ENSREG: FIRST TOPICAL PEER REVIEW

UPDATED NATIONAL ACTION PLAN ON AGEING MANAGEMENT

(Ukraine)

State Nuclear Regulatory Inspectorate of Ukraine

Kyiv

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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, which was 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;
- developed the National Action Plan on Ageing Management (Ukraine) in 2019, which presents the measures planned to improve the aging management practices in Ukraine according to findings of the ENSREG peer review;
- developed an updated revision of the National Action Plan on Aging Management (Ukraine) in 2021 and 2023, which presented the activities completed and specified plans for the future period.

The SSTC NRS, Energoatom and Nuclear Research Institute of the National Academy of Sciences of Ukraine were involved in updating, as well as developing, the National Action Plan. Therefore, the updated 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, December 2023

Acting Chairman

Chief State Inspector for
Nuclear and Radiation Safety of Ukraine **Oleh KORIKOV**

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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
NDE	–	Nondestructive Examination
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 and discussed in May 2018 in Luxembourg during a one-week workshop. Upon the ENSREG workshop, two reports with relevant results were developed and presented:

- European Nuclear Safety Regulator's Group ENSREG First Topical Peer Review Report “Ageing Management”. October 2018 /3/;
- European Nuclear Safety Regulator's Group ENSREG First Topical Peer Review “Ageing Management” Country specific findings. October 2018 /4/.

For each member state of the peer review, the documents /3/, /4/ 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 /2/ developed by Ukraine was published on the SNRIU website in 2019, updated in October 2021 and had an objective to ensure monitoring of the progress for a series of results findings within the topical peer review.

Over the past years, since 2019, many steps have been taken to improve practices regarding the issues determined upon the review results, but not all plans are implemented yet, and this National Plan updated as of December 2023 has the objective to show what has been done and what and within what timeframes should be done.

The Updated National Plan presented below is published on the SNRIU website in February 2024.

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.

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 “First Topical Peer Review “Ageing Management”. Country specific findings…” /4/, which identifies Good Practices or defines Expected Level of Performance individually for each state.

According to document “First Topical Peer Review Report “Ageing Management September 2018. European Nuclear Safety Regulators Group. ENSREG” /3/ and “First Topical Peer Review “Ageing Management”. Country specific findings…” /4/, 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).

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 licensee, 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.

At proper time in Ukraine, the Standard Ageing Management Program for NPP components and structures (Standard AMP) **Ошибка! Источник ссылки не найден.** was developed and agreed with the SNRIU. The main challenge of the Standard AMP **Ошибка! Источник ссылки не найден.** was that it combined aspects of AM and LTO, while they should be governed by separate documents of the operator, as required in NP 306.2.210-2017 /6/. Therefore, the operator should develop two separate documents with specific requirements for AM and LTO. Such activities have been launched and the operator developed, agreed with the SNRIU and put into effect two separate documents:

- SOU NAEK 080:2014 Operation of Technological System. Long-Term Operation of NPP Units. General Provisions /7/;
- SOU NAEK 141:2017 Engineering, Scientific and Technical Support. Ageing Management of NPP Components and Structures. General Requirements /8/.

With the introduction of SOU NAEK 080:2014 /7/ and SOU NAEK 141:2017 /8/ the Standard AMP **Ошибка! Источник ссылки не найден.** was cancelled.

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

Documents SOU NAEK 080:2014 /7/ and SOU NAEK 141:2017 /8/ were agreed by the SNRIU and put into effect by the operator in 2020. The measure according to para. 1 of Table “Summary of the Planned Actions” was completed on time. New measures are not planned, but improvement of SOU NAEK 080:2014 /7/ and SOU NAEK 141:2017 /8/ is ongoing as planned.

Updated information as of December 2023:

– the operator developed, agreed with the SNRIU and put into effect new revision of the document on LTO - SOU NAEK 080:2023 Operation of Technological System. Long-Term Operation of NPP Units. General Provisions.

the operator developed and submitted new revision of the document on ageing management - SOU NAEK 141:2023 Engineering, Scientific and Technical Support. Ageing Management of NPP Components and Structures. General Requirements to the SNRIU for approval.

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, 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 under 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 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 /6//6/, 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 types “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 **Ошибка! Источник ссылки не найден.**).

