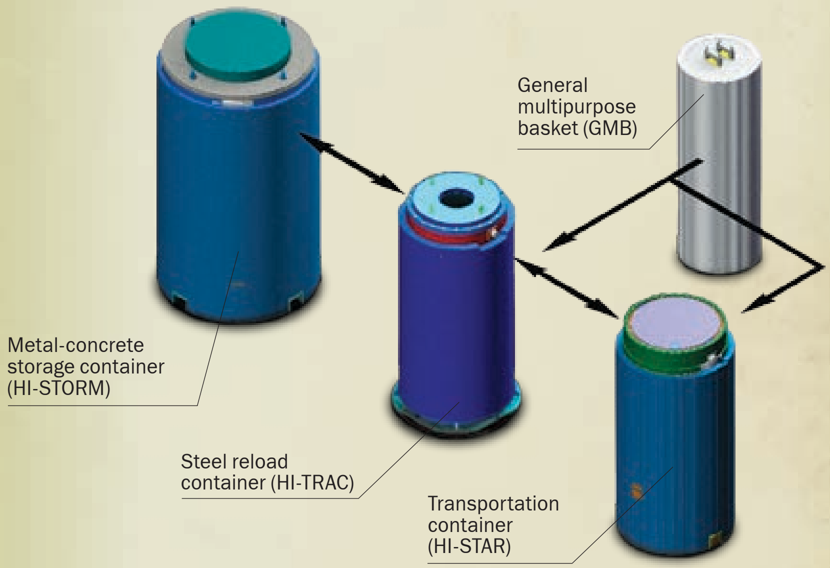


Figure 5.6. Main equipment of the CSFSF

Today ZNPP is the only NPP in operation that has SNF storage facility at its site.

SNF of RNPP, KhNPP and SUNPP at the moment is sent to the Russian Federation. The SNF of reactors WWER-1000 – for storage and WWER-440 (power units №1,2 of RNPP) – for processing.

In accordance with the «Action Plan for 2006-2010 in terms of implementation of the Energy Strategy till 2030» (approved by the Resolution of the Cabinet of Ministers of Ukraine № 427 of 27 July 2006) operating organization NNEGC «Energoatom» concluded a contract with American enterprise «Holtec International» for the construction in Ukraine of centralized storage facility for spent nuclear fuel from RNPP, KhNPP and SUNPP based on the already probated technology of dry storage at the ZNPP.

With regard to the national legislation in force NNEGC «Energoatom» developed «Feasibility Study of investments (FS) for the construction of the centralized spent fuel storage facility (CSFSF) for WWER type fuel of national NPPs», which after comprehensive State expertise was approved by the Resolution of the Cabinet of Ministers of Ukraine of 04.02.2009 № 131-r.

Mentioned FS substantiated economical reasonability of long-term storage of SNF in Ukraine in comparison with shipping to the Russian Federation for processing and the construction of one centralized spent fuel storage facility was substantiated in comparison to other variants of SNF storage.

Within CSFSF the storage of 12500 spent fuel assemblies from WWER-1000 and 4000 spent fuel assemblies from WWER-440 during the period of 100 years is envisaged.

On 09.02.2012 the Law of Ukraine №4383-VI «On management with spent nuclear fuel as for siting, design and construction of centralized storage facility for spent fuel from NPPs with WWER type reactors» approved the decision on siting of the CSFSF in the Exclusion Zone and its design and construction.

On 30.03.2012 SNRIU approved «Licensing plan of CSFSF creation», developed by NNEGC «Energoatom».

Management with SNF from RBMK reactors

The design of the RBMK reactors envisaged the following scheme of SNF management:

- *After utilization in the reactor core nuclear fuel was reloaded to the reactor cooling pool, where it was stored not less than 1,5 years with the purpose to reduce radioactivity and residual heat;*
- *After storage in the cooling pool fuel from RBMK reactors was sent to SNF storage facility of «wet» type for storage.*

Facilities for management with SNF from RBMK reactors were reviewed in details in section 4.2.

The use of radiation in national economy

Management of radiation sources

since accident at Chernobyl NPP the population of Ukraine pays special attention to the issues of radiation influence on human health, including influence of ionizing radiation, caused by man-made* and natural** sources.

Man-made sources are used in many of the areas of national economy, in particular: in medicine – to diagnose and treat oncology diseases, in agriculture – to irradiate and research grain crops, in industry – for radiography and technological control, measurements (weight, number, density), geophysical research of wells, sterilization of products, scientific research etc. Figures of typical radiation sources are given below (6.1-6.3).



** – Man-made sources of ionizing radiations (further – radiation sources) – are physical objects, except for nuclear facilities that contain nuclear substance, or technical devices that produce under certain conditions or may produce ionizing radiation (Article 1 of the Law of Ukraine «On the Use of Nuclear Energy and Radiation Safety»).*

*** – More detailed information about natural sources is given in Section 8 of this Report.*

Management of radiation sources in each area has its specifics and requires protection of people, who performing their professional activities remain in the area of ionizing radiation impact. Provision of radiation protection of human and the environment in the process of radiation sources use is a priority area of state regulation of nuclear and radiation safety.

Functions of state regulation of nuclear and radiation safety are performed by a single state regulatory authority – State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) directly or through its regional offices – eight state regional inspectorates on nuclear and radiation safety.

One of the key principles of state regulation is application of differentiated approach towards different types of activities with the use of radiation sources, taking into account their potential nuclear and radiation danger through:

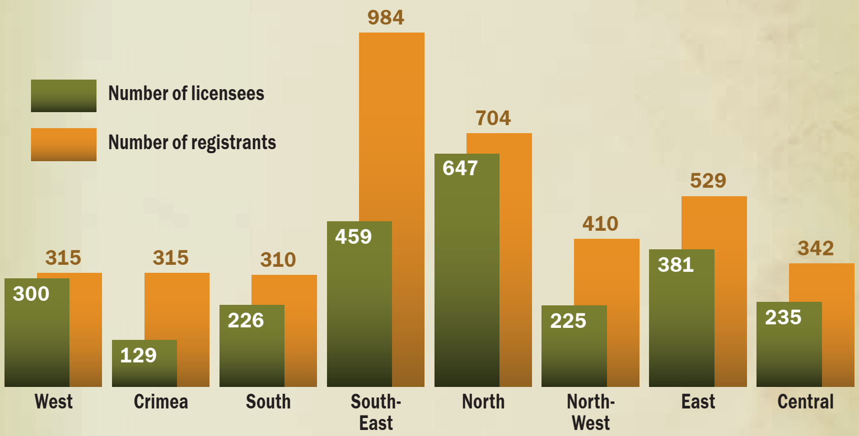
- *release of radiation sources with low level of potential danger from regulatory control. Release levels and procedure are fixed in the Resolution of the Cabinet of Ministers of Ukraine of 16 December 2011 and Order of the SNRIU of 1 July 2010;*
- *registration in the State Register of Sources of all types of radiation sources which are not released from regulatory control. Registration procedure is approved by the Resolution of Cabinet of Ministers of Ukraine of 16 December 2000;*
- *licensing of activities with the use of radiation sources with medium or high level of potential danger. Licensing is performed in accordance with requirements established by the Law of Ukraine «On Licensing activity in the area of nuclear energy use». Decision on release from licensing of the activities with radiation sources is taken be the SNRIU in case if radiation source corresponds to the «Criteria for the release of activities with the use of radiation sources from licensing» approved by the Resolution of the Cabinet of Ministers of Ukraine of 16.11.2011 № 1174.*

Categories for radionuclide radiation sources (1-5) according to the level of their potential danger are approved by the Resolution of the Cabinet of Ministers of Ukraine 05.12.2007 № 1382. According to this categorization radiation sources of 1-3 category posses the highest level of danger and are subject to enhanced regulatory control.

