# ENSREG: 1st TOPICAL PEER REVIEW

# NATIONAL ACTION PLAN ON AGEING MANAGEMENT

# (Ukraine)

**State Nuclear Regulatory Inspectorate of Ukraine**

**Kyiv**

**2019**

## FOREWORD


According to the Association Agreement between Ukraine and the European Union, the Action Plan on Implementation of the Association Agreement between Ukraine, of the One Part, and the European Union, the European Atomic Energy Community and their Member States, of the Other Part, has been underway since 2014.

The ageing management area was selected for the first topical peer review by the European Commission based on proposals of the Western European Nuclear Regulators Association (WENRA) that were approved by the European Nuclear Safety Regulators Group (ENSREG).

According to ENSREG task, the review covers NPP units and research reactors with power more than 1 MW in operation as of 31 December 2017 or under construction as of 31 December 2016.

Ukraine joined this initiative and the State Nuclear Regulatory Inspectorate of Ukraine developed a National Report on the First Topical Peer Review on Ageing Management in 2017. This report has been analyzed by EU member states. A high level of Ukraine was noticed in issues related to ageing management. Besides, a series of aspects to be improved and advanced were determined.

To implement measures on the improvement of ageing management practice, the National Action Plan was developed, which is presented in this document and which will also be assessed by independent Western experts.

The SSTC NRS, Energoatom and Nuclear Research Institute of the National Academy of Sciences of Ukraine joined the development of the Action Plan. Therefore, the developed National Action Plan is a result of joint intention of all interested parties in the improvement of the ageing management process at all Ukrainian nuclear installations.

Kyiv, September 2019

**Chairman of the State Nuclear Regulatory**

**Inspectorate of Ukraine** **Hryhorii Plachkov**

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## ABBREVIATIONS

| | | |
|---|---|---|
| AM | – | Ageing Management |
| AMP | – | Ageing Management Program |
| CAMP | – | Cable Ageing Management Program |
| CPSS | – | Containment Prestressing System |
| Energoatom | – | National Atomic Energy Generating Company "Energoatom" |
| ENSREG | – | European Nuclear Safety Regulators Group |
| Euratom | – | European Atomic Energy Community, EAEC |
| I&C | – | Instrumentation and Control |
| IAEA | – | International Atomic Energy Agency |
| IGALL | – | International Generic Ageing Lessons Learned |
| LTO | – | Long-Term Operation |
| NDI | – | Nondestructive Inspection |
| NPP | – | Nuclear Power Plant |
| NRI | – | Nuclear Research Institute of the National Academy of Sciences of Ukraine |
| NRR | – | Nuclear Research Reactor |
| NRS | – | Nuclear and Radiation Safety |
| PWR | – | Pressurized Water Reactor |
| RPV | – | Reactor Pressure Vessel |
| SNRIU | – | State Nuclear Regulatory Inspectorate of Ukraine |
| SSTC NRS | – | State Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety" |
| TCA | – | Technical Condition Assessment |
| TLAA | – | Time Limited Ageing Analysis |
| VVER | – | Water-Cooled Water-Moderated Power Reactor |
| WENRA | – | West-European Nuclear Regulators Association |

## INTRODUCTION

In 2017, Ukraine joined the first topical peer review arranged by the European Commission based on proposals of the Western European Nuclear Regulators Association (WENRA) that were approved by the European Nuclear Safety Regulators Group (ENSREG) for the “ageing management” area.

The review covered NPP units and research reactors with power more than 1 MW in operation as of 31 December 2017 or under construction as of 31 December 2016.

Within these activities, with the support of the SSTC NRS, Energoatom and Nuclear Research Institute of the National Academy of Sciences of Ukraine, the SNRIU developed the National Report on the First Topical Peer Review on Ageing Management /1/ in 2017 and published it on the website. This and other reports of member states were analyzed by specialized expert groups arranged by ENSREG for independent review. In general, 2300 comments and remarks were made on the National Reports. In May 2018, a weeklong workshop was held in Luxemburg to discuss the results of the first peer review self-assessment. According to the results of this workshop, ENSREG developed and published two reports with relevant results:

– European Nuclear Safety Regulator’s Group ENSREG 1st Topical Peer Review Report “Ageing Management”. October 2018 /2/;

– European Nuclear Safety Regulator’s Group ENSREG 1st Topical Peer Review “Ageing Management” Country specific findings. October 2018 /3/.

For each member state of the peer review, the documents /2/, /3/ defined the status of performance, examples of good practices and the areas to be improved, for which each country developed the National Action Plan with deadlines for the completion of relevant measures. The National Action Plan has an objective to ensure monitoring of the progress on a set of research results obtained from the topical peer review and is a document informing on further measures to eliminate challenges revealed upon the results of the topical peer review.

The National Action Plan of Ukraine presented below was published at the end of September 2019.

# 1 MAIN FINDINGS RESULTING FROM THE SELF-ASSESSMENT

The main objective of the ageing management is to ensure safe and effective operation through implementation of technically and economically feasible measures and upgrades intended to detect degradation of power unit components caused by ageing in a timely manner and keep it within acceptable limits.

The term of ageing management was introduced into operational practice at the beginning of the 2000s, but ageing management components were implemented since the beginning of power unit operation:

- timely maintenance;
- identification of significant degradation and implementation of compensatory measures;
- equipment upgrading and replacement;
- change in operational modes (if necessary).

The national regulatory framework on ageing management was developed to support the implementation of measures according to Cabinet Resolution No. 263-r of 29 April 2004 “On Approval of the Comprehensive Program of Activities for Long-Term Operation of Nuclear Power Plants”.

One of the main principles of Ukraine’s regulatory control is a systematic hierarchic approach to the development and revision of regulatory documents. In practice, this principle is implemented through development of a hierarchic pyramid of NRS regulations, which includes documents of several levels, from legal regulations to detailed technical standards.

In the development of basic regulatory documents, detailed analysis for compliance with international experience and practices is carried out. In some cases, the regulator and operator carry out these activities within international assistance to Ukraine for harmonization of the national regulatory framework with European Union requirements and IAEA recommendations. The results of these activities indicate that Ukrainian standards and regulations that govern principal aspects of ageing management have been developed considering IAEA and WENRA recommendations and advanced international experience. A modern regulatory framework has been developed to conduct ageing management activities at a proper international level. The regulator and operator continuously develop new regulations and improve the existing documents.

Ageing management is conducted on a systematic basis. For this purpose, respective subdivisions have been established at all NPPs and provided with sufficient competent personnel with required authorities and resources.

Two types of ageing management are identified for components and structures: physical ageing and obsolescence. Management of physical ageing that leads to degradation is based on the understanding of ageing effects and prediction of degradation for components and structures and is arranged as follows: detection of degradation mechanism – identification of ageing effect – location of ageing effect on components – methods and means to monitor degradation – analysis of monitoring results – measures to mitigate/limit degradation – analysis of AMP effectiveness.

The operator develops reports on AMP implementation for each power unit and submits them to the SNRIU. AMP development and implementation are necessary conditions for LTO.

Administrative and technical ageing management activities carried out at Ukrainian NPPs comply with NRS regulations, standards and rules and ensure effective implementation of ageing management tasks.

Considering analysis of ageing management at NPPs and NRR, the following can be concluded:

1) existing Ukrainian regulatory and legal framework on ageing management is of the level that complies with IAEA and WENRA documents and safety recommendations. This was confirmed by independent analyses carried out by Western experts within international projects;

2) ageing management is carried out on a systematic basis and properly recorded with inclusion of data into electronic databases;

3) approach to ageing management is based on the understanding of ageing effects of prediction of degradation for components and structures;

4) AMP development and implementation are necessary conditions for LTO of power units;

5) safety factor of ageing is a part of the Periodic Safety Review Report in compliance with IAEA standards.

