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Approaches to Ageing Management for Nuclear Power Plants

International Generic Ageing Lessons Learned (IGALL) Final Report

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APPROACHES TO AGEING MANAGEMENT FOR NUCLEAR POWER PLANTS

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INTERNATIONAL GENERIC AGEING LESSONS LEARNED (IGALL) FINAL REPORT

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

The main deliverable of the International Generic Ageing Lessons Learned for Nuclear Power Plants (IGALL) Extrabudgetary Programme (EBP), the IGALL Safety Report, provides an internationally recognized basis for an acceptable ageing management programme, as well as a knowledge base on ageing management to aid in the design of new power plants, design reviews, modifications and upgrades, and to serve as a source of information on ageing management.

This publication is a summary of the national approaches taken by Member States participating in the IGALL programme. This information was collected during the first phase of the IGALL programme between 2010 and 2013, and explains different national practices in the area of ageing management and the preparation for long term operation.

The contributions of all those who were involved in the drafting and review of this report are greatly appreciated. The IAEA officers responsible for this publication were R. Krivanek, E. Liszka and O. Polyakov of the Division of Nuclear Installation Safety.

CONTENTS

1. INTRODUCTION

The IAEA Safety Standards [1-3] require, in parts pertinent to ageing and its management, that appropriate margins shall be provided in the design for all structures, systems and components important to safety so as to take into account relevant ageing and wear-out mechanisms and potential age related degradation, in order to ensure the capability of the structure, system or component to perform the necessary safety function throughout its design life. Ageing and wear-out effects in all normal operating conditions, testing, maintenance, maintenance outages, and plant states in a postulated initiating event shall also be taken into account. Provision shall also be made for monitoring, testing, maintenance, surveillance and inspection, to assess ageing mechanisms predicted at the design stage and to identify unanticipated behaviour or degradation that may occur in service. Data on operating experience shall be collected and retained for use as input for the management of plant ageing.

Systematic AM provides for the availability of safety functions throughout the service life of the plant, taking into account changes that occur with time and use. This requires addressing both physical ageing of systems, structures and components (SSCs), resulting in degradation of their performance characteristics, and obsolescence of SSCs, i.e. their becoming out of date in comparison with current knowledge, standards and regulations, and technology [4]. Effective AM throughout the service life of SSCs requires the use of a systematic approach to managing ageing that provides a framework for coordinating all programmes and activities relating to the understanding, control, monitoring and mitigation of ageing effects of the plant components or structures and including maintenance, in-service inspection, testing, and surveillance, as well as operations, technical support programmes (including analysis of any ageing mechanisms) and external programmes such as research and development [4-5].

The IAEA started to develop guidance on the safety aspects of AM in the 1990 [6]. Subsequently a number of reports on the subject were published, providing general methodological guidance [7-9], as well as specific guidance for selected major nuclear power plant components, such as reactor vessels, reactor internals, piping, steam generators, containment, etc. [10-20].

In recent decades, the number of IAEA Member States giving high priority to continuing the operation of nuclear power plants beyond the time frame originally anticipated for their operation (typically 30–40 years) has steadily increased. Recognizing the need to assist its Member States in dealing with the unique challenges associated with LTO, the IAEA conducted the Extra-budgetary Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors in 2003–2006 [21]. The outcome of the EBP was consolidated in the Safety Report No. 57 Safe Long Term Operation of Nuclear Power Plants [22]. AM is one of the focal point of Refs. [21-22].

General recommendations on methodology, key elements and implementation of the effective AMPs for SSCs important to safety of nuclear power plants are provided in the IAEA Safety Guide on Ageing Management for Nuclear Power Plants [4]. Ref. [4] however does not provide comprehensive information on specific degradation mechanisms of SSCs or related mitigation-specific AMP.

In parallel with the development of safety related publications described above, the IAEA also developed and published reports related to AM focused on engineering, technological and scientific aspects [23-25].

To complement the existing guidance and technical information described above, the IAEA initiated in 2009 the Extra-budgetary Programme (EBP) on International Generic Ageing Lessons Learned (IGALL) for Nuclear Power Plants (NPPs) with the objective to provide a technical basis and a practical guidance on managing ageing of mechanical, electrical and I&C components and civil structures of nuclear power plants important to safety to support the application of the Specific Safety Requirements on Design [1], Commissioning and Operation [2], of the Safety Guide on Ageing Management [4], of the Safety Guide on Periodic Safety Review [6], and of the Safety Report on Safe Long Term Operation [22].

The products from the EBP on IGALL consist of the followings for SSCs important to safety:

- Generic sample of ageing management review (AMR) tables;
- A collection of proven ageing management programmes (AMPs);
- A collection of typical time limited ageing analyses (TLAA).

This information is based on approaches developed and implemented in various types of water moderated reactors in participating Member States, which will be periodically updated.