In Ukraine there are 4644 entities that use more than 22 728 radiation sources including: radionuclide sources – 10 084; generating devices – 12 644. It is necessary to mention positive tendency on decrease of spent radiation sources number, which are the most vulnerable. In particular in 2012 – 3883 spent radiation sources were transmitted to the specialized enterprises on RW management in frames of the programs implemented by SNRIU together with regional inspectorates since 2009.

The majority of the entities that use radiation sources are located in northern part of Ukraine (Kyiv, Chernigov region, Vinnitsa region, Zhitomir and Cherkassy regions) – almost by 30 % more than in industrial regions of Ukraine, such as South-East part of Ukraine (Donetsk, Lugansk and Zaporizhzhya regions) and East part (Kharkiv, Sumy and Poltava regions). In West part of Ukraine and Crimea, part of the territories of which is a recreation zone, activities with radiation sources are performed by medical institutions mainly.

Figure 6.4. Number of licensees and registrants in the regions of Ukraine

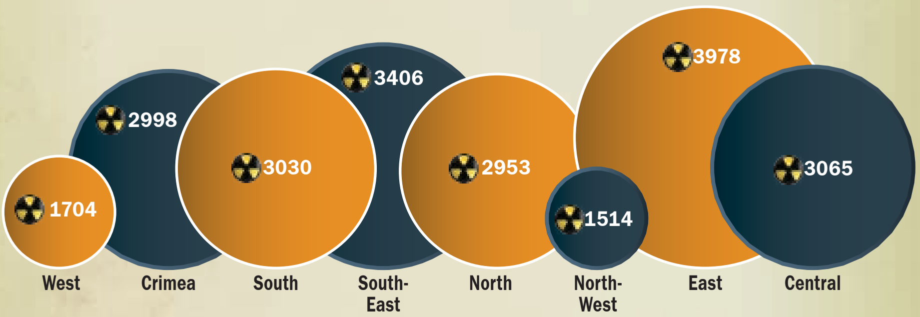


The number of radiation sources and the number of entities that use radiation sources three times more in medicine than in other areas of national economy. The most intense is South-East part of Ukraine with 12 oncology clinics that use radiation sources with high level of potential danger.

According to the quantitative input of medical institutions in the general number of entities in the area of nuclear energy use the most intense is Crimea, North-West and South regions, which is explained by the number sanatorium and spa-treatment medical institutions, located in the recreation area of Ukraine (seacoast, woodlands).

As of 2012 – 2728 entities have licenses for the use of radiation sources, including medical institutions – 1800, industrial entities – 716, entities that «provide» services on radiation safety –

Figure 6.5. Number of radiation sources in the regions of Ukraine



204 (technical maintenance of radiation sources, supply etc.) and 8 licenses for the tests with radiation sources with the purpose to check the proofness for long term operation.

Distribution of radiation sources and number of entities according to the regions of Ukraine is shown on the diagrams 6.4 – 6.5.

Appearance and the wide use during last 10 years of new medical technologies with ionizing radiation improved diagnostic and surgical capabilities. However, there is also increase of exposure doses of patients during diagnostics, and risks of radiation accidents and unintentional exposure during treatment increased as well.

In Ukraine, as in the whole world, this caused special attention of medical professionals and SNRIU towards optimization of medical exposure of patients and personnel, improvement of their radiation protection.

Medical procedures and methods of treatment of oncology diseases are closely related with application of devices and

facilities with radiation sources. For example, one of the most prevailing diagnostic procedures – is examination with the use of x-ray devices, and radiation therapy – one of the most efficient treatment method of the oncology diseases. For each 1000 inhabitants approximately 700-900 diagnostic tests are carried out annually. Of course medical irradiation it aimed at treatment of the patient, therefore the safety of radiation sources use in this field requires introduction of specific measures on radiation protection of personnel (patients), which are different from measures used in industry and other areas of national economy.

For medical irradiation during treatment procedures there is a definition of dose limits. Deviation of the received dose from the dose prescribed by physician more than 10% will lead to high risk of aftereffect, and less than 10% inefficient treatment. The result of medical irradiation is a wide scale of potential radiation risk for specific human and is ranked from minimal (in most of the cases) – to potential fatal outcomes (in single cases).

For example, minimal radiation risk will be for an old person during x-ray diagnostics of breast – absence of deterministic

effect and risks of stochastic effects during the whole life of this person.

The example of considerable potential risk from medical irradiation is a computer tomography – absorbed dose in human organs constitute from 10 to 100 mGy per one procedure. Therefore asymptomatic person who annually passes computer tomography during 30 years will have absorbed dose from 0,3 – 3 Gy, that may cause disease.

Other critical factors that may cause risks of additional or uncontrolled irradiation are: the use of old treatment and diagnostic equipment; absence of control of dose forming parameters of radio diagnostic devices, lack or insufficient training of radiologists, absence of quality control of diagnostic and treatment equipment, absence of timely maintenance; insufficient qualification of personnel whilst introducing the newest radiation technologies, etc.

Any activity with radiation sources is allowed in case if entity proved the capability to adhere to the norms and rules on radiation safety and the safety of these sources is substantiated.

According to the basis safety standard of the IAEA: «Radiation protection and safety of radioactive sources: – basic international safety standards» (GSR Part 3) the following activity with radiation sources can not be allowed: the use of radiation substances in food, feedstuff, drinks, cosmetics, toys or other products for human consumption; for human visualization with ionizing radiation for advertizing or art purposes, to reveal theft and human visualization for professional or legal purposes or insurance without medical factors.

Ukraine as other countries of the world is seeking to introduce international safety regimes through implementation of international safety requirements, best international practice, and the most efficient instruments of state regulation of nuclear and radiation safety.