Upon self-assessment results, Ukraine identified the following potential good practices:

1) accumulation and summary of ageing management experience in the ageing management information analysis system (AMIAS);

2) implementation of performance indicators to assess effectiveness of the ageing management process;

3) consideration of ageing management measures in the program documents approved by the Ukrainian Government.

After the detailed consideration of the National Report of Ukraine by ENSREG independent experts, the following conclusions were made.

Summarized information on the review of the National Reports on Ageing Management of reactor pressure vessels and building structures is presented in the “1st Topical Peer Review “Ageing Management”. Country specific findings…” /3/, which identifies Good Practices or defines Expected Level of Performance individually for each state.

According to “1st Topical Peer Review “Ageing Management”. Country specific findings…” /3/, seven issues were identified for Ukraine as those recommended for improvement (two issues relate to general information on AMP, three issues relate to ageing management of underground pipelines, two issues relate to RPV).

Results of reviewing ageing management of electrical cables were not included into the above document and are presented in “1st Topical Peer Review Report “Ageing Management September 2018. European Nuclear Safety Regulators Group. ENSREG” /2/. According to this document, seven issues were defined, which were recommended for improvement.

## 1.1 Overall Ageing Management Programmes (OAMPs)

### 1.1.1 State finding (area for improvement or challenge) from the self-assessment for OAMPs

Upon summary of the ageing management processes by the license, the following conclusions are made:

- in compliance with regulatory requirements, the operator developed detailed technical requirements that cover all aspects of ageing management activities. These requirements were developed considering international and national experience and practices, IAEA recommendations and provisions of WENRA documents;
- operator established subdivisions at each NPP that carry out ageing management activities. These subdivisions are provided with adequate financial, material and human resources;
- regulatory documents were developed to clearly determine requirements for the selection of components and structures for ageing management;
- regulatory requirements were established for timely implementation of preventive and remedial measures to mitigate degradation;
- AMP efficiency is assessed and the operator’s self-assessment and independent assessment of ageing management activities are carried out on a permanent basis;
- results of ageing management activities are properly recorded and included into AMIAS.

Results of independent assessments by international organizations indicate that current Ukrainian regulatory requirements for ageing management form a strong framework for the solution of these issues. The Ukrainian regulations in this area were developed considering IAEA and WENRA recommendations and the best international experience and practices. The regulations are revised and improved in a planned manner.

Upon analysis of operator's conclusions, the SNRIU made the following specifications.

Currently, the Overall Standard Ageing Management Program (Standard AMP) /4/ is in force in Ukraine. The main challenge of the Standard AMP /4/ is that it combines aspects of AM and LTO, while they should be governed by separate documents of the operation, as required in NP 306.2.210-2017 /5/. Therefore, the operator should develop two separate documents with specific requirements for AM and LTO. Such activities have been launched and the operator developed two separate documents:

- SOU NAEK 080:2014 Operation of Technological System. Long-Term Operation of NPP Units. General Provisions /6/;
- SOU NAEK 141:2017 Engineering, Scientific and Technical Support. Ageing Management of NPP Components and Structures. General Requirements /7/.

These documents are still under the process of SNRIU approval.

#### 1.1.2 Country position and action on (licensee, regulator, justification) approaches to OAMPs

The documents /6/ and /7/ after their revision by the operator taking into account SNRIU comments shall be subject to the final stages of agreement. Upon agreement results, they will be put into effect by the end of 2019. An appropriate measure is provided by the National Action Plan (see para. 1 of the Table "Summary of the Planned Actions").

### 1.2 Electrical cables

#### 1.2.1 State finding (area for improvement or challenges) from the self-assessment for electrical cables

Upon analysis of ageing management process related to electrical cables, the licensee made the following main conclusions:

1) regulatory documents have been developed to govern AM and LTO of cables;

2) working programs for technical condition inspection for single-type cables have been developed at NPPs for all cable types subject to ageing management;

3) operating conditions of cables at power units have been monitored in all cable rooms, permanent monitoring is conducted on a permanent basis only at hot spot identified in primary monitoring. Primary monitoring is conducted at individual power units;

4) cables have been identified at power units, lists of representative cables for inspection have been made;

5) representative cables have been analyzed in laboratory and operating conditions. Inspection findings for cables used in the containment are mainly positive. Some cables that show unsatisfactory mechanical and capacity characteristics of insulation in laboratory tests after accelerated thermal and radiation ageing are replaced;

6) in replacement of cables in rooms where hot spots are revealed, surveillance specimens are placed (deposited);

7) database on cables is kept for information support of ageing management processes. The database is a model of the URDB “Automated Database on Cable Operation” intended for information support of ageing management activities for power unit cables, in particular:

- analysis of design, operational and maintenance documentation;
- preparation of lists of cable for their technical condition assessment;
- analysis of monitoring of cable operating conditions and technical conditions;
- reporting.

Ageing management measures on cables of NPP units are carried out in compliance with current regulatory and working documents. The main scope of these activities is carried out within regular operations and technical condition assessment and lifetime reassignment. The results are finalized as technical reports and decisions to be agreed with the SNRIU.

Introduction of cable ageing management at NPPs allows timely response to changes in cable operating conditions (which is one of the important parameters in determination of the residual life) and optimum planning of LTO.

Upon analysis of operator’s conclusions, the SNRIU made the following specifications:

1. The analysis of information related to ageing management of cables presented in this Section makes it possible to develop the following conclusion: proper attention is paid to the ageing management of cables at NPP units both during the design-basis life and in the LTO period.

2. Ageing management measures on cables are implemented in compliance with requirements of current standards and rules of nuclear and radiation safety. The main scope of these activities is carried out during regular operations and in TCA and LTO. Cables were qualified for harsh environments. The results are finalized as technical reports and decisions, which, in accordance with NP 306.2.210-2017 /5/, are submitted by the operator to the SNRIU for agreement for permanent oversight and monitoring of AMP implementation and particularly CAMP /12/ implementation at NPP units. The information provided in the reports is assessed and checked during scheduled inspections, including aspects related to cable ageing management.

3. The results of the evaluation of TCA and cable qualification for harsh environment is mainly positive. Separate cables that showed unsatisfactory results in tests are replaced: for example, cables KMPEVE, KPoSG and KPoESV that are laid in rooms with harsh environments. In addition, in the framework of measures related to replacement of equipment in instrumentation and control systems and electrical equipment, control and power cables have been or are going to be replaced with fire retardant ones and those in automated firefighting systems and emergency power supply systems with fireproof ones.

#### 1.2.2 Country position and action on finding (licensee, regulator, justification) for electrical cables

The following can be stated after analysis of information on ageing management of cables provided above: ageing management of cables at NPP units is paid proper attention both during the design-basis life and in the LTO period.

Taking into account all the above mentioned, it is assumed that the development of targeted measures to improve ageing management of electrical cables is impractical. At the same time, CAMP shall be improved on a permanent basis (see provisions of Section 3).

### 1.3 Concealed pipework

#### 1.3.1 State finding (area for improvement or challenge) from the self-assessment for concealed pipework

Upon analysis of ageing management process related to concealed pipework, the licensee made the following main conclusions.

Monitoring of technical condition of NPP underground piping is performed on a permanent basis according to operator’s documents and envisages the following:

- identification of technical condition, observation and diagnostics of underground piping parameters;
- use of state-of-the-art TCA methods of underground piping;
- technical condition forecasting of underground piping and assessment of its service life;
- ageing management of underground piping.

Since the most of piping is not accessible for external and internal examination, the main monitoring methods are methods of contactless diagnostics for underground piping, namely:

- contactless magnetometric diagnostics method;
- acoustic tomography method.

These methods reveal loss of integrity of piping and do not require direct access to piping external surface. Diagnostics is carried out from ground surface above the piping. 100% of piping from all observation groups are inspectable.