The IGALL provides a common internationally agreed basis on what constitutes an acceptable AMP, as well as knowledge base on ageing management for design of new plants, design reviews, safety reviews (such as periodic safety review - PSR), etc. and will serve as a roadmap to available information on ageing management.

In parallel with compilation and development of the information described above, each Member States participating in the EBP was asked to provide a summary description of the national approach to ageing management, which is provided in Section 2 of this publication.

1.1. DESCRIPTION OF IGALL EBP

In the frame of the follow-up activities of the SALTO EBP, the discussions to initiate an international programme to establish the guidance similar to US NRC Generic Ageing Lessons Learned (GALL) Report [26] started during Consultants' Meetings organized by the IAEA in Vienna in May and December 2008 and September 2009.

US NRC, at request of the IAEA, agreed to provide the current revision of the Ref. [26], the GALL report, as a basis to be used for the IGALL EBP.

Subsequently the technical meeting organized by the IAEA in Vienna in May 2009 chaired by A. Blahoianu, Canada recommended to initiate the IGALL EBP and provided guidance on its objective and scope.

Following the presentation and discussion of the EBP proposal to the Permanent Missions of the IAEA Member States, the EBP was initiated in the middle of 2010. This phase of the EBP was scheduled to be completed in 2013.

After EBP initiation, its organization was established. EBP activities were guided by a steering group (SG) composed of senior Member State representatives, implemented by three working groups (WG), coordinated and reviewed by a clearing group (CG). The 3 WGs dealt with the following areas:

- WG1- mechanical components;
- WG2- electrical and I&C components;
- WG3- civil structures and components.

The Programme implementation relied on voluntary in kind and financial contributions from Japan and the USA as well as in kind contributions from Argentina, Belgium, Brazil, Bulgaria, Canada, China, the Czech Republic, France, Germany, Hungary, India, Mexico, the Netherlands, Russian Federation, Slovakia, Spain, Sweden, Switzerland, the Ukraine, the European Commission and the NEA of the OECD.

In total more than 100 experts from 22 Member States participated in the EBP.

The EBP activities relied heavily on work carried out by the participating experts in their countries. The EBP meetings served mainly co-ordination purposes.

The products of the EBP activities include, in addition to this report that provides overview of the EBP and summarizes the current status of ageing management (AM) approaches in participating Member States:

- IGALL Safety Report (providing guidance on using the IGALL database);
- IGALL database (containing AMR tables and proven AMPs and TLAAs).

The IGALL EBP participants pointed out the importance of maintaining the EBP products as living documents and concluded that the IGALL EBP activities should continue in the future to improve the products and incorporate future operational experience, results of research and development and new proven AMPs and TLAAs as well as new contributions of Member States.

1.2. APPROACHES TO AGEING MANAGEMENT IN MEMBER STATES

In this Section, an overview of approaches to AM in participating Member States is provided and covers the following topics:

- National regulatory requirements for AM and LTO;
- Management of physical ageing;
- Management of obsolescence;
- Scoping and screening of SSCs for AM and LTO (passive and active components, long term and short term components);
- AMR for LTO;
- Review of AMPs for LTO;
- Revalidation of TLAAs for LTO.

The contributions of individual Member States in following subsections are as provided, and were not edited or modified by the IAEA.

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2. ARGENTINA

The Argentine Republic has two operating nuclear power plants, the Atucha-I Nuclear Power Plant (CNA-I) and the Embalse Nuclear Power Plant (CNE) which began their commercial operation in 1974 and 1984 respectively. Atucha II Nuclear Power Plant (CNA-II) is in the commissioning process, located at the same site of the CNA-I.

CNA-I reactor type is a pressure vessel based Pressurized Heavy Water Reactor (PHWR), moderated and cooled with heavy water, which provides a net electrical power of 335 MW. The CNE is also a PHWR pressure tube based CANDU type reactor, moderated and cooled with heavy water which provides a net electrical power of 600 MW. The CNA-II is a reactor with similar characteristics and design that CNA-I, with some improved safety features. It generates a net electrical power of 695 MW.

The holder of the Operating Licenses and responsible for operating the two Argentinean nuclear power plants is Nucleoeléctrica Argentina SA (NA-SA), a state-owned company, and the regulatory body is the Nuclear Regulatory Authority (ARN).

2.1. REGULATORY APPROACH

In the early stage of operation of Argentinean NPPs, the AM was managed on a review for approval basis. In 1998, ARN issued a Regulatory Requirement so that the CNA-I and CNE should implement an AMP which formalized the AM requirement of important components from the safety point of view, by optimizing the inspection and maintenance programmes, and the monitoring, prevention and mitigation of ageing effects.

In 2003, ARN decided to modify the operating license duly granted to the Licensee (NA-SA) for CNA-I, to incorporate the aforementioned Regulatory Requirement and new conditions in reference to radiological and nuclear safety, safeguards and physical protection of facilities. Also in 2007, a modification was made with similar characteristics to the Operating License granted to CNE. Following the same criteria, ARN establish the regulatory framework for the licensing process of Atucha II setting the AMP as mandatory documentation.