With this purpose SNRIU in 2012 provided for:

- *approval of new list of documents to be submitted to obtain a license for separate types of activities in the area of nuclear energy use (Order of 06.08.2012 № 153) – which provided for reduction of regulatory pressure over the users of radiation sources with low level of potential danger, format and requirements to the content of licensing documents were unified, etc.;*
- *criteria to define the license period were revised – the license period was extended for the use of radiation sources from 3-7 years till 5-9 years (for radiation sources with low level of potential danger);*
- *procedure of licensing documents review defined by the Law of Ukraine «On Licensing activity in the area of nuclear energy use» was unified;*

- *activities on the development of safety requirements and conditions for each area of radiation sources use are underway. Differentiated approach towards regulation of safety of radiation sources will facilitate efficiency of regulatory authority, improvement of safety culture at the entities, facilitate correct allocation of resources and as a result compliance with international safety regimes at the territory of Ukraine.*

Management of radioactive waste generated in the process of radiation sources utilization

The important condition of safety provision in the process of radiation sources use is their safe storage or disposal at the end of life cycle with the purpose to exclude possibility of their

Figure 6.7. Areas covered by SISP of UkrDO «Radon»

loss and reveal in public places. The important precondition of safety provision in the process of use of radiation sources is their safe storage or disposal at the end of lifecycle with the purpose to avoid the possibility of their loss or relocation to the places where a danger to the population can be done.

Because even spent sources after the expiration of the design lifetime remain radiation dangerous substances, because contain radioactive material, which in case of spreading or unintentional use can harm human health. Spent radiation sources belong to the category of radioactive waste (RW) and their further management is performed according to the safety requirements on RW management.

With the purpose to provide the safety of RW, both spent radiation sources or other RW generated as result of radiation sources use in different fields of industry and medicine, in 60-ies of the last

Figure 6.8. Hangar type storage facility of Kharkov SISP (internal and external view)

century six specialized enterprises for management with RW were created at the territory of Ukraine, these are: Kyiv, Donetsk, Odessa, Kharkov, Dnipropetrovsk, Lviv state interregional specialized plants (SISP).

Now these plant are united in State Corporation «UkrDO «Radon» subordinated to the State Agency of Ukraine on Exclusion Zone Management.

These plants perform, at the territories they cover, collection, transportation and safe location of the spent radiation sources and RW in storage facilities, they also provide the operation of linen, protective closing and means of individual protection decontamination points at medical facilities and other enterprises.

Taking into account the fact that RW storage facilities at the SISPs were constructed, commissioned and operated during soviet times without all safety measures that are applied now, in 90-ies a decision was taken to restructure and reequip the plants with the purpose of transfer to new technology of temporary container RW storage.

Hence, operation of old RW storage facilities was stopped. Instead at the SISPs sites temporary storage facilities of hanger type were constructed and are under operation now. Old storage facilities were preserved and maintenance activities and activities to support safe condition of these facilities are performed.

Further actions to restructure and reequip the plants are outlined in the National environmental program on radioactive

Figure 6.9.

Specialized plant of UkrDO «Radon»	Number of spent radiation sources	Activity, Bq	Amount of solid RW, m^3	Activity, Bq
Dnipropetrovsk	176071	$7{,}52 \cdot 10^{14}$	573,3	$2{,}43 \cdot 10^{15}$
Donetsk	45	$3{,}77 \cdot 10^{11}$	2,3	$7{,}66 \cdot 10^{7}$
Kyiv	96474	$7{,}50 \cdot 10^{14}$	2076	$4{,}95 \cdot 10^{15}$
Lviv	38380	$1{,}81 \cdot 10^{14}$	694	$6{,}64 \cdot 10^{12}$
Odessa	43994	$2{,}70 \cdot 10^{14}$	522,2	$5{,}10 \cdot 10^{14}$
Kharkov	102889	$4{,}03 \cdot 10^{14}$	1999,7	$8{,}18 \cdot 10^{12}$
TOTAL	**457853**	**$2{,}91 \cdot 10^{16}$**	**5867,5**	**$7{,}90 \cdot 10^{15}$**

waste management. Amongst others actions to remove RW from old facilities and re-disposal in centralized storages of the Complex Vector in the Exclusion Zone are foreseen. This will allow to liquidate old disposal sites and related potential threat of radionuclides spread into the environment. In each case such decisions will be taken based on the results of safety reassessment, which is not performed by the by the plants in accordance with conditions of license issued by SNRIU.

Also these plants are involved in emergency actions of competent authorities on elimination of emergency situations related to the reveal of orphan sources or sources in illicit trafficking. All these radiation sources are transferred to the storage facilities of the plants, where safe and controlled storage is provided.

During all period of SISP operation a large number of spent radiation sources and RW was accumulated. Corresponding data is shown in Figure 6.9.

Radiation around us

Natural radiation: levels, doses, risks.

The system of radiation protection of the population is set on the results of medical and biology research that can give the following conclusion: the level of potential negative impact of the exposure to human health is defined only by the dose level irrespective of the sources of ionizing radiation either natural or man-made.

Of all sources of ionizing radiation the largest doses population receives from technologically enhanced sources of natural origin. These are radiation sources of natural origin, which as a result of economic or industrial activity of human were concentrated (natural radionuclides in building materials, radon in the air of premises) or their availability was increased (natural radionuclides in drinking water, artesian wells), which caused additional natural radiation exposure.

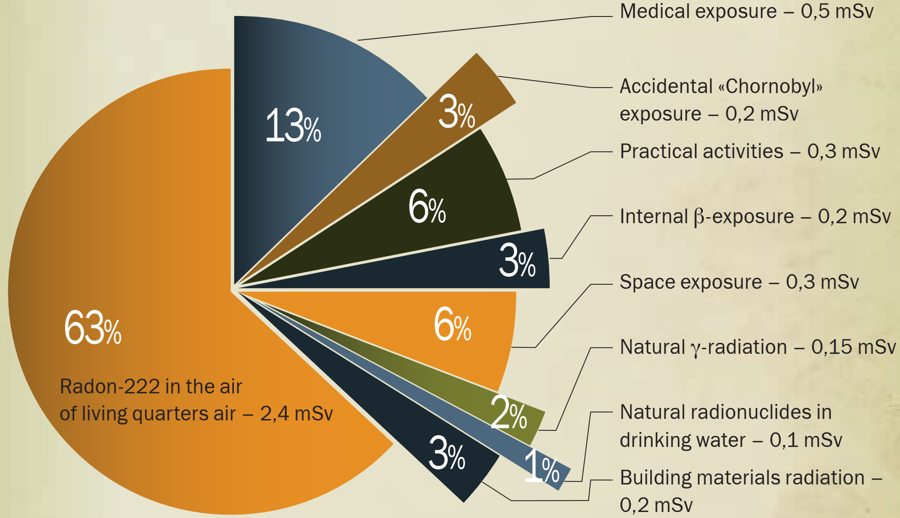
For Ukraine this component constitutes more than 70% out of total amount (figure. 7.1), though left part of the figure is present at the cost of radon-222 in the air of living premises.