Updated information as of December 2023

At units of Ukrainian NPPs, control and power cables are being routinely replaced with fire retardant cables, and those in automated firefighting systems and emergency power supply systems - with fireproof ones.

Regulations are constantly being improved, in particular, the operator has revised CAMP /12/ taking into account the following:

- application of relevant technologies to assess the technical condition and qualification of cables located in places inaccessible for inspection;

- establishing requirements, assessment criteria for environmental conditions and developing measures to minimize water in cables with polymeric insulations.

These measures are taken into account in the revised CAMP /12/ agreed upon by the SNRIU in 2021.

The measure according to para. 7 of Table 1 “Summary of the Planned Actions” was completed on time. New measures are not planned.

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 the 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 at the places defined by the Utility based corresponding analysis and operational experience.

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 of 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.

As of December 2023, these measures continue to be implemented on an ongoing basis.

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

Updated information as of December 2023

The operator developed the Standard Ageing Management Program for Concealed Pipework of the Essential Service Water System for VVER-1000 NPPs. PM-T. 0.03.465-21 /25/ and agreed it with the SNRIU. Based on the provisions of the Program /25/ the Operator of VVER-440 (there are two units on the Rivne NPP site) has developed and presented the approach to ageing management of concealed pipes for VVER-440 in the "Ageing management programme of Units No1 and No2. 191-136-ПР-УС-08" /29/. Ageing management measures were developed in the framework of current technical state evaluation of concealed piping for VVER-440 over the periodic safety reassessment at 2020 and 2021.

The Program /25/ establishes methods and tools for determining the places and mechanisms of degradation of concealed pipework, presents the methodology for scoping and screening piping for their consideration within the AMP, defines approaches for testing etc.

The operator continues to implement measures on an ongoing basis, such as:

– analysis of up-to-date scientific and technical developments (methods, techniques, equipment), whose purpose is to adequately assess (provide diagnostics) the current technical condition of concealed piping that are not easily accessible for testing;

– analysis of existing international experience in assessing the current technical state conditions of piping, which is deepened in the ground and is not easily accessible for examination;

– analysis of experience in the design, operation and maintenance of similar piping in other industries, etc.

The measure according to para. 2 of Table 1 “Summary of the Planned Actions” is under performance in an ongoing basis. Measures according to para. 6 of this table were completed. New measures are not planned.

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 Utility uses the following procedures ageing mechanisms definition and monitoring of reactor pressure vessel and reactor closure head:

– NDE of the base metal, welds, and cladding /30/, **Ошибка! Источник ссылки не найден.**;

– monitoring of RPV metal properties using surveillance specimens /32/;

– internal/external inspection of equipment /30/;

– tightness test of the reactor main flange /30/.

The documents /30/, **Ошибка! Источник ссылки не найден.** and /32/ define corresponding provisions for VVER-1000 but similar documents are also developed for VVER-440.

According to the provisions of the Program **Ошибка! Источник ссылки не найден.** and based on the technical state conditions analysis the following degradation mechanisms, ageing effects and tools for the control are defined and carried out (see the Table 3.0 below).

Table 3.0 - Potential degradation mechanisms of RPV elements, ageing effects, technical condition parameters and methods of its control.

Degradation mechanisms	Ageing effects	Technical condition parameters	Ageing effect control method
Radiation and thermal embrittlement	Change of mechanical properties	Ultimate stress, yield stress, relative elongation, relative reduction	Testing of “irradiated” and “temperature” surveillance specimens sets
		Critical brittleness temperature	Calculations of brittle fracture resistance
Cyclic fatigue	Change of mechanical properties	Ultimate stress, yield stress, relative elongation, relative reduction	Destructive methods for inspection of mechanical properties or defining mechanical properties of metal by hardness
	Cracking	The condition of the base metal, welded joints and claddings	Periodic non-destructive examination of metal condition (visual inspection, liquid penetrant inspection / magnetic particle inspection, ultrasonic inspection
		The value of accumulated fatigue damageability. Number of number of reactor loading cycles	Cyclic strength calculations. Control of the number of reactor loading cycles
Stress corrosion cracking	Cracking	The condition of the base metal, welds and claddings	Periodic non-destructive examination of metal condition (visual inspection, liquid penetrant inspection / magnetic particle inspection, ultrasonic inspection)

Mechanical wear	Cracking of threaded joints Mechanical damage, crushing, change in geometric dimensions of grooves	Condition of sealing and threaded surfaces	Periodic non-destructive examination of metal condition (visual inspection, liquid penetrant inspection / magnetic particle inspection, ultrasonic inspection

The monitoring and analysis of ageing effect trends are carried out on the permanent basis. 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 summarizing comments.