Upon analysis of operator's conclusions, the SNRIU made the following specifications:

1. The activities performed by the operator regarding ageing management of concealed pipework meet the regulatory requirements at the same time taking into account that the contactless diagnostics methods are constantly improved, in particular in terms of improving accuracy of determining parameters, the SNRIU recommended the operator to continue the following measures on a permanent basis:

- analyze current research and development (methods, methodologies, equipment), whose purpose is to perform adequate assessment (diagnostics) of current technical condition for piping, which is deepened in the ground and is not easily accessible for examination;
- analyze current international experience in assessing the current technical condition of piping that is deepened in the ground and is not easily accessible for examination;
- involve specialized organizations having experience in designing, operating and repairing similar piping in other industries, etc.

#### 1.3.2 Country position and action on finding (licensee, regulator, justification) for ageing management of concealed pipework

SNRIU recommendations were reflected in the relevant measures identified by the operator, which will be included into the National Action Plan (see para. 2 of the Table "Summary of the Planned Actions").

### 1.4 Reactor pressure vessel

#### 1.4.1 State finding (area for improvement or challenge) from the self-assessment for reactor pressure vessel

Upon analysis of ageing management process related to reactor pressure vessel, the licensee made the following main conclusions.

The following procedures are used to define ageing mechanisms of reactor pressure vessel and reactor closure head:

- NDI of the base (clad) metal and welds;
- monitoring of RPV metal properties using surveillance specimens;
- internal/external inspection of equipment;
- density control of the reactor main flange.

According to the results of the procedure on revealing ageing mechanisms, analysis and assessment of the technical state, the following degradation mechanisms were defined for RPV:

- radiation embrittlement (for RPV);
- thermal ageing (for reactor pressure vessel and reactor closure head);
- fatigue (for reactor pressure vessel and reactor closure head);

– stress corrosion cracking (for reactor pressure vessel and reactor closure head);

– boron corrosion (for reactor pressure vessel and reactor closure head);

– creasing/mechanical damage (for reactor pressure vessel and reactor closure head).

Preventive and corrective measures are established for all degradation mechanisms aimed at degradation mitigation. Continuous monitoring and analysis of ageing effect trends are carried out. AMP is supplemented by the results of activities within TCA and on the basis of industry summary reports on conducted activities with ageing management of NPP components.

The results of performed activities on RPV TCA and LTO considering TLAA results indicate that in a number of cases the operator faces a lack of representative data based on tests of surveillance specimens. Certain actions are taken in order to exclude such a situation. In particular, a surveillance program for the RNPP-1 RPV after annealing has been developed and implemented and the design-basis container assemblies for surveillance specimens are under upgrading to locate them more favorably relative to the core.

Upon analysis of operator's conclusions, the SNRIU made the following specifications.

1. According to the specified aspects, new systems of remote NDI of RPV metal condition (such as CMM-SAPHIRplus, RPV-1000, etc.) are implemented at Ukrainian NPPs. There are improvements in the methodology for calculation of fluence, thermohydraulic parameters and strength calculation, which are reflected in TLAA used to justify safety of reactor pressure vessel long-term operation.

2. To provide more reliable results of tests for the surveillance specimens already removed from the reactor, the operator uses the reconstruction technology to increase the number of specimens to plot serial curves of bending tests and improve the accuracy and reliability of the mechanical properties of irradiated RPVs.

3. The operator developed and is implementing the Integrated Program /8/ in order to receive additional data on regular, modernized and new surveillance programs to improve reliability of the assessment of changes in RPV metal properties. According to provisions of this program, the surveillance specimens are irradiated opposite the core. At the same time, the applied use of the results of implementing this program is complicated by a number of factors that are still not resolved by the operator (compliance with the conditions in which the results of surveillance specimen tests conducted in accordance with the Integrated Program /8/ can be used for specific conditions of RPV operation in Ukraine has not been demonstrated).

4. Over the years of AMP implementation, the operator identified the main ageing mechanisms, determined parameters to be monitored and established acceptance criteria. All these aspects are continuously and carefully monitored by the operator under regulatory supervision.

5. The process of RPV AM continues to be improved based on accumulated national and international experience and results of the implementation of research and development programs.

### 1.4.2 Country position and action on finding (licensee, regulator, justification) for ageing management of reactor pressure vessel

The above information is the basis for the formation of such measures to be included into the National Action Plan (see para. 3 of the Table “Summary of the Planned Actions”):

- further implementation of state-of-the-art systems of remote NDI of RPV metal condition to receive the most reliable results on the state of RPV metal during operation;
- improvement of provisions of the Integrated Program /8/ in order to ensure possibility for its applied use (formation of conditions under which the results of testing surveillance specimens within the Integrated Program /8/ can be used for specific conditions of RPV operation in Ukraine);
- development of AMP for RPV of each power unit.

## 1.5 Concrete containment structures

### 1.5.1 State finding (area for improvement or challenge) from the self-assessment for concrete containment structures

Upon analysis of ageing management process related to concrete containment structures, the licensee made the following main conclusions.

The activities on ageing management of concrete containment structures are performed in compliance with NPP AMP for NPP structures and components.

Analysis of degradation mechanisms of containment building structures and components is performed on the basis of results of familiarization with technical documents, visual and instrumental inspection, and verification calculation for the reactor compartment.

The general factor defining the progression of degradation processes includes operating conditions, namely the temperature fluctuations of the environment and the quality of construction works.

The assessment of the condition of structures and buildings is carried out by means of visual and instrumental observations. According to observation results, measures are developed to put containment components and structures into condition that ensures durability of structures for the period of LTO by eliminating the defects and damages revealed during observations:

- current repair of defective structures or components;

– reinforcement of structural components adjoining the area of impact of the defect.

Measures on AM of building structures and components are implemented in accordance with the approved schedules based on the results of instrumental and visual observations.

The gained experience in performing activities on TCA based on results of instrumental, visual observations and calculations of strength and carrying capacity indicates that revealed defects and damages do not affect the carrying capacity of structures. Further operation (LTO period) of building structures is allowed in design mode without any restrictions, but on condition of implementation of ageing management measures.

Upon analysis of operator's conclusions, the SNRIU made the following specifications.

1. Measures on ageing management shall be defined on continuous monitoring of the condition of building structures, results of activities on TCA and taking into account results of the research and development programs.

2. The list of building components and structures to be included into AMP shall be defined based on the classification by safety impact taking into account data on design, engineering and operational documents. The list of such structures is made for each specific power unit and for each specific building.

3. To ensure safe operation of the containment, the operator developed and the regulator approved "Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000". This plan provides for the implementation of measures to 2024 and includes:

– implementation of a remote inspection system for CPSS tendon tension at NPP units;

– implementation of activities on TCA (in particular, activities on TCA and calculation justification of containment reliability to check compliance with requirements of regulatory documents (with determination of minimum allowed tendon tension)).

4. The results of assessing ageing management of concrete containment structures provide grounds for claiming that the system for ageing management and monitoring of the technical state of NPP buildings and structures established at Ukrainian NPPs allows controlling basic parameters that ensure the reliable operation of buildings and structures, which is especially relevant at LTO stage. At the same time, all measures planned within the document "Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000" require to be implemented till the end of 2024.

### 1.5.2 Country position and action on finding (licensee, regulator, justification) for ageing management of concrete containment structures

The above information is the basis for the formation of such measures to be included into the National Action Plan (see para. 4 of the Table “Summary of the Planned Actions”):

– Completion of all measures envisaged within “Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000” till 31 December 2024.

# 2 SPECIFIC FINDINGS RESULTING FROM THE TPR

## 2.1 Overall Ageing Management Programmes (OAMPs)

### 2.1.1 TPR expected level of performance

According to para. 4.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/:

1) “Methodology for scoping the SSCs subject to ageing management: The scope of the OAMP is reviewed and, if necessary, updating, in line with the new IAEA Safety Standards after its publication”.