Technologically increased sources of natural origin are referred to the managed components of total dose their contribution could be reduced through application of corresponding measures. Therefore in the Norms on Radiation Safety in Ukraine (NRBU-97) there was a fourth group of radiation-hygienic requirements was introduced that contain provisions for limitation of radon in the air of premises, composition of natural radionuclides in building materials and drink water as well as requirements to control these sources.

For example, for the radon in premises – key dose-formatting source in Ukraine, two scenarios of exposure are envisaged: exposure in buildings in use and new buildings under commissioning. The regulations require that the equilibrium equivalent

radon activity in the air (ERAA) for existing buildings not exceeding 100 Bq/m^3, which corresponds to the 250 Bq.m-3 in term of volume activity, which is used in most European countries. For comparison, the new IAEA safety standard – BSS, the reference level for radon identified in 300 Bq/m^3. For new homes, child care centers and hospitals, this value is 50 Bq/m^3 (or 125 Bq/m of radon gas). For measurements of radon, the NRBU-97, as well as regulations of other countries, require measurements by

Figure 7.1. The amount of total effective exposure dose of Ukrainian population from all existing sources of irradiation.

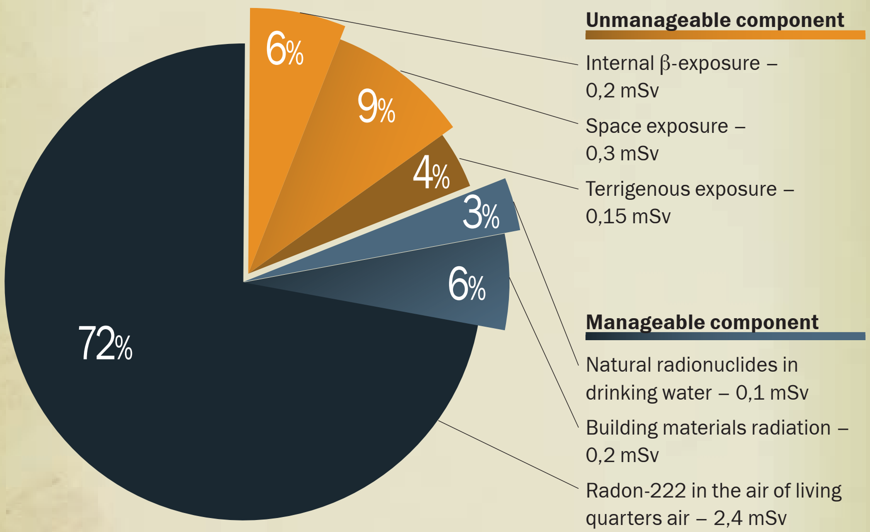


integral methods only. This requirement is important because the level of radon in the air of a house or apartment can be changed 100 times during one day.

The situation in Ukraine. According to hydro geological and natural conditions the territory of Ukraine is very diverse. A third of the country is located on crystalline panel with high natural radionuclides of the uranium and thorium series. Industrial eastern and central regions of the country have additional significant impacts by companies with mining and processing of uranium, so-called «tails» – waste products with high composition of natural radionuclides of the uranium and thorium series and so on. According to the research, conducted in Ukraine in recent years the structure and size of existing exposure was analyzed and found that the main source for dose-forming is radon in indoor air (Figure 7.2).

Radon-222 is a gas, appear during the decay of natural radionuclides of uranium series. During the decay, radon-222 creates short-lived daughter products of decay (DPD) – polonium, lead, bismuth, which together with particles of dust or humidity create

Figure 7.2. Structure and the seize of the average annual efficient exposure doses of population in Ukraine from sources of natural origin



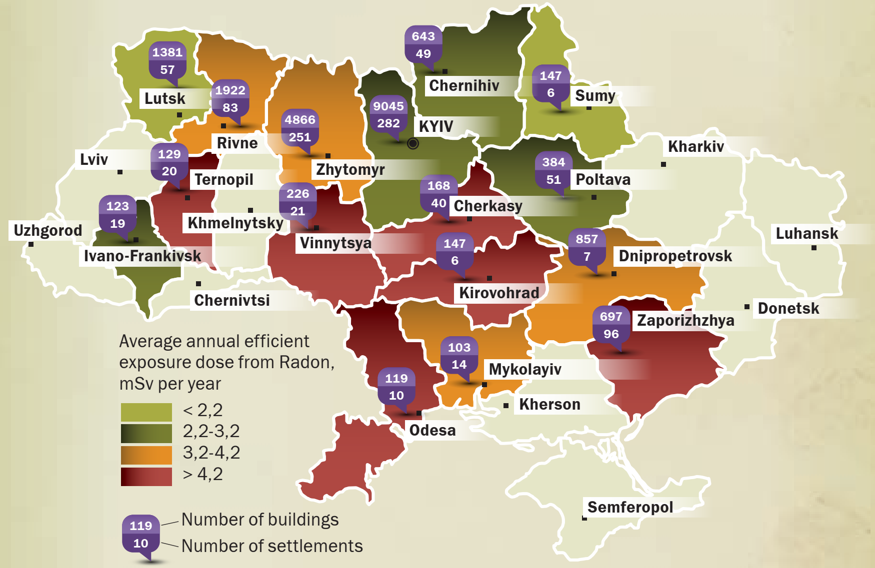
radioactive aerosol. Getting into the lungs, radioactive aerosol, through a small half-life of radon-222 DPD, irradiates the bronchial epithelium, leading to relatively high doses of radiation, which can cause additional risk of lung cancer (ICRP, Publ. 115, 2011).

According to a survey of houses in some regions of Ukraine (28,000 homes) made by Marzeev Institute of Hygiene and Medical Ecology National Academy of Medical Sciences of Ukraine, average, in individual regions, annual effective dose from radon exposure of the population constitutes 2,4 mSv/year for the rural population, this value is almost twice as much, and is 4.1 mSv/year (Figure 7.3).

In some regions the dose from radon vary quite widely from 1.2 mSv/year to 4.3 mSv/year (Fig. 7.3), and the individual dose of the population may exceed the dose limit for the professionals of category A (20 mSv/year).

If measure by the internationally accepted assessment methods the mortality from lung cancer caused by the exposure of radon-222 in indoor air in Ukraine is approximately 6,000 cases

Figure 7.3. Efficient exposure doses of Ukrainian population from radon in the air of premises



per year. Direct losses to the country due to non-participation of deceased persons in GDP are estimated at 0.5 billion per year, consequential damages – 6-30 billion per year.

Also it should be noted that in recent years new knowledge was gained about the effects of radon. According to epidemiological studies, radon can cause leukemia in children. According to AS Evrard (Health Physics, 2006), the link between radon and leukemia in children has increase 20% for every 100 Bq/m^3. According Raaschou-Nielsen (Epidemiology, 2008), this increase even more – 34% for every 100 Bq/m^3.

Radon in the air can be easily reduced by increased ventilation of the premises or restriction of gas flow by sealing basement space.