The Operating License of Argentinean NPPs is valid for 10 years from the date of issue. In both cases the Operating License establishes that it is a condition for renewal, to perform a PSR considering the safety-related aspects of the installation, developed with a level equivalent to the one indicated in the document NS-G 2.10 `Periodic Safety Review of Nuclear Power Plants` [2.1] of the IAEA which involves the analysis of 14 `safety factors`, among which ageing is one of them.

ARN monitors the AMP's of NPP through regulatory inspections, evaluations, and audits during normal operation period and scheduled outages, planned to verify the results considering the AMP objectives. ARN also assess the test results related to in-Service inspection programme, the programme of predictive and preventive maintenance, and periodic reports derived from the operating license. The most important documentation defined as mandatory are the Argentinean Regulatory Standards related with general ageing requirements is:

- Nuclear Power Plant Quality System, AR 3.6.1 [2.2];
- General Safety Criteria in the Design of Nuclear Power Plants, AR 3.2.1 [2.3];
- General Criteria for Operational Safety in Nuclear Power Plants, AR 3.9.1 [2.4].

For particular requirements, the international publications used as guidance, are:

- IAEA Safety Series Nº.15 “Implementation and Review of a Nuclear power Plant Ageing Management Programme”, 1999 [2.5];
- IAEA Safety Standards No. NS-G-2.12 “Ageing Management for Nuclear Power Plants” [2.6];
- Safe Management of the Operating Lifetimes of Nuclear Power Plants, INSAG-14, IAEA, 1999 [2.7];
- The Management System for Facilities and Activities. Safety Requirements. Safety Standards Series No GS-R-3, IAEA, 2006 [2.8];
- Application of the Management System for Facilities and Activities. Safety Guide. Safety Standards Series No. GS-G-3.1. IAEA, 2006 [2.9];
- IAEA Technical Report Series No. 338 “Methodology for the Management of Ageing of Nuclear Power Plant Components Important to Safety, 1992 [2.10];
- IAEA-TECDOC-1037 “Assessment and Management of Ageing of Major Power Plant Components Important to Safety: CANDU Pressure Tubes” [2.11];
- IAEA Safety Standards Series N° NS-R-1. Safety of Nuclear Power Plants: Design, 2000 [2.12];
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- IAEA, Safety Standards Series N° NS-G-2.6. Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, 2002 [2.14];
- CSA N285.4 Periodic inspection of CANDU nuclear power plant components [2.15];
- CSA N286-05 Management System Requirements for Nuclear Power Plants [2.16];
- CNSC Regulatory Standard S-210. Maintenance Programs for Nuclear Power Plants [2.17].

As it was mentioned, in the framework of the PSR, the AMPs of Atucha and Embalse NPPs had been evaluated in order to actualize them, considering modern standards and practices. Therefore upgraded AMP will be implemented in both plants.

2.2. AGEING MANAGEMENT AND LTO BY THE LICENSEE

In 2007 NA-SA started an extensive AMR as the first stage for the refurbishment process for CNE NPP life extension. The refurbishment process includes a replacement of major components as Pressure Tubes, Feeders, Main Control Computer, Steam Generators and other structures and components important to safety. The engineering tasks for this process are currently ongoing. A comprehensive set of AM Activities will be developed for the life extension.

In 2010 NA-SA gathered a specific group for dealing with AM of both CNA-I and CNA II NPPs and additionally an AMR was started for Atucha I. This process is currently ongoing.

The AMR in Embalse and Atucha NPPs was performed by NA-SA with the assistance of a National Technical Support Organization (CNEA).

Scoping and screening process for AM was performed following the procedure recommended in IAEA Safety Standards N° NS-G 2.12 'Ageing Management for Nuclear Power Plants' [2.6].

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3. BELGIUM

3.1. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

In Belgium, the licenses for operation of the nuclear power plants granted by Royal Decree do not specify a fixed lifetime. The oldest plants, Doel 1&2 and Tihange 1, have been operational since 1975. The 2003 law regarding the exit from nuclear power limits the operation of nuclear power plants to 40 years.

However, in October 2009, the Belgian government declared that they intended to make it legally possible for Doel 1&2 and Tihange 1 to operate until 2025, which would mean a total lifetime of 50 years (this statement was confirmed by the Belgian government in June 2012, only for the Tihange 1 plant).

The Belgian Federal Agency for Nuclear Control (FANC) published in 2009 a strategic note [3.1] regarding the requirements of long-term operation for Doel 1&2 and Tihange 1. Electrabel GDF SUEZ started its LTO programme in order to respond to these requirements.

The LTO programme consisted of the following areas of concern, identified in the FANC strategic note:

- Preconditions for long-term operation considering the IAEA expectations;
- Ageing management;
- Design re-evaluation;
- Knowledge, competence and behaviour management.