Currently, taking into account IAEA documents:

– “Ageing Management for Nuclear Power Plants. Safety Guide. NS-G-2.12” /9/;

– “Ageing Management for Nuclear Power Plants: International Generic Aging Lessons Learned (IGALL) SRS 82” /10/;

– “Safe Long Term Operation of Nuclear Power Plants SRS 57” /11/

Energoatom developed a regulatory document SOU NAEK 141:2017 “Ageing Management of NPP Components and Structures” /7/, which was submitted to the SNRIU.

At the same time, taking into account recommendations of IAEA document “Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants. SSG-48” /15/ and results of IAEA mission Pre-SALTO, Energoatom planned activities at SUNPP-3 on the development of document on the selection of components and structures of 4N safety class, whose failure or damage can affect the operation of systems important to safety. The deadline for development is 2020.

2) “During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or others effects”.

Requirements for the need to control technical state of equipment and structures in order to reveal possible degradation mechanisms of components and structures and implementation of relevant measures to mitigate degradation during long-term construction and shutdown of NPP units (if necessary) will be specified in SOU NAEK 141:2017 /7/. Deadline – 2019.

Taking into account the above mentioned, the development of the regulation SOU NAEK 141:2017 /7/ “Ageing Management of NPP Components and Structures” /7/ will consider and include requirements for the revealing of ageing effects and development of relevant measures to control any occurrence of ageing or other defects during long-term construction or shutdown. Requirements for the selection of components and structures of 4N safety class, whose failure or damage can affect operation of systems important to safety, will be included into a separate document (see para. 5 of the Table “Summary of the Planned Actions”).

### 2.1.2 Country position and action (licensee, regulator, justification)

Taking into account the above mentioned, the development of the regulation SOU NAEK 141:2017 /7/ “Ageing Management of NPP Components and Structures” /7/ will consider and include requirements for the revealing of ageing effects and development of relevant measures to control any occurrence of ageing or other defects during long-term construction or shutdown. Requirements for the selection of components and structures of 4N safety class, whose failure or damage can affect operation of systems important to safety, will be included into a separate document (see para. 5 of the Table “Summary of the Planned Actions”).

## 2.2 Concealed pipework

### 2.2.1 TPR expected level of performance

According to para. 6.2.3 of the ENSREG report “1st Topical Peer Review Report “Ageing Management…” /2/:

– Inspection of safety-related pipework penetrations through concrete structures are part of ageing management programs, unless it can be demonstrated that there is no active degradation mechanism;

– Scope of concealed pipework included in AMPs: The scope of concealed pipework included in ageing management includes those performing safety functions, and also non-safety-related pipework whose failure may impact SSCs performing functions;

– Opportunistic inspections: Opportunistic inspections of concealed pipework is undertaken whenever the pipework becomes accessible for the others purposes.

The development of a separate AMP is necessary to enhance control over ageing management of underground piping. AMP for underground piping will be developed based on own operating experience, TCA during carrying out LTO activities and taking into account international experience and IAEA recommendations presented in the document “Buried and Underground Piping and Tank Ageing Management for Nuclear Power Plants” NP-T-3.20. The deadline for development is 2020.

Currently, the lists of NPP components and structures subject to ageing management include underground piping referred to systems important to safety. The decision on the need to include underground piping whose failure or damage can affect operation of systems important to safety to ageing management lists will be made during the development of the document on the selection of components and structures referred to 4N safety class (see para. 5 “2)” of the Table “Summary of the Planned Actions”).

The issue on the need for additional inspection of underground piping (opportunistic inspections) will be considered during the development of AMP for underground piping. The deadline for development is 2020.

### 2.2.2 Country position and action (licensee, regulator, justification)

Taking into account the above mentioned, the development of the regulation SOU NAEK 141:2017 /7/ will consider requirements for the selection of components and structures of 4N safety class whose failure or damage can affect operation of systems important to safety. A separate AMP for concealed (underground) pipework will be developed (see para. 6 of the Table “Summary of the Planned Actions”).

## 2.3 Reactor pressure vessel

### 2.3.1 TPR expected level of performance

According to para. 7.2.3 of the ENSREG report “1st Topical Peer Review Report “Ageing Management…” /2/, it is expected that the country will develop measures aimed at the improvement of the following practices:

– Non-destructive examination in the base of beltline region: Comprehensive Non-destructive examination is performed in the base material of the beltline region in order to detect defects;

– Environmental effect of the coolant: Fatigue analyses have to take into account the environmental effect of the coolant.

Regarding NDI of base metal, it should be stated that NDI of RPV metal was performed for all NPPs at producing plants and there was preoperational control performed on NPP sites. All recorded indications were defined as admissible and are monitored with a frequency of once every four years in the amount of 100 % within the periodic operational NDI. The control is performed using certified remote systems applying visual inspection, ultrasonic and eddy current methods of inspection.

No unacceptable defects have been detected in any RPV during the entire operation period. Development of targeted measures in this case is inappropriate.

During LTO of power units, fatigue calculations for equipment and piping are performed. Coolant impact on corrosion damage of metal within design operation and LTO is considered. No ageing effects indicating a negative influence of the coolant on RPV metal fatigue were revealed.

Development of targeted measures in this case is inappropriate.

At the same time, based on self-assessment results, the National Action Plan envisages a general approach “Improvement of RPV AM on the basis of accumulated national and international experience and results of the implementation of research and development programs” (see para. 3 of the Table “Summary of the Planned Actions”).

### 2.3.2 Country position and action (licensee, regulator, justification)

The development of targeted measures for the areas specified in para. 2.3.1 was recognized as inappropriate by the operator. In general, the SNRIU agreed the proposed approach, but an issue of improving practice of RPV AM have already been included in the National Action Plan based on the results of self-assessment. Measures related to RPV were reflected in para. 3 of the Table "Summary of the Planned Actions", namely:

1) further implementation of state-of-the-art systems of remote NDI of RPV base metal;

2) improvement of provisions of the Integrated Program for surveillance specimens /8/ for the possibility of its applied use (formation and compliance with the criteria of results applicability);

3) development of AMP for RPV of each power unit.

## 2.4 Concrete containment structures

### 2.4.1 TPR expected level of performance

According to the Report "European Nuclear Safety Regulator's Group ENSREG. 1st Topical Peer Review "Ageing Management" Country specific findings" /3/, no areas for improvement were revealed for the area "Concrete containment structures" in Ukraine. However, good practices related to such areas as "Performance Monitoring of pre-stressing forces: Pre-stressing forces are monitored on a periodic basis to ensure the containment fulfils its safety function" were stated.

At the same time, specific activities on improving safety of the containments in Ukraine are still ongoing and they are performed according to the "Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000" approved by the SNRIU. The completion of activities under this schedule is envisaged by the National Action Plan upon results of self-assessment until 31 December 2020.

### 2.4.2 Country position and action (licensee, regulator, justification)

Activities to complete measures according to the "Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000" approved by the SNRIU are planned until 31 December 2020 (see para. 4 of the Table "Summary of the Planned Actions").

# 3 GENERIC FINDINGS RELATED TO ELECTRICAL CABLES

## 3.1 Good practice: characterize the state of degradation of cables aged at the plant

### 3.1.1 Country implementation

Ageing management of cables at NPP is paid proper attention both during the design-basis life and in the LTO period. The main objective of ageing management of cables is the timely detection of deterioration in properties of cable insulation materials to predict their further operation period. Besides inspection of representative cables in laboratory and operating conditions, it is also important to monitor cable during operation. Introduction of cable ageing management at NPPs allows timely response to changes in cable operating conditions and optimum planning of LTO. In addition, in the framework of measures related to replacement of equipment in instrumentation and control systems and electrical equipment, control and power cables have been or are going to be replaced with fire retardant ones and those in automated firefighting systems and emergency power supply systems with fireproof ones.

The results of evaluation of TCA and cable qualification for harsh environment are mainly positive. Separate cables that showed unsatisfactory results in tests are replaced: for example, cables KMPEVE, KPoSG and KPoESV that are laid in rooms with harsh environments. In addition, in the framework of measures related to replacement of equipment in instrumentation and control systems and electrical equipment, control and power cables have been or are going to be replaced with fire retardant ones and those in automated firefighting systems and emergency power supply systems with fireproof ones.