According to the Department of Radiation Hygiene Marzeev Institute of Hygiene and Medical Ecology National Academy of Medical Sciences of Ukraine, about 23% of houses of Ukraine do not meet current regulatory framework for radon in indoor air. If housing issues were brought to the current norms the losses could be reduced to two.

Kirovograd regional program «STOP-RADON»

For the first tine in Ukraine in 2011 a regional program to reduce the exposure doses of population from radon – was launched – Program of Kirovograd Regional State Administration «Stop Radon». This Program was initiated by the Head of Kirovograd Regional State Administration Sergiy Larin and with the support of the regional charity foundation «Development of Kirovograd Region».

Kirovograd region is one of the most problematic regions of Ukraine as regards the exposure of population by radon (Fig.7.3). The existing situation is explained not only by hydro geological features of the territory, but also additional human impacts on Kirovograd by enterprises on uranium mining. It should also be noted that in recent years in the field there was a certain social tension associated with the increase of cancer incidence that as people say is caused by radiation. To determine the true causes of the growth of cancer incidence, it was decided to establish an appropriate regional program.

Kirovograd Program «Stop radon» consists of three stages, two of which were implemented in 2011-12, respectively. The third stage concerns against-radon measures and determines their effectiveness and will be implemented during 2013.

To implement the program a working group was established, meetings and decisions of which were widely covered in the mass media. In addition for on-line information about the progress of the program a special website «Stop radon» (http://stopradon.kr.ua/) was set up.

At the first stage, in frames of Swedish Ukrainian cooperation project «Reduction of Risks Caused by Exposure to Radon Gas and

Natural Radiation», financed by Swedich Agency for International Development (SIDA), experts of the Swedish Radiation Safety Agency (SSM) together with experts from laboratory of natural research of the Marzeev Institute organized 5 training courses for the specialists of Kirovograd region, who know implement this Program «Stop radon».

These training courses, in particular: «Radon-basis», «Natural radionuclides in water», «Radon – measurements», «Radon – coun-

Survey of the radon presence in the class room of one the schools in Kirovograd region.

terradon measures», «Mapping of radon risks», contain both theoretical and practical knowledge, which allow in short terms learn basic terminology and measurement units, physical and biological characteristics of radon, methodological approaches towards measurements, mechanism of radon levels formation, etc.

Later these specialists took active part in drafting the tasks of the Program and its direct implementation.

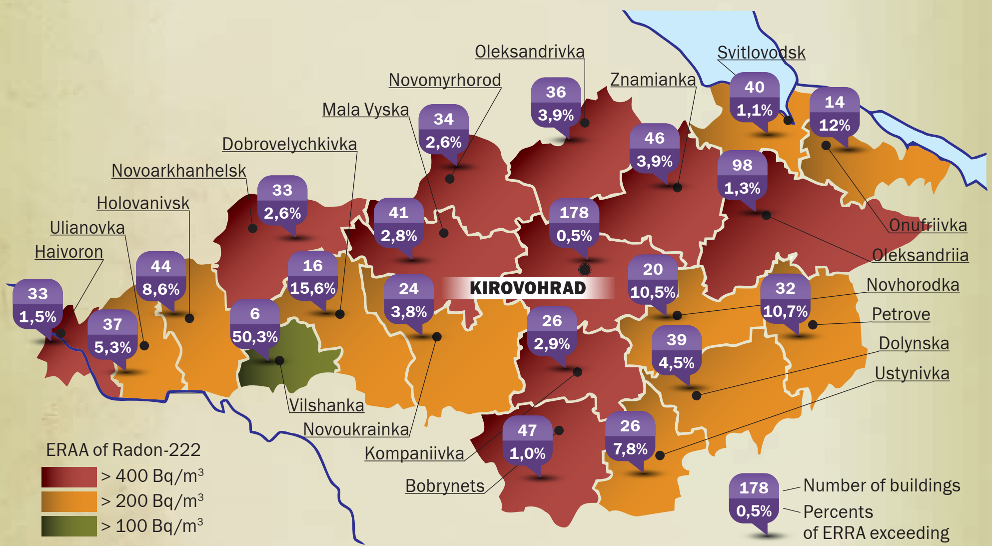
Main tasks of the second stage of the Program was explanatory work with population about radiation risks and survey of the premises of public buildings, nursery and children daycare facilities, schools to measure the level of radon in the air.

In frames of the first task a health lesson was carried out in all schools of the region. The practice showed that such approach is the most efficient.

Busy adults do not have time, and sometimes desire to learn new information, but they always are interested by the life of their child. In such a way information is disseminated not only among children but also among adults.

During this lesson a lot of information in easy-understanding format was delivered to the pupils, including the influence of radon on human health, the most primitive methods of control, etc.

Table 7.4. Levels of radon in nursery and children daycare facilities of Kirovograd region.



Pupils received devices and by themselves made measurements of radon in school premises.

Moreover, international on-line conference was organized and dedicated to the radon, where pupils from Kirovograd region schools and the children of the same age from Netherlands and Lebanon participated.

Another task was solved in parallel together with experts from Marzeev Institute – measurements of radon in the air of nursery and children daycare facilities in Kirovograd region started. In order to perform this work in human settlements of

the region 149 «radon» consultation centers were established. As a result of this work 1043 facility was surveyed – nursery and children daycare facilities, schools, public buildings.

Main results are shown in Figure 7.4. Table shows average meaning of the ERAA of radon in the air of surveyed premises and percent of the limits exceeding.

Meeting of the Working group of the Program «Stop radon»

The analysis of the radon survey results showed that the requirements established by the NRBU-97 are exceeded in 30% of surveyed facilities. Direct damages caused by this radiation source for the region were evaluated by the experts of Marzeev Institute. It was stated that Kirovograd region loses 10 mln. hryvnas per year, at the cost of radon impact. The biggest radiation risks and corresponding losses bear Kirovgrad, Znamensk and Oleksandrovsk districts. It also stated that the interference to reduce the exposure doses at the territory of Kirovograd region is duly substantiated.

The results if this research became a basis for the third stage of the Program – planning and implementation of counterradon measures.

For this purpose and with the support of the SSM of Sweden experts from «Bjerking AB» company were invited. These experts consulted specialists of local organizations about counterradon measures, which later were implemented on the territories of Kirovograd city and Znamianka city, Kirovograd, Malovyskivsk and Znamensk districts.

In total experts carried out counter radon measures in 349 nursery and children daycare facilities, schools, and medical

Practical training on mapping of the radon risks in Kirovograd region (Training courses under Swedish project).

institutions of the region. For each facility recommendations were defined with description of design and engineering solutions, which later were implemented at all facilities.

In September 2012 «State Scientific and Technical Center on Nuclear and Radiation Safety» (SSTC NRS) of the SNRIU was involved in the Program. SSTC NRS with use of mobile laboratory Ranid SONNI carried out additional radiation survey of the radiation risks territories of Kirovograd region and defined territories and facilities where additional attention should be paid in future. Corresponding report was submitted to the regional Administration.