The note also stated that the long-term operation of the plants should be evaluated within the framework of the fourth ten-yearly PSR, based upon IAEA NS-G-2.10 [3.2]. As such a license renewal was not required for LTO and the LTO approval will be integrated in the approval process of the 4th PSR.

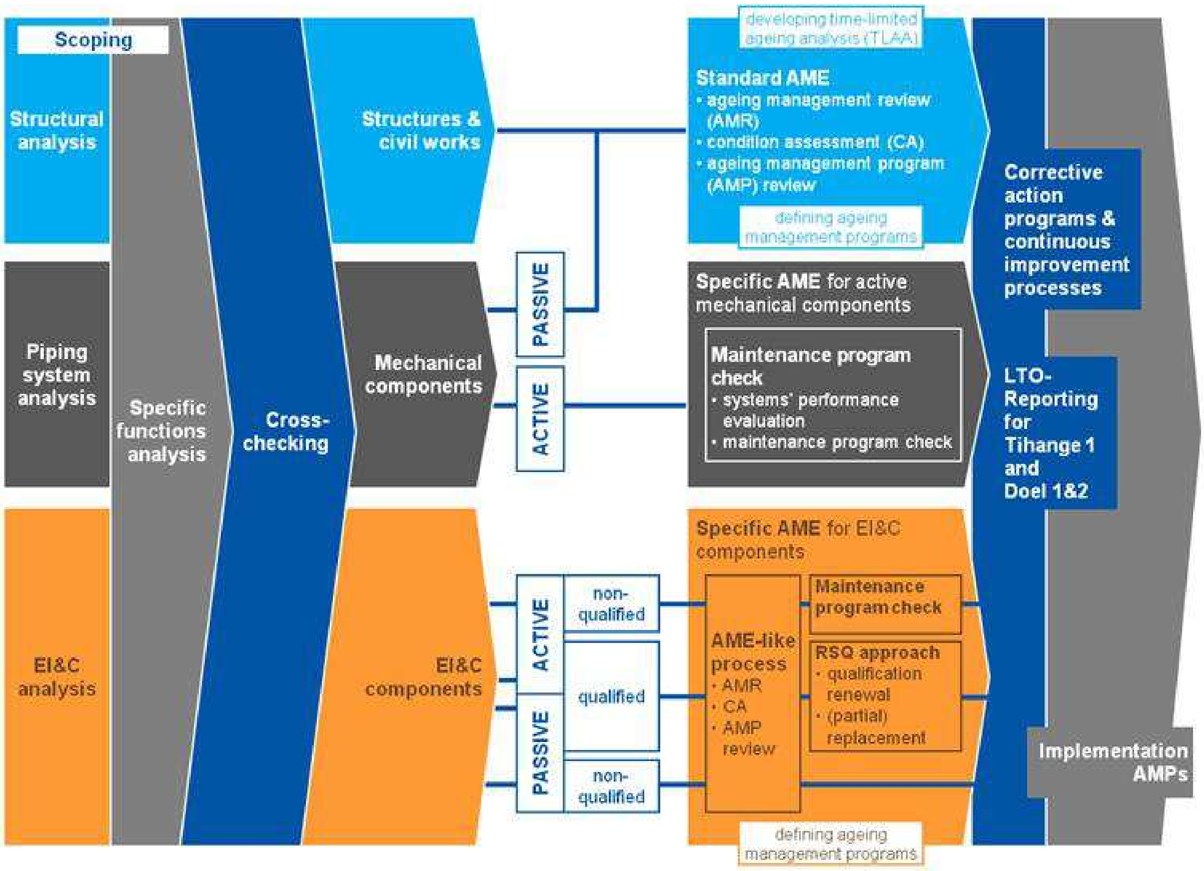
In its strategic note, the Belgian Federal Agency for Nuclear Control explicitly states that the AMP has to be in conformity with the USNRC 10CFR54 [3.3] and IAEA SRS 57 [3.4].

3.2. MANAGEMENT OF PHYSICAL AGEING

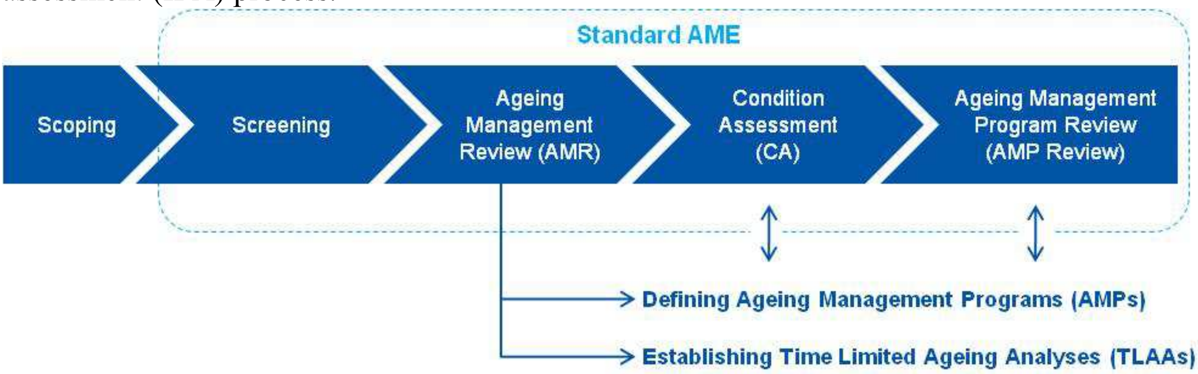
The following paragraph gives a high-level view on Belgian IPA (Integrated Plant Assessment) process, including the following:

- Scoping and screening of SSCs for AM and LTO (passive and active components, long term and short term components);
- AMR and condition assessments of in scope SSC;
- TLAA and AMP re-evaluation.

The overall process is presented in the figure below.



Electrabel GDF SUEZ bases its LTO-ageing approach on the US NRC Integrated plant assessment (IPA) process.



Scoping was the first step for all SSCs. The LTO-ageing project covers safety-related and non-safety-related SSC. SSC that are in LTO-ageing scope are defined according to 10CFR54.4 (a). The scoping process consists of four different analyses:

- Three types of basic analysis, one for each of the three technical domains: mechanical, structures, EI&C (safety related - criterion 1 - and safety impacting - criterion 2);
- One specific analysis, across the three basic domains, related to five specific functions: fire protection, environmental qualification (EQ), pressurized thermal shock (PTS), anticipated transients without scram (ATWS), station blackout (criterion 3).

A continued cross-check between the technical domains and the scoping deliverables guaranteed the overall coherence of the SSC in scope for LTO-ageing.

The subsequent process steps made up the ageing management evaluation (AME). The presented basic assessment process had been adapted for a number of situations: it was performed system-by-system (mechanical domain), commodity group by commodity group (EI&C domain) and structure type by structure type (structures domain).

The need for an AMP, a TLAA, or a plant-specific programme was identified in the AMR. As AMPs did not always exist, AMP development was progressively integrated in the AME for SSC that are subject to LTO analysis. Up to now, IPA was mainly dedicated to passive components, whereas the FANC's LTO strategic note requests the coverage of active and passive components. Therefore, a specific approach for active components was added.

This specific AME was focuses on the planned maintenance programmes and evaluation of these programmes. The plant maintenance programmes applicable to active components identified as within LTO ageing scope are reviewed using the Reliability Centred Maintenance (RCM) approach in order to achieve the optimum reliability of the functions of the systems and components. The RCM basics are as follows:

- Establishing the leading failure modes for each type of equipment;
- Criticality analysis and evaluation (gradation of severity and frequency of the risk of failure) of the failure modes of active functional locations in scope;
- Identification of run-to-failure equipment;
- Check of preventive maintenance programmes and surveillance and inspection programmes regarding their capability to prevent critical functional failure;
- Improvement of task and frequency definition of periodic activities.

Action plans were defined and will be implemented. These programmes will be subject to the continuous improvement process (living programme).

The effectiveness of the living maintenance and AMPs will be monitored through system health reporting.

3.3. MANAGEMENT OF OBSOLESCENCE

The several types of obsolescence (knowledge, technology and finally standards and regulations) are addressed in the main LTO areas, as required in the FANC Strategic Note (see chapter 1).

Additionally, a review of the management of obsolescence is parts of regular themes in PSRs.

Obsolescence of knowledge: Cultural changes, the loss of knowledge and competence due to an ageing workforce (retirement) are specific parts of non-physical ageing processes.

Electrabel GDF Suez has performed and reported a self-assessment in order to ensure that these types of obsolescence are adequately managed and not jeopardizing the long term operating period. If needed, action plans to fulfil them were defined.

This area is connected with the following themes:

- Nuclear safety culture, as well as the behaviour and values that support it;

– Competence management, specifically the training and qualification of personnel;
– Knowledge management.

Personnel, organization and procedural subjects were taken into account in every of these 3 domains. In the analysis of the results the most recent OSART audits were used, specifically in the domain human behaviour, training and self-evaluations.

Obsolescence of standards and regulations: The area of LTO-design includes the systematic reassessment of plant against current standards (e.g. PSR) and appropriate upgrading, back-fitting or modernization. The objective is to develop improvement measures that upgrade the design (see FANC strategic note), in order to reduce the residual risk as far as reasonable achievable (i.e. the probability on core damage and /or large scale radioactive releases).

The LTO-design activities are:

– Design review;
– Development of the improvement plan and the Agreed Design Upgrade (ADU);
– Implementation of the ADU, after approval and according to the time schedule set.

The following information sources were used during the design review:

– Regulation watch;
– WENRA reference levels;
– Benchmarks;
– PSR look-back;
– Operational experience feedback;
– Design basis documentation.