1. According to the specified aspects, new systems of remote NDE of RPV (such as CMM-SAPHIRplus, RPV-1000, etc.) are implemented at Ukrainian NPPs. There are improvements of 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 test results of the surveillance specimens already removed from the reactor, the operator uses the reconstitution 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 Integrated Program **Ошибка! Источник ссылки не найден.** is aimed only for getting the additional data to standard, modernized and new surveillance programs, for improving the reliability of the assessment of changes in RPV metal properties. Because the conditions of embrittlement of specimens within the Integrated Program **Ошибка! Источник ссылки не найден.** are different from realistic embrittlement within the individual vessel.

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.

As of December 2023, these measures continue to be implemented on an ongoing basis.

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

Updated information as of December 2023

State-of-the-art systems for remote NDE of RPV metal condition are implemented on an ongoing basis, in particular, as part of implementing the CMM-SAPHIRplus-ADVANCED automated remote NDE system certified to identify the location of discontinuities and measure their size. To date, the existing methodologies and system equipment have been certified, in case of engagement of the new ones methodologies and system equipment, they also have to be certified according Ukrainian norms and rules for nuclear safety (the requirements of NP306.2.113-2005 /33/). Within preparation for personnel certification as part of the control system, the work is underway to produce sealed test samples of the cylindrical part of the reactor pressure vessel with weld. This work is being carried out within international technical assistance project under the support of the Governments of Norway and Sweden “Design, Manufacture and Delivery of Two Seale,d Test Samples of the VVER-1000/VVER-440 RPV with Weld to the State Enterprise “NAEK Energoatom” and Transfer Knowledge to the Ukrainian Certification Body in Applying the ENIQ Recommended Practices” (hereinafter referred to as the Project). According to the Project implementation schedule, test samples were planned to be delivered to the Rivne NPP by 30 March 2022. Due to the introduction of martial law in Ukraine, supplies of test samples have been suspended.

As for the development of the RPV AMP for each power unit, as of December 2023, all RPV AMP for Ukrainian NPP units have been developed and agreed by the SNRIU.

The implementation of measures under para. 3 of Table “Summary of the Planned Actions” is continued for bullet 1) and is completed for bullet 2), 3) of column “Planned action”

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 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.

Updated information as of December 2023

The implementation of measures according to “Schedule for Implementation of Measures on Safe Operation of Containment at NPPs with VVER-1000” is continued within the established timeframe and should be completed till 31 December 2024 (see para. 4 of Table “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/:

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

Currently, taking into account IAEA documents:

- Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants. SSG-48 /15/;
- Ageing Management for Nuclear Power Plants: International Generic Aging Lessons Learned (IGALL) SRS 82 /10/,

Energoatom developed a regulatory document SOU NAEK 141:2017 “Ageing Management of NPP Components and Structures” /8/ and agreed it with the SNRIU in 2020 (as of December 2023, SOU NAEK 141:2017 is at the stage of approval of the updated revision by the SNRIU). Additionally, in order to meet the requirements of SSG-48 /15/ regarding the selection of components and structures of safety class 4N, whose failure or damage may affect the operation of systems important to safety, the operator developed document “Methodology for the Selection of NPP Components and Structures, whose Damage Can Cause the Failure of Components and Structures of Safety Systems to Perform their Design Functions. SOU-N NAEK 135:2021” /26/ and agreed it with the SNRIU. Currently, SOU-N NAEK 135:2021 is proved at Khmelnitsky NPP Unit 2. Upon the results, a list of potentially hazardous components and structures will be developed to include them in the NPP AMP (if necessary).

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”. The indicated requirement is implemented in SOU NAEK /8/ in 2020 and agreed in the SNRIU.

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

Measures under paras. 1 and 5 of Table “Summary of the Planned Actions” were completed on time. New measures are not planned.