Now, third stage of the Program is underway, directed at implementation of countermeasures to reduce radiation risks of the population in the region and first of all for children. The results of this stage will be available next year.

ANNEX 1. Radiation events in Ukraine

From 1989 till 2012 at the territory of Ukraine 503 radiation accidents and events were registered at the territory of 22 administrative regions. Regional allocation of the events is given in Figure 8.1.

The majority of radiation events (46,3 %) is related to the identification of contaminated metal in the scrap (or identification of the radiation sources in the scrap). Other events are related with theft of radiation source (22.3 %), loss of radiation source (4 %), violation of operation condition of the equipment with the source (5 %) and illicit trafficking of the source (18.9 %).

Cases with detection of radiation-contaminated scrap metal are often related to a possible hit in a scrap of equipment from oil and gas processing facilities (pump tubing contaminated with natural radionuclides) from coal mines (drainage pipes) and former uranium mining and uranium milling companies (equipment contaminated with radionuclides of the uranium series) and so on.

Unfortunately, among total number of radiation accidents that occurred in Ukraine in the period mentioned above, there are cases of overexposure of human, namely:

1. In 1989 the family, which first got an apartment in the building of Kramatorsk city, the mother died and two children. The new family that moved in this apartment, because of the cancer lost 11-year-old son, junior son and the head of the family fell ill. The doctors found no cause of diseases of their patients. Radiation accident was discovered only after resident contacted local SES. In the wall of the apartment a radiation source was found with radionuclide cesium-137, on the surface of which exposure dose of gamma radiation constituted 1,800 R/h. After removal of fragments of the walls gamma background in the apartments was 25-30 mR/h.

Figure. 8.1. Regional allocation of the events is given

Administrative region	Accidents and events in total	Theft	Loss of radiation source	Radiation contaminated scrap metal	Illicit trafficking	Source decapsulation	Absence of physical protection system	Violation of equipment operation with sources	Orphan sources
Crimea	3	1			1*		1		
Vinnitsa	13	7		1	3			1	1
Dnipropetrovsk	42	7	2	24	4(1*)	3		2	
Donetsk	194	38	7	132	5(1*)	4		8	
Zhytomyr	5	1		3	1				
Zaporizhzhya	34	4		29	1			1	
Kyiv	11	2			8				1
Lugansk	41	17		7	12(1**)			4	1
Mykolaiv	9	5	2	1	1*				
Odessa	14			7	3	2		2	
Poltava	18	2	2	9				5	
Rivne	3	1			1				1
Sumy	5	3			2(1*)				
Kharkiv	17	3	2	8	4				
Kherson	12		2	5	2			2	1
Khmelnitsky	1	1							
Cherkassy	9	6	1	1				1	
Chernivtsy	4	3			1				
Chernigyv	9	5	2	2		1			
Kyiv city	57	6		4	44(18*)	1	2		1
Ternopyl	1				1				
Ivano-Frankivsk	1				1**				
Total	**503**	**112**	**20**	**233**	**95**	**9**	**3**	**25**	**6**

* identification of products, products with phosphor
** identification of nuclear materials

As of December 12, 1989 the sources with cesium-137 type IGR-C-4 had activity – 4,22*10^{10} Bq. It was established that the radiation source of this type was a component of radioisotope devices of technological control. Radiation source dropped out from the level indicator device lost 10 years before at the Karansk stone pit and was packed with crashed stone in the wall panel.

The main reason for this failure – the failure of accounting and control of radioactive sources, violations of physical protection of radioactive sources and low level of safetyt culture in the company.

2. In 1989 at Nikolaev plant of silicate products a radiation source with cesium-137, activity 0.2 TBq, fell out from radioisotope device and led to exposure of three people (hands – to 5 Sv, body – to 0.03 Sv).

3. In 1991 at the Volnogorsk mining and smelting plant (processing factory, laboratory of automated process control systems) blocking of the power supply failed of the X-ray tube of the X-ray multichannel spectrometer instrument CPM-18, leaving one person injured (acute radiation injury of left hand).

4. In 1992 in Moyivka village of Vinnitsa region radiation accident was registered, which resulted in eight people injured, exposure doses ranged from 6 to 78 mSv. The cause of the accident was the contamination of buildings and areas of the two estates with radionuclide cesium-137, which was contained in radioisotope instruments stolen in 1969 from Moyivsk sugar plant. Found sources were transferred to the Kiev regional plant UkrDo «Radon» for disposal. The area has suffered radiation contamination; decontamination was performed with partial removal of soil.

5. In 1998 in the Donetsk region in DOLKO endovascular surgery department an x-ray machine «Polidiahnost» of «Phillips» was in operation for six years without permission of regulatory authority and without proper protection. Levels of radiation at the staff workplace exceeded permissible in 50-100 times.

6. In 1998 in Zhmerenka village 2 radioactive sources were identified. One person injured received a dose of 3 mSv.

7. Irradiation of patients above threshold levels was recorded in Zaporizhzhya Regional Oncology Center in 1995, due to the lack of filter in X-ray machine.

8. In 1998 at ZNPP the exposure of personnel was registered above the established levels due to the fact that the source trapped in ampoule wire of gamma flaw.

There cases of negative impact of radiation accidents on the environment:

1. The biggest area for radiation accident in Ukraine was recorded in July 15, 1989 in the village Taromske, Dnipropetrovsk City, Shevchenko street. Brigade of geologists from Production Association «Kirovgeologiya» found on the roadway outside the territories of seven private households of this village several local radioactive contamination of soil from 120 to 40,000 mR/h in an area of about 800 m^2. In the area of radioactive contamination with cesium-137 were driveways, front gardens, garden plots and yard building houses №36, 38. The main cause of pollution was depressurization of two sources of cesium-137, which were brought with blast furnace slag in about 1964-65, respectively. At a distance of 10 cm from the remote source dose rate was 50 R/h (according to the Dnipropetrovsk Regional SES). Sources were transferred to the Dnipropetrovsk regional Specialized UkrDo «Radon».

As a result of decontamination approximately 900 m^3 of contaminated soil were taken to the radioactive waste disposal facilities. The units of non-military civil defense, chemical protection, trucking companies, experts of radiological units of local and regional sanitation centers were involved in mitigation of consequences of the accident.

Medial survey and research of 273 persons of population showed no radiation pathology.

2. In the Kharkiv region in 1995 local spots of contaminated soil were identified at the former pioneer camps «Medic» and «Forest stars» near the route Kharkiv-Belgorod. EDR was recorded in the range of 300 mR/h to 26 mR/h. Studied soil samples showed the presence of radionuclide radium-226. About 20 m^3 of contaminated soil was put to Kharkiv SISP. Cases of overexposure of population and personnel were not registered.