Qualification of cables through the testing method is performed according to the procedure allowing justification of cable resistance to harsh environmental conditions taking into account ageing. The performed assessment of NPP cable qualification for harsh environmental condition did not reveal ageing effects that deteriorated qualification characteristics.

### 3.1.2 Country planned action if relevant

Implementation of CAMPs /12/ together with other AMPs of NPP equipment is a necessary condition for NPP LTO. They are periodically revised, improved taking into account gained national and international experience, practice and technical capabilities to perform activities on ageing management.

Country planned actions are to improve AMP for cables according to national and international experience and practice, new recommendations of IAEA, WENRA.

## 3.2 TPR expected level of performance: documentation of the cable ageing management program

### 3.2.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ “The AMP is sufficiently well-documented to support any internal of external reviews in a fully traceable manner”.

CAMP currently in force in Ukraine specifies:

- content of ageing management activities;
- requirements for the “Cable Ageing Management Program for Nuclear Power Plant Unit”;
- requirements for the contents of Working Programs for Technical Condition Assessment of Cables;
- requirements and principles for the development of lists of cables subject to TCA;
- procedures to monitor operating conditions of cables and detect hot spots;
- methods for cable TCA;
- requirements for cable TCA aimed at their lifetime extension;
- requirements for databases and information on cables to be included into databases on cabling operation;
- records on ageing management measures;
- content of scientific and technical support and assistance to activities;
- requirements for quality.

Development of targeted corrective measures was recognized as inappropriate.

#### 3.2.2 Country planned action if relevant

Country planned action is to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.3 TPR expected level of performance: methods for monitoring and directing all AMP-activities

#### 3.3.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ “Methods to collect NPP cable ageing and performance data are established and used effectively to support the AMP for cables”.

The following methods have been established at Ukrainian NPPs and effectively used to obtain data on cable ageing:

- monitor operating conditions;
- identify cables;
- place (deposit) surveillance specimens;
- develop TCA working programs and methodologies for groups of single-type cables;
- perform TCA of cables.

Development of targeted corrective measures was recognized as inappropriate.

#### 3.3.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.4 TPR expected level of performance: Systematic identification of ageing degradation mechanisms considering cable characteristics and stressors

#### 3.4.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ - “Degradation mechanism and stressors are systematically identified and reviewed to ensure any missed or newly stressors are revealed before challenging the operability of cables”.

The main degradation mechanisms include: thermal, electric, mechanical and radiation ones.

According to CAMP developed in Ukraine, the specified mechanisms are controlled during cable lifetime extension according to developed working programs.

Development of targeted corrective measures was recognized as inappropriate.

#### 3.4.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.5 TPR expected level of performance: prevention and detection of water treeing

#### 3.5.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ – “Approaches are used to ensure that water in cables with polymeric insulation is minimized, either by removing stressors contributing to its or by detected degradation by applying appropriate methods and related criteria”.

The specified aspect requires the improvement of operating practices in ensuring that the presence of water in cables with polymeric insulation will be reduced to minimum. The recommendation was found to be appropriate and the specified aspects will be taken into account during the revision of CAMP. The deadline for revision is in 2020.

#### 3.5.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.6 TPR expected level of performance: consideration of uncertainties in the initial environmental qualification

#### 3.6.1 Country implementation

According to para. 5.2.3 of the ENSREG Report 1st Topical Peer Review Report “Ageing Management…” /2/ – “The accuracy of the representation of the stressors used in the initial Environmental Qualification is assessed with regard to the expected stressors during normal operation and Design-Basis Accidents”.

Requirements for cable qualification are presented in the Energoatom document SOU NAEK 179:2019 “Qualification of NPP Equipment” /13/, which is kept updated and extended taking into account gained experience, practices and new IAEA requirements.

Development of targeted corrective measures was recognized as inappropriate.

#### 3.6.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.7 TPR expected level of performance: determining cables’ performance under highest stressors

#### 3.7.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ - “Cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design Extension Conditions and throughout their expected lifetime”.

According to the results of qualification held at Ukrainian NPPs, cables necessary for prevention of accidents fulfil their functions in LTO during the whole service life, which is confirmed by the results of cable qualification for the environmental conditions. Requirements for them are established in SOU NAEK 179:2019 “Qualification of NPP Equipment” /13/ and in the document “Cable Ageing Management Program for Nuclear Power Plants. PM-T.0.08.121-14” /14/. These documents envisage the preservation of qualification during the whole service life.

Development of targeted corrective measures was recognized as inappropriate.

#### 3.7.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

### 3.8 TPR expected level of performance: techniques to detect the degradation of inaccessible cables

#### 3.8.1 Country implementation

According to para. 5.2.3 of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/ – “Based on international experience, appropriate techniques are used to detected degradation of inaccessible cables”.

The specified aspect requires the improvement of operating practices to ensure that relevant technologies are used for the cables located in inaccessible places. The recommendation was found to be appropriate and the specified aspect will be taken into account during the revision of CAMP. The deadline for revision is in 2020.

#### 3.8.2 Country planned action if relevant

Country planned action is to improve cable AMP according to national and international experience and practice, new recommendations of IAEA, WENRA.

#### 3.8.3 Measures to be included in the National Plan to improve cable ageing management processes

Taking into account the analysis of data presented in paras. 3.1-3.8, the following approaches to improve operating practices related to cable ageing management were developed. The measures specified in Table 3.1 are included into the National Action Plan.

Table 3.1

| No. | Issue | Conclusion | Measure | Deadline |
|---|---|---|---|---|
| 1 | Electrical cables | The requirements and provisions on the consideration of the following aspects shall be included in CAMP:<br>– use of relevant technologies for the technical condition assessment and qualification of cables located in inaccessible places;<br>– establishment of requirements, criteria and development of measures to minimize the presence of water in cables with polymeric insulation. | Amendment of cable ageing management program and approval with the SNRIU. | 31.12.2020 |

# 4 ALL OTHER GENERIC FINDINGS

## 4.1 Overall Ageing Management Programmes

### 4.1.1 Good practice: External peer review services

External peer review services for NPP power units (such missions as SALTO, OSART-LTO, INSARR-Ageing) are widespread in the world and are also used in Ukraine. A pre-SALTO mission was held at SUNPP-3 in 2019. The direct SALTO mission is planned for 2020.

### 4.1.2 TPR expected level of performance: Data collection, record keeping and international cooperation

Ukraine actively participates in international projects on ageing management and LTO of NPP units. In particular, experts of the operator and the SNRIU take part in IAEA projects on international generic lessons learnt (IGALL). Gained experience is used in the development of ageing management documents.

The national database on ageing management was developed using the international database developed within IAEA IGALL project to improve ageing management effectiveness.

### 4.1.3 TPR expected level of performance: Methodology for scoping the SSCs subject to ageing management

AMP developed by Energoatom and approved by the SNRIU is kept updated and is revised according to new requirements of IAEA and WENRA, best international experience and practices.

Currently, it is updated with the consideration of the following IAEA documents:

- “Ageing Management for Nuclear Power Plants. Safety Guide. NS-G-2.12” /9/;
- “Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) SRS 82” /10/;
- “Safe Long-Term Operation of Nuclear Power Plants SRS 57” /11/

Energoatom developed an industry standard SOU NAEK 141:2017 “Ageing Management of NPP Components and Structures” /7/, which was submitted to the SNRIU and passed state review of nuclear and radiation safety and is currently revised by the operator to consider the peer review conclusions.

#### 4.1.4 TPR expected level of performance: Delayed NPP projects and extended shutdown

During the construction of a power unit due to various objective or subjective factors, delays are possible for an indefinite period, in which case it is necessary to implement certain ageing management measures to prevent degradation and deterioration of properties over time for the components and structures, the construction of which was suspended. The requirement for the need to control the technical condition of components and structures in order to reveal possible degradation mechanisms and implementation of relevant measures on the mitigation of degradation during delayed construction and NPP shutdowns (if necessary) will be specified in SOU NAEK 141:2017 /7/. The relevant measure was included into the National Action Plan.