2.2 Concealed pipework

2.2.1 TPR expected level of performance

According to para. 6.2.3 of the ENSREG report “First Topical Peer Review Report “Ageing Management…” /3/:

- 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.

In order to enhance monitoring the technical condition of underground piping of the essential service water system at power units and 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, Energoatom developed the Standard Ageing Management Program for Concealed Pipework of the Essential Service Water System for VVER-1000 NPPs. PM-T.0.03.465-21 and agreed it with the SNRIU. Strengthening the SNRIU capabilities on technical condition assessment, ageing management and long-term operation of underground pipework is provided also within individual projects, including international ones. Thus, in the second half of 2023, project U3.01./21 “Continued alignment of the Russian regulatory regime with the EU acquis” was launched in Ukraine, in which a separate task is devoted to the SNRIU activities on the “Improvement of the AM practices for concealed pipework”.

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 selection of components and structures referred to 4N safety class that will be performed according to methodology SOU-N NAEK 135:2021 /26/ after its approval.

The issue on the need for additional inspection of underground piping (opportunistic inspections) will be taken into account during the development of AMP /25/ for underground piping.

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

Taking into account the above mentioned, the regulation SOU NAEK 141:2017 /8/ considers requirements for the selection of components and structures of 4N safety class, whose failure or damage can affect operation of systems important to safety. These requirements were included in an individual document and a separate AMP for concealed (underground) pipework was developed (see paras. 2 and 6 of Table 1 “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 “First Topical Peer Review Report “Ageing Management…” /3//3/, it is expected that the country will develop measures aimed at the improvement of the following practices:

- Non-destructive examination: Comprehensive Non-destructive examination of the base matal of the belt-line region shall be performed in order to detect defects;
- Environmental effect of the coolant: Fatigue analyses have to take into account the environmental effect of the coolant.

Regarding NDE it should be stated that NDE of RPV metal (based and welds) 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 NDE according to the reqirements of /30/ and /31/. 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. State-of-the-art systems for remote NDE of the RPV are implemented on an ongoing basis. No additional measures are necessary.

During LTO of power units, fatigue calculations for equipment and piping are performed.

Environmental effect of the coolant on the fatigue usage factor during design operation and LTO is considered by analysis. The usage factor remains within acceptable limits and no damage of the RPV metal by environmentally assisted fatigue is expected. Mitigating measures are not necessary.

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”).

Strengthening the SNRIU capabilities on technical condition assessment, aging management and long-term operation of reactor pressure vessels is provided also within individual projects, including international ones. Thus, in the second half of 2023, project U3.01./21 “Continued alignment of the Russian regulatory regime with the EU acquis” was launched in Ukraine, in which a separate task is devoted to the SNRIU activities on the “Improvement of remote inspection practice for RPV”.

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

The development additional measures for the areas specified in para. **Ошибка! Источник ссылки не найден.** was recognized as not necessary 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 Table 1 “Summary of the Planned Actions”.

2.4 Concrete containment structures

2.4.1 TPR expected level of performance

According to the Report “European Nuclear Safety Regulator’s Group ENSREG. First Topical Peer Review “Ageing Management” Country specific findings” /4/, 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, the part of measures (that are not completed yet) on improving safety of the containments in Ukraine are still ongoing and they are performing 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 2024.

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 2024 (see para. 4 of Table 1 “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.

The results of TCA and cable qualification for harsh environment are mainly positive. Separate cables that showed unsatisfactory results in tests are replaced: for example, cables with types of “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 AMPs for cables /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: completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ “The AMP is sufficiently well-documented to support any internal or 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.

Developing of additional corrective measures is recognized unappropriated.

3.2.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ “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.

Developing of additional corrective measures is recognized unappropriated.

3.3.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA were completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ - “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.

Developing of additional corrective measures is recognized unappropriated.

3.4.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ – “Approaches are used to ensure that water in cables with polymeric insulation is minimized, either by removing stressors contributing to it 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.

3.5.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 First Topical Peer Review Report “Ageing Management…” /3//3/ – “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.

Developing of additional corrective measures is recognized unappropriated.

3.6.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ - “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, the 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 (existing cables are subject to qualification during operation and new ones before the operation). 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.

Developing of additional corrective measures is recognized unappropriated.

3.7.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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 “First Topical Peer Review Report “Ageing Management…” /3/ – “Based on international experience, appropriate techniques are used to detected degradation of inaccessible cables”.