3. In the Poltava region at the territory of the Ukrainian Medical Dentist Academy a contamination spot up to 1 m^2 was found. The results of gamma spectrometric studies of soil samples showed radium-226 with activity 5500 Bq/kg. During the work on the decontamination of area, carried out by radiology department up to 3 m^3 of radioactively contaminated soil was removed. Radioactive contamination may be due to the fact that in the past at this place Oncology Center was located, that used radium preparations. Radioactive soil was put into Kharkiv SISP.

4. On 17 April 2007 at the territory of unauthorized industrial waste landfill, located near the village of Illichivka, Kostyantinivsk district of Dnipropetrovsk region, areas with dose levels of gamma radiation 3 mR/h were revealed. It was determined that the source of contamination is cesium-137.

In 2008, experts of UkrDo «Radon» together with fire units of the Ministry of Emergencies of Ukraine conducted activities to bring this industrial waste landfill in radiation safe condition. The professionals from Donetsk, Kyiv, Dnipropetrovsk and Kharkiv special plants UkrDo «Radon» were involved.

When the works were completed 36 containers SC SRW-1-2-04 and 1 container KTNS-2 (total 37 containers) were filled in. The total weight of the removed contaminated slag from this industrial dump was about 100 tons with total activity $3.46*10^{11}$ Bq. All removed slag was loaded in certified containers and set off to Dnipropetrovsk Specialized UkrDo «Radon» for disposal. The average specific activity of contaminated slag was 10^5-10^7 Bq of cesium-137.

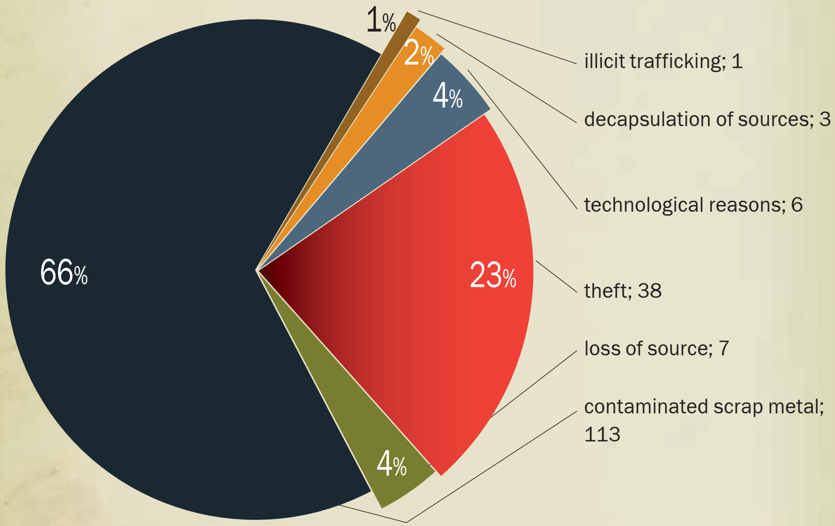
The work was carried out with the use of remote-control system, or manually. Remote-control system was used in areas with the highest pollution.

The largest number of radiation incidents was recorded in the Donetsk region. Distribution of causes of radiation accidents and incidents (194 cases) in the Donetsk region are as follows.

66% of these cases – detection in steel mills of Donetsk region with the use of dosimetry units RPS «Border» of contaminated scrap metal. 38% of cases, due to the theft of radioactive sources, indicating a lack of / inadequate physical protection of radioactive sources, the elimination of industrial enterprises, the poor state of radiation safety in coal mines and so on.

Radiation contaminated scrap metal during entry control was identified at the Public Corporation «ММК of Illicha», Public Corporation «МК «Azovstal», Closed Corporation «Azovelektrostal» (all cases took place in Mariupol city), Joint Stock Company «Donetsk metallurgist plant», Public Corporation «Dniprospezstal» (Zaporizhzhya city) and Public Corporation «Alchevsk metallurgist plant» (Alchevsk city). In all cases of exceeding the radiation exposure level from the scrap at the metallurgist plants of Donetsk region

Distribution of causes of radiation accidents and incidents (194 cases) in the Donetsk region



Donetsk SISP of Ukr DO «Radon» was involved in sorting and extracting activities. In Lugansk – radiological survey was performed by South-East Inspectorate, uploading and extraction activities were performed by personnel of Public Corporation «Alchevsk metallurgist plant» under the control of radiation safety services.

Radiation – contaminated scrap was transmitted to the specialized enterprise for radioactive waste management UkrDo «Radon».

Of particular concern is the increasing number of radiological accidents involving depressurization or other technological factors in gamma-therapy units that are equipped with high-activity

radionuclide radiation sources. Such cases were registered in recent years in health care institutions of Donetsk, Ivano-Frankivsk, Krivoy Rog, Chernihiv regions, Kyiv and Crimea. The main cause of these cases is the failure to timely replacement, repair and periodic maintenance of gamma therapy devices.

During 2012 – 47 radiation incidents were identified. Among them there are:

Radiological survey of the carriage with scrap metal.

Overall columns with source (SPD), found in the car with scrap metal

Radiation source (SPD), containing ^{226}Ra

- *14 – cases of contaminated scrap metal,*
- *2 – loss of regulatory control over radiation source as a result of technological accidents,*
- *29 – identification of radiation source in illicit trafficking (including 14 devices with phosphor of ^{226}Ra – at the postal offices, where radiation control frames were established),*
- *2 – exceeding of controlled levels of medical personnel exposure.*

ANNEX 2. Events at NPP of Ukraine in 2012

The account and analysis of events at Nuclear Power Plants is an element of operational experience, which directly influences safe operation of NPPs.

In 2012 at operating power units of Ukraine 15 events took place, in particular:

- *ZNPP – 5 events;*
- *RNPP – 4 events;*
- *KhNPP – 2 events;*
- *SUNPP – 4events.*

At the table 9.1 the distribution of number of events at NPPs of Ukraine during 2008-2012 is shown, where it could be seen that the number of events in 2012 remained at the low level.

At the table 9.2 the distribution of events among the sites during 2008-2012 is shown.

Figure 9.1. Number of events at NPPs of Ukraine during 2008-2012.