#### 4.1.5 TPR expected level of performance: Overall Ageing Management Programmes of research reactors

According to the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/, a general drawback is typical for all research reactors that is related to the fact that AMPs require revision and bringing them in compliance with IAEA recommendations SSG-10 /24/. The same is the situation with AMP of the Kyiv Nuclear Research Reactor and relevant measures shall be implemented.

The National Action Plan provides for the revision of AMP of NRI of NAS of Ukraine in order to take into account the graded approach regarding the risk, requirements of international safety standards and IAEA recommendations SSG-10 /24/.

### 4.2 Concealed pipework

#### 4.2.1 Good practice: use of results from regular monitoring of the condition of civil structures

Taking into account operational conditions of underground piping of the essential service water system and according to recommendations of the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/, results of regular monitoring of the state of buildings and structures shall be used as input data for the development of AMP.

According to the monitoring of operational conditions of civil structures, no effect on state and operational conditions of the concealed pipework was determined. Therefore, the specified issue is not relevant for the concealed piping of Ukrainian NPPs.

#### 4.2.2 Good practice: performance checks for new or novel materials

According to the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/, the approach is used according to which a fragment of piping is cut for the research to assess integrity of materials, of which the underground piping is made.

Considering this aspect, it is necessary to state that the results of monitoring underground piping at Ukrainian NPPs confirm their satisfactory condition. The cutting of metal fragments is not envisaged by the current regulatory documents. The control of piping metal is performed only using the non-destructive inspection.

#### 4.2.3 TPR expected level of performance: inspection of safety-related pipework penetrations

According to the ENSREG Report "1st Topical Peer Review Report "Ageing Management…" /2/, inspection of penetrations through concrete structures for piping important to safety shall be the part of AMP or, at least, it is necessary to demonstrate the absence of degradation mechanisms related to sealed penetrations.

Energoatom established the need to develop an individual AMP to strengthen control over the ageing management of underground piping. AMP for underground piping will be developed based on own operational experience, TCA during performance of LTO activities and taking into account international experience and IAEA recommendations presented in the document "Buried and Underground Piping and Tank Ageing Management for Nuclear Power Plants" NP-T-3.20. The deadline for development is 2020. The relevant measure is included to the National Action Plan.

#### 4.2.4 TPR expected level of performance: scope of concealed pipework included in AMPs

According to the ENSREG Report "1st Topical Peer Review Report "Ageing Management…" /2/, AMP shall include piping fulfilling safety functions and those piping whose damage can affect piping fulfilling safety functions.

Currently, the lists of NPP components and structures subject to ageing management include underground piping referred to systems important to safety. The decision on the need to include underground piping whose failure or damage can affect operation of systems important to safety to ageing management lists will be made during the development of the document on the selection of components and structures referred to 4N safety class. The relevant measure was included into the National Action Plan.

#### 4.2.5 TPR expected level of performance: opportunistic inspections

According to the ENSREG Report "1st Topical Peer Review Report "Ageing Management…" /2/, additional inspections of the concealed pipework are used (if possible) to obtain additional data (information) on the conditions of the concealed pipework.

The issue on the need for additional examination of underground piping will be considered during the development of AMP for underground piping. The relevant measure was included into the National Action Plan.

### 4.3 Reactor pressure vessel

#### 4.3.1 Good practice: Hydrogen water chemistry

Such an ageing effect through the degradation mechanism is typical for boiling water reactors. Pressurized water reactors are operated in Ukraine, for which the specified degradation mechanism was not revealed.

#### 4.3.2 Good practice: Implementation of a shield

The world practice uses such an approach, under which relevant protective measures are applied in case of significant neutron fluence towards reactor wall. Fuel loadings with reduced neutron flow (for all power units) and protective shield (for RNPP-1) are used as a preventive measure to minimize RPV metal degradation upon the results of its radiation embrittlement.

#### 4.3.3 TPR expected level of performance: Inspection of base metal and RPV cladding

Operational NDI of RPV cladding is performed regularly once every four years in the scope of 100% at all Ukrainian NPPs to ensure early detection of stress corrosion cracking. The control is performed using certified remote systems applying visual inspection, ultrasonic and eddy current methods of inspection.

No unacceptable cladding defects were revealed on any reactor pressure vessel during the whole operation of the power units.

#### 4.3.4 TPR expected level of performance: Non-destructive inspection in base metal and welds

NDI of RPV metal was performed for all NPPs at producing plants and there was preoperational control performed on NPP sites. All recorded indications were defined as admissible and are monitored with a frequency of once every four years in the amount 100 % within the periodic operational NDI. The control is performed using certified remote systems applying visual inspection, ultrasonic and eddy current methods of inspection.

No unacceptable defects were revealed on any reactor pressure vessel during the whole operation period. The development of additional/corrective measures is inappropriate.

#### 4.3.5 TPR expected level of performance: Coolant effect on RPV degradation

During the transfer of Ukrainian NPP units to LTO, relevant analysis and fatigue calculations for equipment and piping are performed. Coolant impact on corrosion damage of metal within design operation and LTO is considered. The development of additional/corrective measures is inappropriate.

#### 4.3.6 TPR expected level of performance: compliance of placement and reliability of studies applying surveillance specimens

Most power units in Ukraine implement regular surveillance program; one of its disadvantages is that one layer accumulates neutron fluence in a range that exceeds the requirements of PNAE G-7-002-87. In this regard, to select representative groups of surveillance specimens and, as a consequence, increase the reliability in determining the properties of RPV metal, the surveillance specimen sets should be tested under the regular program using the reconstruction technology for tested specimens and then reconstructed surveillance specimens should be tested. Relevant measures on the improvement of AMP for RPV were included into the National Action Plan.

### 4.4 Concrete containment structures

#### 4.4.1 Good practice: monitoring of concrete structures

Additional devices are used for better prediction of mechanical behavior of the containment, prestressing system control and for the compensation of losses of sensors mounted at the design stage.

Due to the loss of performance of the most of specially embedded force converters built into concrete at Ukrainian NPPs, the approach to monitoring of containment stress strain state and loss of tension in tendons.

Currently, after equipping the NPP units with systems of remote control of tension in tendons, the sufficiency of containment stress strain state is assessed according to tension of the prestressing in each tendon at its tight end, together with periodic measurements of its spatial geometry.

Control of tension in every tendon ensures a more conservative approach when assessing the containment stress strain state. The acceptance criterion is the prevention of reduction of tension in all tendons below the minimum permissible values at the moment of commencement of the next control and preventive activities at NPP containments. The implementation of the system for control of tension in tension at all Ukrainian NPPs is envisaged by the National Action Plan.

#### 4.4.2 Good practice: assessment of inaccessible and/or limited access structures

TCA of inaccessible essential components and structures of buildings at Ukrainian NPPs is performed in the following order:

- analyze operating experience of inaccessible components and structures based on indirect features and indicators of their overall reliability;
- analyze operating experience of analogues with greater performance in close and no less mild conditions;
- analyze behavior of materials and structures of inaccessible components based on laboratory tests taking into account the actual operating conditions;

– for components and structures within the visual contact, take into account the state of their visible surfaces to detect faults, stains due to leaching and/or corrosion, cracks, integrity of the protective coating;

– TCA of inaccessible components and structures is considered positive in case of positive results for all the above procedures.

In case of failure to carry out a survey of structures due to the limited (impossible) access to perform TCA, it is permitted to perform expert TCA of such structures.

For this purpose, an expert commission is organized consisting of representatives of the operator, leading experts of the specialized organizations and certified experts in the sphere of maintenance of buildings and structures.