The aspect stated above on was considered over the improving 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 was taken into account during the last revision of CAMP.

3.8.2 Country planned action if relevant

Country planned action to improve CAMP according to national and international experience and practice, new recommendations of IAEA, WENRA was completed (see para. 7 of Table 1 “Summary of the Planned Actions”).

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. **Ошибка! Источник ссылки не найден.-Ошибка! Источник ссылки не найден.**, the following approaches to improve operating practices related to cable ageing management were developed.

Table 3.1

No.	Issue	Conclusion	Measure	Deadline	Status
1	Electrical cables	The following aspects shall be included in CAMP: – use of relevant technologies for TCA and qualification of cables located in inaccessible places; – establishment of requirements, criteria and development of measures to minimize the presence of water in cables with polymeric insulation	Amendment of CAMP and approval with the SNRIU	31.12.2020	Completed, new measures are not planned

The mentioned measures were completed that is indicated in para. 7 of Table 1 “Summary of the Planned Actions”. New measures are not planned.

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 2018. The direct SALTO mission was planned for 2022 (although it should be implemented in 2020, it was canceled due to quarantine measures for preventing the spread of SARS-Cov-2019). At the same time, due to the war unleashed by the Russian Federation against Ukraine, the SALTO mission was again postponed indefinitely (until the end of hostilities and improvement of the security situation).

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

Ageing management programs developed by Energoatom for different NPP units and approved by the SNRIU are kept updated according to new requirements of IAEA and WENRA, best international experience and practices.

Currently, taking into account IAEA and WENRA documents, the operator updated document SOU NAEK 141:2017 /8/, as well as developed SOU-N NAEK 135:2021 and agreed it with the SNRIU.

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) was specified in SOU NAEK 141:2017 /8//8/. The relevant measure was completed.

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

According to the ENSREG Report “First Topical Peer Review Report “Ageing Management…” /3/, 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 in 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/. As of December 2023, the revision of AMP of NRI of NAS of Ukraine, taking into account the graded approach to risk, requirements of international safety standards and IAEA recommendations SSG-10 /24/, was completed. The updated AMP of NRI of NAS of Ukraine (Ageing Management Program for Systems, Components and Equipment of VVR-M Research Nuclear Reactor, PUS.3-017-20/21) was approved by the SNRIU and put into effect at NRI.

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 “First Topical Peer Review Report “Ageing Management…” /3/, 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 “First Topical Peer Review Report “Ageing Management…” /3/, the approach is used according to which a fragment of piping is cut for 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 non-destructive inspection.

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

According to the ENSREG Report “First Topical Peer Review Report “Ageing Management…” /3/, 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.

In order to enhance monitoring the technical condition of underground piping of the essential service water system at NPP units and 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, Energoatom developed the Standard Ageing Management Program for Concealed Pipework of the Essential Service Water System for VVER-1000 NPPs. PM-T.0.03.465-21 and agreed it with the SNRIU. The relevant measure was completed.

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

According to the ENSREG Report “First Topical Peer Review Report “Ageing Management…” /3/, 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 after approval of methodology SOU-N NAEK 135:2021 /26/.

4.2.5 TPR expected level of performance: opportunistic inspections

According to the ENSREG Report “First Topical Peer Review Report “Ageing Management…” /3/, 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 was considered during the developing of AMP for underground piping /25/ and agreed by the SNRIU. The relevant set of measures were developed, included into the National Action Plan and in the AMP /25/, in particular:

1) analysis of state-of-the-art technical developments, whose purpose is to perform assessment (diagnostics) of the current technical state of concealed piping;

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 use;

3) involvement of specialized organizations with relevant experience in TCA of concealed pipework.

Currently these measures are being implemented on an ongoing basis.

4.3 Reactor pressure vessel

4.3.1 Good practice: Hydrogen water chemistry

Ageing effects by the degradation mechanism intergranular stress corrosion cracking are typical for boiling water reactors. Only 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 NDE 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

NDE 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 NDE. 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 not feasible.

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 unfeasible.

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 of specimens 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 and then using the reconstitution technology for tested specimens reconstituted 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 containment stress strain state and loss of tension in tendons are monitored.

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 similar and harsher 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 based on the results of periodic safety reassessment provided 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.