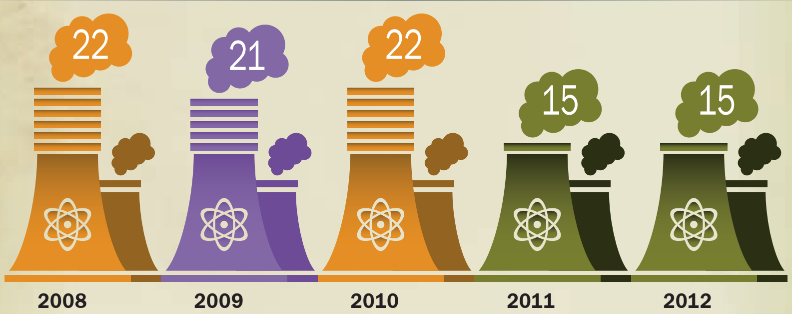
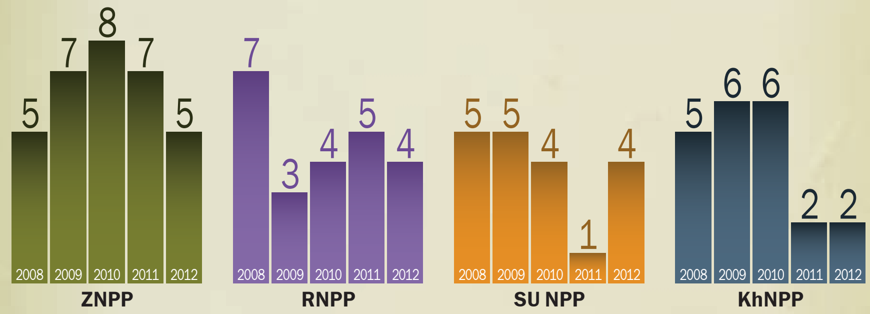


Figure 9.2. Distribution of events among the NPP sites in 2008-2012

Figure 9.2. Distribution of events among the NPP sites in 2008-2012



Considerable increase of events in 2012 took place only at SUNPP, where numbers increased in 4 times. At ZNPP and RNPP the reduction of the number of events took place. At KhNPP the number of events remained the same.

According to the type of reactor facility all power units under operation can be divided in two groups: power units with WWER-1000 (13 units) and WWER-440 (2 units). On the table 9.3 the distribution of the average number of events per one power unit of separate types of reactor facility is shown.

Figure 9.3. Distribution of the average number of events per one power unit of separate types of reactor facility

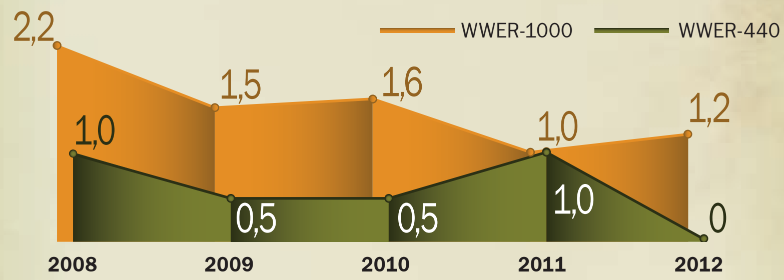
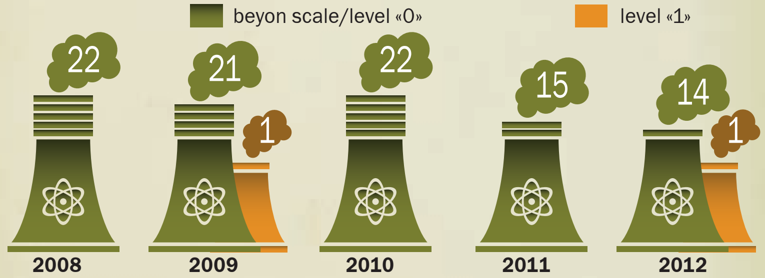


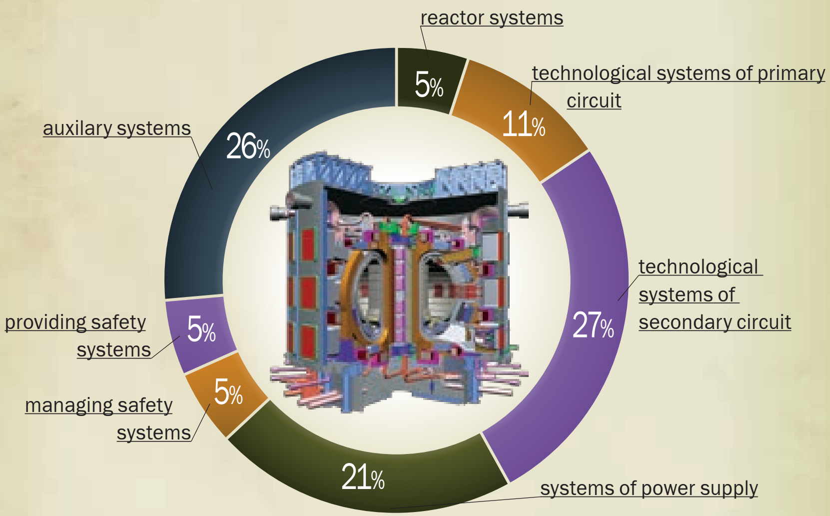
Figure 9.3. Distribution of the average number of events per one power unit of separate types of reactor facility

Figure 9.4. Distribution of events at NPPs of Ukraine according to INES scale in 2008-2012.



Absence of events in 2012 at power units with WWER-440 could be explained by long term operation activities, which included replacement of old equipment and introduction of complex of measures to enhance safety.

Figure 9.5. Distribution of systems that denied or exposed during abnormal events

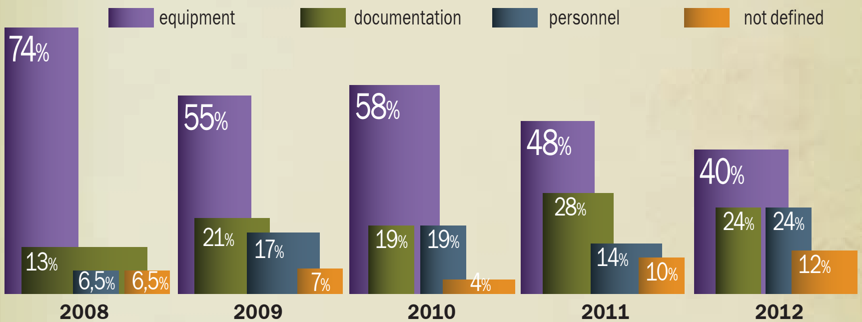


According to the INES scale in 2012 in Ukraine one violation of level 1 (anomaly) took place, which was related to the damage of several FAs produced by Westinghouse company at power units № 2, 3 of SU NPP. Other events at NPPs of Ukraine were classified beyond the scale «level 0» (not important for safety).

Depending on the characteristics and consequences the distribution of events at the plants in 2012 was as follows:

- *Suspension or disconnection of the reactor unit from the mains - 66% (10 event);*
- *Reactor power - 20% (3 events);*

Figure 9.6. Distribution of root causes of abnormal events



- *Falling and / or damage to fuel assemblies, fuel elements in transport operations and technology - 7% (1 event);*
- *Failure of safety important AC equipment and pipelines - 7% (1 violation).*

During NPP operational events deviation from the normal mode of operation (abnormal events) takes place, which can be caused by equipment failures, external influences, human error or lack of procedure. Figure 9.5 shows the distribution of systems that denied or exposed during abnormal events.