Obsolescence of technology: Some types of obsolescence are included in the scope of this area such as unavailability of qualified spare parts for old equipment, disappearance of the original manufacturer or supplier for the plant Maintenance programme.

Electrabel GDF Suez has performed and reported a self-assessment in order to ensure that the preconditions for LTO have been met with the IAEA expectations used as reference for evaluation. If needed, action plans to fulfil them were defined.

The management of these types of obsolescence were considered as preconditions for LTO and assessed as part of the plant programmes, especially for maintenance and equipment qualification.

3.4. REVIEW OF AMP's FOR LTO

During the screening/AMR analysis, a set of different AMPs (AMP) applicable to the plant is defined. The implementation of these AMP's has to ensure that the intended functions of safety equipment will be maintained consistent with the current licensing base (CLB) for the period of extended operation.

The AMPs contain the AM policies in a standardized, systematic and structured way and describe for different areas of concern (i.e. closed cycle cooling water, buried piping, boric acid corrosion, …) the actions to be taken (preventive, monitoring, corrective) in different domains (maintenance, in-service inspection and surveillance, operations, technical support) based on international programmes (NUREG1801) [3.5] in order to ensure that the effects of ageing are adequately managed, so that the acceptance criteria for safe operation are maintained and not exceeded.

For some specific ageing topics, for which the NUREG 1801 didn't give clear guidance, plant specific AMPs were issued.

In reference to NUREG1801, new AMPs were developed in a standardized way, using the known specific attributes for passive components.

It is assumed that the ageing of active components is managed through solid and proven maintenance programmes (see living RCM programme in paragraph 2).

3.5. REVALIDATION OF TLAAs FOR LTO

The TLAA definition as specified in the 10 CFR part 54.3 was applied. The TLAA addressed for LTO can be viewed in the following broad categories:

- Major NSSS components designed in accordance with the ASME Boiler and Pressure Vessel Code. The design specifications and stress reports for these components address a design life of the component for use in fatigue and wear analyses; they also describe neutron irradiation limitations for the expected plant life in consideration of the components material properties;
- Major non-NSSS structural and safety related components subject to the effects of ageing, fatigue, relaxation, and degradation due to environmental conditions;
- Electrical equipment initially qualified for a specific time period.

The environmental qualification of electrical equipment is treated within the EI&C qualification approach.

In a first step, potential TLAA subjects were identified and listed in two ways:

- Reviewing lists of previously identified TLAA and choosing those potentially applicable to Tihange 1 and Doel 1-2 for further evaluation. In particular the following information sources were consulted:
  - List of the TLAA established by the WOG (Westinghouse Owners Group);
  - TLAA listed in NUREG-1800 [3.6] and NUREG-1801, (GALL);
  - TLAA listed as examples in NEI 95-10 (NEI) [3.7];
  - TLAA performed in US NPP with similar design to the Tihange 1 and Doel 1&2 plants;
  - Engineering judgment of GDF Suez Tractebel Engineering, the responsible designer, specialists;
- Searching the unit's current licensing basis for calculations/analyses with a time element.

The necessity of reviewing these TLAA-subjects was examined and the final list of TLAAs to be reviewed was validated by the Authorities.

In a second step, the necessary studies and analysis were done in order to update and revalidate the existing TLAA. For newly identified topics, new TLAA have been issued.

In some exceptional cases, where the TLAA approach was unable to justify continuous operation in the LTO time window, specific programmes to manage the ageing mechanisms have been established.

REFERENCES TO SECTION 3

[3.1] AGENCE FEDERALE DE CONTROLE NUCLEAIRE, Note stratégique "Long term operation" des centrales nucléaires belges : Doel 1&2 et Tihange1, 008-194 révision 2, AFCN (2009), (www.afcn.fgov.be).

[3.2] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA, Safety Guide NS-G-2.10, (August 2003).

[3.3] OFFICE OF THE FEDERAL REGISTER , NATIONAL ARCHIVES AND RECORDS ADMINISTRATION, Requirements for renewal of operating licenses for Nuclear Power Plants, 10 CFR part 54, Codes and standards, (2005).

[3.4] INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants, IAEA, Safety Report Series No. 57, (October 2008).

[3.5] UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Ageing Lessons Learned (GALL) Report, NUREG 1801, Vol. 1 and 2, Rev. 1, (September 2005).

[3.6] UNITED STATES NUCLEAR REGULATORY COMMISSION, Standard Review Plan for review of License Renewal Applications for Nuclear Power Plants, NUREG 1800, Rev. 1, (September 2005).

[3.7] NUCLEAR ENERGY INSTITUTE, Industry Guideline for Implementing the Requirements of 10 CFR part 54 – The License Renewal Rule, NEI 95-10, Rev. 6, (June 2005.