At the ENSREG Report “First Topical Peer Review Report “Ageing Management…” /3/ was stated that existing AMP of RR should be revised considering /3/IAEA recommendations in SSG-10 /24/. The mesure for AMP revising was included in National Action Plan. The revision of AMP was started in 2019 and completed in the December 2023. The graded approach for research reactors has been considered according to recommendations of SSG-10 /24/. Updated NRI AMP (Ageing Management Program for Systems, Components and Equipment of VVR-M Research Nuclear Reactor, PUS.3-017-20/21) /27/ was approved by the SNRIU and put inforce at Nuclear Research Institute.

Over the period 2021-2023 the NRI carried out an additional analysis of systems, components and structures regarding the need for their inclusion in the list of systems, components and structures subject to obsolescence management. Based on the analysis, it was concluded that the research nuclear reactor currently does not have systems, components and structures important to safety that should be included in the ageing management list as obsolete

The Table 5.1 presents the detailed updated analysis of measures.

Table 5.1

No.	Planned measure	Operator’s actions on the measure	Deadline	Executor	Notes
1	Revise AMP /27/ according to SNRIU comments	Approval of revised AMP /27/	Completed	NRI	
2	Revise approaches, identify measures and elements to be included in AMP /27/, which are subject to obsolescence management	Additional analysis of systems, components and structures to determine the need for their inclusion in the list of systems, components and structures subject to obsolescence management	Completed	NRI	
3.	Improve AMP provisions /27/ regarding approaches to obsolescence management	Analysis of the need to include components important to safety in the AMP list based on the PSRR results, which are subject to obsolescence management	Completed	NRI	

The status of the measures indicated in Table 5.1 is reflected in the National Action Plan (see para. 8 of Table “Summary of the Planned Actions”).

In November 2023, NRI of NAS of Ukraine applied to the SNRIU with a request to extend license EO400051 for operation of the nuclear installation until 31 December 2026 with amendments, namely, limiting of VVR-M operation to the shutdown state, unloading of nuclear fuel and use of VVR-M only for maintenance of equipment, systems and components.

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

Currently, the following nuclear installations other than NPPs are in operation / under construction in Ukraine, that also pose high risks from the point of view of nuclear and radiation hazards:

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 “nuclear installation operation”);

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).

For all of the above nuclear installations, except ISF-2, CSFSF and nuclear fuel fabrication plant, 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/.

AMPs were developed and agreed upon for all of the above nuclear installations that were put into operation. In November 2023, the SNRIU received document “Aging Management Program for Systems, Structures and Components of Chornobyl NPP ISF-2” (10PR-ITs)” for review and approval; the assessment of the ChNPP document is currently underway.

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 in 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 component, 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.

The SNRIU started developing document “Requirements for Aging Management of Nuclear Installations (other than NPPs)”, but at the final stage of preparation it was decided to divide these requirements into two separate documents. The following requirements are currently being developed:

“General Requirements for Aging Management of Components and Structures of Nuclear Research Installations” (draft);

“General Requirements for Aging Management of Components and Structures of Spent Nuclear Fuel Storage Facilities” (draft).

The planned completion date for the development and implementation of these documents is December 2024. These adjusted plans are reflected in the National Action Plan (see para. 9 of 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. An additional column was added to this table as part of updating the National Action Plan, which presents the current status as of December 2023 and contains details of new deadline (where applicable).

Table 1.

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
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 /7/ SOU NAEK 141:2017 /8/. Cancellation of Standard AMP **Ошибка! Источник ссылки не найден.**.	March 2020	Upon results of performance	The operator developed, agreed with the SNRIU and put into effect new revision of SOU on LTO - SOU NAEK 080:2023 /7/, as well as developed and submitted new revision of SOU on ageing management - SOU NAEK 141:2023 /8/ to the SNRIU for approval. The documents are improved on an ongoing basis. Standard/overall AMP **Ошибка! Источник ссылки не найден.** was cancelled in 2020.	**Completed**

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
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 concealed piping; 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 use; 3) involvement of specialized organizations with relevant experience in TCA of concealed pipework	Constantly	Annual control of performance (according to relevant reports of the operator)	Relevant research measures are implemented on an ongoing basis. Strengthening the SNRIU capabilities on technical condition assessment, ageing management and long-term operation of underground pipework is provided also within individual projects, including international ones, see para. 2.2.1.	**Is being implemented** (*on an ongoing basis*)