#### 4.4.3 TPR expected level of performance: monitoring of pre-stressing forces

Monitoring of tendon tension is performed with the periodicity of once in a week. The data that are recorded with the system for remote control of tension with their further archiving, both during the maintenance and inter-maintenance period, are analyzed by NPP personnel with relevant knowledge, experience and skills.

The values of the tension recorded by the system at the moment of commencement of control and preventive activities at containment prestressing system are used during forecasting for the next inter-maintenance period and for the formation of volumes of future control and preventive activities. The minimum permissible values of tension in tendons are defined in the design justification of containment reliability performed for each NPP unit to confirm the strength of the containment for the boundary values at all types of loads, covering places weakened by slots and penetrations.

## 5 RESEARCH REACTOR

The VVR-M research reactor of the Nuclear Research Institute of the National Academy of Sciences of Ukraine has been in operation since 12 February 1960. The design did not establish its lifetime. Currently, the research reactor is in LTO. NRI has a license issued by the SNRIU for VVR-M NPP operation until 31 December 2023. The possibility of NRR operation after 2023 will be decided by the SNRIU upon the operator's application, based on periodic safety review and AMP implementation. Preliminary safety review was carried out in 2008-2013.

In 2005-2008, the operator upgraded individual systems and replaced some equipment with new one to bring the reactor compartment and systems into compliance with current safety requirements:

- heat exchangers and part of the primary and secondary reactor coolant systems were replaced;
- CPS and I&C were replaced by hardware and software for automatic control, instrumentation and protection;
- emergency control room was introduced;
- power supply system and emergency power supply systems were upgraded: emergency generators and their control equipment, control equipment for electric engines of primary and secondary pumps, electrically driven gate valves of primary and secondary systems, fans and electric valves of special ventilation system, and cooling tower fans were replaced;
- power and control cables were replaced with copper cables whose isolation is flame retardant (VVGng type), radiation monitoring equipment was replaced with equipment based on automated radiation monitoring devices AKRB-06, etc.

Based on periodic safety review, AMP was updated /23/. AMP implementation is under strict supervision of SNRIU and AMP results are analyzed in NRR inspections by SNRIU.

Ageing management has been introduced into the NRR life cycle of operation (ageing management at the NRR decommissioning stage will be decided by the operator).

The main scope of ageing management activities on NRR components and structures is carried out under regular operations and during TCA of components and structures.

SNRIU takes active part in the WENRA topical working group for development of reference levels for research reactors. It is planned to review and update the regulatory requirements for research reactors considering the WENRA reference levels, IAEA standards and operating experience.

According to the ENSREG Report “1st Topical Peer Review Report “Ageing Management…” /2/, all research reactors have a general flaw regarding the fact that AMP require revision in accordance with IAEA recommendations SSG-10 /24/. The same applies to AMP of the Kyiv Nuclear Research Reactor and it requires the implementation of appropriate measures.

Such an Action Plan was developed at SNRIU request (No. 15-27/2386 dated 21 February 2019) for improvement of the “Ageing Management Program for Vessel (Tank) and Primary Equipment and Piping of the NRI VVR-M Nuclear Research Reactor” current in NRI of Ukraine.

This program has been developed according to requirements of Standard AMP /4/, which is revised once every two years and which is approved by the SNRIU. The Standard Program for the only nuclear research reactor in Ukraine has not been developed.

The Action Plan envisages the revision of NRI AMP to take into account the graded approach to risk, requirement of international safety standards and IAEA recommendations SSG-10 /24/.

The Plan development considered the recommendations presented in ENSREG Reports “European Nuclear Safety Regulator´s Group. ENSREG. 1st Topical Peer Review Report. “Ageing Management”. September 2018” /2/ and “European Nuclear Safety Regulator´s Group. ENSREG. 1st Topical Peer Review. “Ageing Management”. Country specific findings. September 2018” /3/.

The Plan alto took into account experience of other countries participating in the one-week workshop of the European Nuclear Safety Regulator´s Group devoted to the discussion of the National Reports (May 2018) and IAEA safety documents “Ageing Management for Research Reactors, No. SSG-10” and “Management of Research Reactor Ageing, IAEA-TECDOC-792”.

The Plan provides for the individual issue on the ageing management of electrical cables, the need for which was highlighted in the ENSREG Report. The Plan envisages the improvement of AMP of cables of systems important to safety.

Table 5.1 presents the detailed analysis of measures.

Table 5.1

| No. | Planned measure | Operator's actions on the measure | Deadline | Executor | Notes |
|---|---|---|---|---|---|
| 1 | Put the structure of ageing management program current in NRI in compliance with the structure recommended in IAEA safety documents | Make amendments to the structure of AMP current in NRI according to IAEA documents "Ageing Management for Research Reactors No. SSG-10" and "Management of Research Reactor Ageing IAEA-TECDOC-792" | to 31.12.2019 | NRI | |
| 1.1 | Change in current AMP name | Make amendments to AMP name to comply with the actual state of VVR-M systems, components and equipment considered in the program. | | | |
| 1.2 | Revision of names of AMP subsections | Analyze the available structure and include structural subdivisions of AMP to comply with recommendations of IAEA documents | | | |
| 2. | Revision of AMP general provisions | Analyze general provisions for ageing management provided in current NRI AMP for compliance with IAEA documents and make relevant amendments taking into account recommendations of IAEA documents (Sections 2, 3, 4 of SSG-10) | first quarter of 2020 | NRI | |

| No. | Planned measure | Operator's actions on the measure | Deadline | Executor | Notes |
|---|---|---|---|---|---|
| 3. | Revision of selection of structures, systems and components important to safety that are subject to ageing management | Analyze the completeness of selected structures, systems and components of NRR presented in the current AMP. Provide AMP with new, if necessary, structures, systems and components to comply with requirements of recommendations of IAEA documents (Section 5 of SSG-10). | second quarter of 2020 | NRI | |
| 4. | Specify the list of critical components of structures, systems and components of NRR that are subject to ageing management | Analyze completeness of critical components presented in current NRI AMP and, if necessary, provide new ones. | second quarter of 2020 | NRI | |
| 5. | Revision of operator's (NRI) measures on ageing management of structures, systems and components of NRR | Analysis and extension (if necessary) of measures on ageing management taking into account requirements of IAEA documents and recommendations provided in ENSREG Reports (September 2018). Take into account operating experience of similar class reactors of other countries. | third quarter of 2020 | NRI | |
| 6. | Improve CAMP | Analyze ageing management for cables in the current AMP | fourth quarter of 2020 | NRI | |

| No. | Planned measure | Operator's actions on the measure | Deadline | Executor | Notes |
|---|---|---|---|---|---|
| 6.1 | Define electrical cables of systems important to safety | Define the list of electrical cables subject to AMP | fourth quarter of 2020 | NRI | |
| 6.2 | Develop AMP for electrical cables according to the graded approach to risk used in rules and standards of Ukraine, international safety standards and taking into account the advanced experience | Define the ageing management program for electrical cable according to IAEA recommendations | fourth quarter of 2020 | NRI | |

The measures specified in Table 5.1 were included in the National Action Plan (see para. 8 of the Table: "Summary of the Planned Actions").

## 6 STATUS OF THE DEVELOPMENT AND IMPLEMENTATION OF AMP TO OTHER RISK SIGNIFICANT NUCLEAR INSTALLATIONS

Currently, such nuclear installations are under operation/construction in Ukraine other than NPPs, but which also pose high risks from the point of view of nuclear and radiation hazards. Such installations include:

1) dry spent nuclear fuel storage facility (DSFSF) of Zaporizhzhya NPP (activities at the stage of “nuclear installation operation”);

2) spent nuclear fuel storage facility 1 (ISF-1) of Chornobyl NPP (activities at the stage of “nuclear installation operation”);

3) spent nuclear fuel storage facility 2 (ISF-2) of Chornobyl NPP (activities at the stage of “construction”);

4) industrial complex for solid radioactive waste management (ICSRM) (activities at the stage of “commissioning”), which includes:

- construction confining the space over the solid radwaste storage facility cover and auxiliary systems building from the western side of the solid radwaste storage facility, which together form a facility for retrieval of solid radioactive waste from solid radwaste storage facility compartments;
- walking and production gallery;
- solid radioactive waste treatment plant (SRTP);
- temporary storage facility for high-level waste and low-level and intermediate-level long-lived radioactive waste in the building of ICSRM;

5) centralized spent fuel storage facility (CSFSF) (activities at the stage of “construction”;

6) ChNPP-1, 2, 3 (activities at the stage “decommissioning);

7) nuclear fuel fabrication plant “Nuclear Fuel” (NFFP) (activities at the stage of “design”).