4. BRAZIL

4.1. APPROACH TO AGEING MANAGEMENT OF BRAZIL

Eletrobras Eletronuclear, the Brazilian company responsible for the construction and operation of nuclear power plants, operates two PWR units at Central Nuclear Almirante Álvaro Alberto – CNAAA, situated in Angra dos Reis city. Angra 1 is a 640 MWe Westinghouse plant, operating since 1985, and Angra 2 is a 1350 MWe plant, designed by Areva-Siemens-KWU which started operation in 2001. A third unit, similar to Angra 2, is being constructed at the same site and is due to commence operation in 2016. Angra 1 and 2 nuclear steam supply systems have been designed to ASME and KTA codes, respectively.

Brazilian nuclear power plants are licensed for a period of 40 years in accordance with the rule CNEN NE-1.04, 'Licensing of Nuclear Installations', issued by, the Brazilian regulatory board: Comissão Nacional de Energia Nuclear (CNEN) [4.1]. PSRs are conducted in accordance with CNEN NE-1.26, 'Safety in Operating Nuclear Power Plants' [4.2], consistent with IAEA Safety Guide No. NS-G-2.10, 'Periodic Safety Review of Nuclear Power Plants' [4.3].

A comprehensive AMP at Angra NPP is being developed with the objective of coordinating operations, maintenance and engineering actions to control under acceptable limits the effects of ageing to maintain integrity and functional capability of SSCs important to safety the way that the licensing basis of the plants are maintained during the period of the current operating license and during the period of LTO, as defined in IAEA Safety Reports Series No.57, 'Safe Long Term Operation of Nuclear Power Plants' [4.4].

The AMP implementation project at Angra counts on the technical support of the designers of both plants. During the initial phase, technical visits of Westinghouse and Areva and the development of a pilot project for a mechanical system (by Westinghouse) contributed to the first assessments of the available documental infrastructure and of the proposed methodology for the development of AMP processes.

The approach to implement the AMP at Angra NPP comprises a systematic process based on the following tasks consistent with IAEA Safety Guide No. NS-G-2.10 [4.3]:

- Operation within operating procedures and applicable guidelines to minimize the rate of degradation;
- Inspection and monitoring in accordance with the applicable requirements with the aim of detecting and characterizing any degradation prior to acceptance criteria being exceeded;
- Assessment of the impact of any observed degradation to the structural integrity or functional capability of structures and components;
- Maintenance to prevent unacceptable degradation or mitigate its effects.

Ageing assessments (including scoping and screening phases) for the implementation of the AMP at Angra NPP are based on the US-NRC rule 10 CFR 54, 'Requirements for Renewal of Operating Licenses for Nuclear Power Plants' [4.5], and IAEA Safety Guide NS-G-2.12 'Ageing Management for Nuclear Power Plants' [4.6]. For Angra 2, the German rule KTA 1403 'Ageing Management in Nuclear Power Plants' [4.7] is also considered.

Structures, systems, and components to be considered in the scoping and screening phases of the AM assessments for LTO are:

- Safety-related SSCs which are those relied upon to remain functional during and following design-basis events to ensure (i) the integrity of the reactor coolant pressure boundary; (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition; or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures;
- All non-safety related SSCs whose failure could prevent satisfactory accomplishment of any of the functions identified above;
- All SSCs relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the regulatory requirements for fire protection, environmental qualification, pressurized thermal shock, anticipated transients without scram, and station blackout.

Technical assessments in the scope of the AMP in Angra NPP comprise the following aspects:

- Integrated plant assessment;
- Time limited ageing analyses review;
- Obsolescence management.

Integrated plant assessment consists of a demonstration that passive long-lived structures and components in the scope of the AMP for LTO have been identified and that the effects of ageing on the structural integrity and on the functionality of such structures and components will be managed to maintain the current licensing basis during the period of the plant operation.

Time limited ageing analyses comprise existing safety analyses involving time limited assumptions as defined in US-NRC rule 10 CFR 54.3 [4.5] and in IAEA Safety Reports Series No. 57 [4.4]. TLAA include environmental qualification in accordance with US-NRC rule 10 CFR 50.49, `Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants` [4.8].

The management of obsolescence, focusing on technological aspects, is addressed in a specific engineering programme consistent with IAEA Safety Guide NS-G-2.12 [4.6].

Ageing of active components is managed in the scope of the programme for monitoring the effectiveness of maintenance in accordance with US-NRC rule 10 CFR 50.65, `Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants` [4.9].

IAEA safety standards, reports, and guidelines; WANO, INPO, and EPRI guidelines; industry guidelines like NEI 95-10, `Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule` [4.10] and NUMARC 93-01, `Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants` [4.11]; US-NRC NUREG 1801, `Generic Ageing Lessons Learned (GALL) Report` [4.12]; and the internal and external operating experience are the basis for the assessment of existing plant AMPs as well as for the development of new programmes along the process of the implementation of the AMP at Angra nuclear power plants.