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
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: 1) implementation of state-of-the-art systems for remote NDE of RPV metal;	Constantly	Annual control of performance (according to relevant reports of the operator)	State-of-the-art systems for remote NDE of RPV metal condition are implemented on an ongoing basis, in particular, as part of implementing the CMM-SAPHIRplus-ADVANCED automated remote NDE system certified to identify the location of discontinuities and measure their size. The work is underway to produce sealed test samples for the irradiation surveillance program of the cylindrical part of the reactor pressure vessel with weld. Strengthening the SNRIU capabilities is provided also within individual projects, including international ones, see par. 2.3.1.	**Is being implemented** (*on an ongoing basis to introduce up-to-date systems, and was planned by March 2022 for manufacturing sealed test samples. Due to the introduction of martial law in Ukraine, supplies of test samples have been suspended)*
				2) improvement of provisions of the Integrated Program for surveillance specimens **Ошибка! Источник ссылки не найден. Ошибка! Источник ссылки не найден.**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)	The SNRIU granted permit to use the results obtained within the Integrated Program to determine the degree of embrittlement for RPV materials and justify the timeframe of their safe LTO	**Completed**

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
				3) development of AMP for RPV of each power unit	31.12.2020	Quarterly control of performance (approval of development documents)	AMP for RPV were developed for each power unit	**Completed**
4	All NPPs	Containment concrete structures	AM improvement 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)	Performance of measures according to the "Schedule…" is continued within the established timeframe	**Is being implemented** (*December 2024*)
Measures identified upon peer review results and received recommendations								
5	All NPPs	Overall AMP	Bring in compliance with IAEA recommendations /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 141:2017/8/ (see para. 1 of the Table);	See para. 1 of this Table	Upon results of performance	1) Requirements for consideration of 4N safety class components and structures were included in SOU NAEK 141:2017 /8/	**Completed**
				2) development of the document 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	2) The operator developed document "Methodology for the Selection of NPP Components and Structures, whose Damage Can Cause Failure of Components and Structures of Safety Systems to Perform their Design Functions. SOU-N NAEK 135:2021" and agreed it with the SNRIU	**Completed**

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
6	All NPPs	Concealed pipework	Definition of 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	The operator developed the Standard Ageing Management Program /25/ and agreed it with the SNRIU	**Completed**
7	All NPPs	Electrical cables	Amendments to cable ageing management program (CAMP)	Correction of CAMP taking into account: – use of relevant technologies to assess the technical state and qualification of cables inaccessible for visual examination – 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)	CAMP /12/ was revised taking into account the application of relevant technologies, establishing requirements, criteria and developing measures to minimize water in cables with polymeric insulations. CAMP /12/ was agreed upon by the SNRIU in 2021	**Completed**

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
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. 2. Development of AMP for electrical cables taking into account the graded approach	December 2021	Semi-annual control of performance upon NRI reports	AMP of NRI of NAS of Ukraine was revised taking into account the graded approach according to IAEA recommendations SSG-10 /24/. The updated AMP of NRI of NAS of Ukraine (Ageing Management Program for Systems, Components and Equipment of VVR-M Research Nuclear Reactor, PUS.3-017-20/21) /27/ was approved by the SNRIU and put into effect at NRI	**Completed**
9	Nuclear installations other than NPPs	AM of nuclear installations other than NPPs	Absence of requirements in Ukraine for ageing management of components and structures of nuclear installations in Ukraine (other than NPPs)	Requirements for ageing management of components and structures of nuclear installations in Ukraine (other than NPPs)	December 2024	SNRIU self-control	The SNRIU started developing document "Requirements for Aging Management of Nuclear Installations (other than NPPs)", but at the final stage of preparation it was decided to divide these requirements into two separate documents. The following requirements are currently being developed: "General Requirements for Aging Management of Components and Structures of Research Nuclear Installations" (draft);	**Is being implemented** (*December 2024*)

No.	Nuclear installation	Issue	Conclusion/Results	Planned action	Deadline	Regulator's approach to control	As of December 2023	Note about implementation
							"General Requirements for Aging Management of Components and Structures of Spent Nuclear Fuel Storage Facilities" (draft).	

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