For all of the above nuclear installations, except ISF-2, CSFSF and NFFP, there are individual AMPs, namely:

- “Ageing Management Program for Zaporizhzhya NPP DSFSF. 00.OB.YY.PM.25-17.3N” /18/;
- “Ageing Management Program for Chornobyl NPP ISF-1. 4PR-TO” /19/;
- “Ageing Management Program for Industrial Complex for Solid Radioactive Waste Management 9PR-TO” /20/;
- “Ageing Management Program for ChNPP-1(2). 1PR-TO” /21/;
- “Ageing Management Program for ChNPP-3. 2PR-TO” /22/.

From the above mentioned AMPs, DSFSF AMP was approved by the SNRIU. ISF-1 AMP, ICSRM AMP and ChNPP-1, 2, 3 AMP are under revision according to comments of individual state reviews.

AMPs developed for the specified installations define the procedure for maintaining degradation of equipment, systems and components important to safety (due to ageing, wearing, corrosion, erosion, fatigue and other mechanisms) within permissible limits, as well as for maintaining their operability and reliability at all stages of operation including LTO and final disposal and shutdown at the stage of decommissioning.

Since there are no individual documents in Ukraine that regulate requirements for ageing management of nuclear installations other than NPPs (installations under decommissioning, waste storage facilities and others), requirements as for NPPs are taken into account during the development of AMPs for such installations considering specific peculiarities of the installation and IAEA recommendations SSG-48 /15/, SSR-4 /16/, SSG-15 /17/, etc.

AMPs of other nuclear installations include the list of components and structures subject to ageing management. The ageing management list is developed separately for each nuclear installation.

Within ageing management of components and structures included to the ageing management list, the following data are defined and recorded:

- systems in which the components, structure is operated;
- component, structure under consideration;
- material of which component, structure is made;
- environment and operating conditions of component, structure;
- ageing effects and degradation mechanisms typical for component, structure;
- AMP (if relevant) of component, structure;
- results of ageing analysis that defines the service life of component, structure.

At other nuclear installations, where AMP has been developed and approved by the SNRIU, this process is arranged on a systematic basis and is recorded. Relevant structural subdivision is created at each nuclear installation for systematic performance of ageing management activities. This subdivision is ensured by sufficient quantity of competent personnel, required authorities and resources.

The arrangement of ageing management process at other nuclear installations is a necessary condition to ensure high safety level at all stages of operation and to reach maximum effectiveness of operation through the implementation of measures aimed at timely definition and maintaining of degradation of systems and components of other nuclear installations due to ageing within acceptable limits.

At the same time, the SNRIU planned the development of individual requirements for ageing management of nuclear installations other than NPPs. These plans have also been reflected in the National Action Plan (see para. 8 of the Table “Summary of the Planned Actions”).

## 7 SUMMARY OF THE PLANNED ACTIONS

Taking into account the results of self-assessment, peer review and received recommendations on the improvement of ageing management practice in Ukraine, the National Action Plan was developed that is presented in Table 1.

Table 1.

| No. | Nuclear installation | Issue | Conclusion/Results | Planned action | Deadline | Regulator's approach to control |
|---|---|---|---|---|---|---|
| Measures identified upon self-assessment results | | | | | | |
| 1 | All NPPs | Overall AMP | Need for development and implementation of two separate documents with requirements for ageing management and LTO | Development and implementation of SOU NAEK 080:2014 /6/ SOU NAEK 141:2017 /7/. Cancellation of Standard AMP /4/. | March 2020 | Upon results of performance |
| 2 | All NPPs | Concealed pipework | Taking into account constant improvement of contactless diagnostics methods, the SNRIU recommends to continue relevant research measures on a permanent basis | Implementation of such measures: 1) analysis of state-of-the-art technical developments, whose purpose is to perform assessment (diagnostics) of the current technical state of piping dug into the ground and inaccessible for inspection; 2) analysis of available international experience on the assessment of the current technical condition of concealed pipework to define control and diagnostics systems appropriate for using; | Constantly | Annual control of performance (according to relevant reports of the operator) |

| No. | Nuclear installation | Issue | Conclusion/Results | Planned action | Deadline | Regulator's approach to control |
|---|---|---|---|---|---|---|
| | | | | 3) involvement of specialized organizations with relevant experience in TCA of concealed pipework | | |
| 3 | All NPPs | Reactor pressure vessel | Improvement of RPV AM process based on gained national and international experience and results of implemented research and development programs | Implementation of such measures:<br>1) implementation of state-of-the-art systems for remote NDI of RPV metal; | Constantly | Annual control of performance (according to relevant reports of the operator) |
| | | | | 2) improvement of provisions of the Integrated Program for surveillance specimens /8/ for the possibility of its applied use (formation and compliance with results applicability criteria); | 31.12.2020 | Annual control of performance (according to relevant reports of the operator) |
| | | | | 3) development of AMP for RPV of each power unit | 31.12.2020 | Quarterly control of performance (approval of development documents) |
| 4 | All NPPs | Concrete containment structures | Improvement of AM process | Completion of all measures of "Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000" | 31.12.2024 | Quarterly control of performance (approval of development documents) |

| No. | Nuclear installation | Issue | Conclusion/Results | Planned action | Deadline | Regulator's approach to control |
|---|---|---|---|---|---|---|
| Measures identified upon results of peer review and received recommendations | | | | | | |
| 5 | All NPPs | Overall AMP | Bring in compliance with IAEA recommendations /9/, /10/, /11/ on consideration of 4N safety class components and structures and consideration of ageing during delayed construction/shutdown | 1) Inclusion of requirements for consideration of 4N safety class components and structures into SOU NAEK 141:2017 /7/ (see para. 1 of the Table); | See para. 1 of this Table | Upon results of performance |
| | | | | 2) Development of the documents with requirements for the selection of 4N safety class components and structures, failure or damage of which can affect operation of systems important to safety | December 2020 | Quarterly control of performance |
| 6 | All NPPs | Concealed pipework | Need to define degradation mechanisms in penetrations for concealed pipework, list of piping to be included in AMP, direct control applying opportunistic inspections | 1) Development of ageing management program for concealed pipework | December 2020 | Semi-annual control of performance |

| No. | Nuclear installation | Issue | Conclusion/Results | Planned action | Deadline | Regulator's approach to control |
|---|---|---|---|---|---|---|
| 7 | All NPPs | Electrical cables | Amendments to cable ageing management program | Correction of CAMP taking into account:<br>– use of relevant technologies to assess the technical state and qualification of cables inaccessible for visual examination<br>– establishment of requirements and criteria and development of measures on the minimization of water in cables with polymer insulation | December 2020 | Quarterly control of performance (approval of developed documents) |
| 8 | Research reactor | AMP improvement | Need for improvement is caused by the requirement for compliance with IAEA recommendations | 1. Improvement of Overall AMP for NRR.<br>2. Development of AMP for electrical cables taking into account the graded approach | December 2021 | Semi-annual control of performance upon NRI reports |
| 9 | Nuclear installations other than NPPs | AM of nuclear installations other than NPPs | Absence of requirements in Ukraine for ageing management of nuclear installations other than NPPs | Requirements for ageing management of components and structures of nuclear installations in Ukraine (other than NPPs) | December 2024 | SNRIU self-control |

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