REFERENCES TO SECTION 4

[4.1] COMISSÃO NACIONAL DE ENERGIA NUCLEAR - CNEN, Licensing of Nuclear Installations, CNEN NE-1.04.

[4.2] COMISSÃO NACIONAL DE ENERGIA NUCLEAR - CNEN, Safety in Operating Nuclear Power Plants, CNEN NE-1.26.

[4.3] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA, Safety Guide NS-G-2.10.

[4.4] INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants, IAEA, Safety Reports Series No.57.

[4.5] US-NUCLEAR REGULATORY COMMISSION, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, US-NRC 10 CFR 54.

[4.6] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, IAEA Safety Guide NS-G-2.12.

[4.7] KERNTECHNISCHER AUSSCHUSS – KTA, Ageing Management in Nuclear Power Plants, KTA 1403.

[4.8] US-NUCLEAR REGULATORY COMMISSION, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants, US-NRC 10 CFR 50.49.

[4.9] US-NUCLEAR REGULATORY COMMISSION, Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, US-NRC 10 CFR 50.65.

[4.10] NUCLEAR ENERGY INSTITUTE, Industry Guideline for Implementing the Requirements of 10 CFR Part 54 – The License Renewal Rule, NEI 95-10.

[4.11] NUCLEAR ENERGY INSTITUTE, Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01.

[4.12] US-NUCLEAR REGULATORY COMMISSION, Generic Ageing Lessons Learned, (IGALL) Report, US-NRC NUREG 1801.

5. CANADA

5.1. APPROACH TO AGEING MANAGEMENT OF CANADA

The Canadian regulatory approach to ensuring the implementation of effective AMPs for nuclear power plants is summarized as follows. Canada currently has 22 CANDU nuclear power reactors under operating licenses issued by the Canadian Nuclear Safety Commission (CNSC). The reactors began operation between 1971 and 1993. Through operating licenses, the CNSC requires licensees to comply with a number of in-service inspection standards and regulatory documents under CNSC Safety and Control Area 'Fitness for Service' of SSCs. These provide extensive requirements related to understanding, controlling and managing ageing, including:

– Periodic inspection of CANDU pressure retaining components in accordance with Canadian Standards Association (CSA) N285.4 Standard [4.1];
– Periodic inspection of CANDU containment components per CSA N285.5 [4.2];
– In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants per CSA N287.7 [4.3];
– In-service evaluation of zirconium alloy pressure tubes in CANDU nuclear power plants per CSA N285.8 [4.4];
– Equipment environmental qualification programmes per CSA N290.13 [4.5];
– AMPs per CNSC REGDOC-2.6.3 [4.6];
– Equipment reliability programmes per CNSC RD/GD-98 [4.7];
– Maintenance programmes per CNSC RD/GD-210 [4.8];
– Notification and reporting of events and operational experience per CNSC S-99 [4.9];
– Other specific conditions of an NPP operating license.

CNSC regulatory documents can be obtained at www.nuclearsafety.gc.ca. CSA standards can be obtained at www.csa.ca. The CNSC document REGDOC-2.6.3 `Aging Management of Nuclear Power Plants` [4.6] provides regulatory expectations for the AM of nuclear power plants to ensure that safety and performance of SSCs remain within acceptable limits throughout the life cycle. Both physical ageing and obsolescence of SSCs in NPPs are addressed. REGDOC-2.6.3 emphasizes the need for early and pro-active consideration of AM for all stages of a plant's life cycle: design, fabrication, construction, commissioning, operation, LTO, and decommissioning. CNSC requires licensees to provide condition assessment of systems, structures and components on a periodic basis as part of the requirements for AM. In addition, regulatory requirements are provided for the establishment, implementation, and improvement of AMPs through application of a systematic and integrated approach. This regulatory document represents the CNSC's adoption and adaptation, consistent with the Canadian regulatory framework, of the guidance established by the IAEA in Safety Guide NS-G-2.12 [4.10]. Key principles and elements used in REGDOC-2.6.3 are consistent with international practices.

CNSC Regulatory Document RD-360 `Life Extension of Nuclear Power Plants` [4.11] provides information on the key elements to be considered when a licensee undertakes a project for the long-term operation of a nuclear power plant (NPP). Long-term operation of an NPP denotes operation beyond the assumed design life of the facility, which has been justified by safety assessment, considering life limiting processes and features for SSCs. For the current fleet of reactors in Canada, this is operation beyond approximately 30 years. One of the major activities is to assess the ability of the plant to safely operate for the extended period through the performance of an integrated safety review (ISR). The ISR is a comprehensive assessment (by the licensee) of plant safety performed in accordance with IAEA Safety Guide SSG-25 [4.12], which addresses PSR of NPPs. In the framework of an ISR, the licensee evaluates the effects of ageing on NPP safety, the effectiveness of AMPs for future operation, and carries-out a comparison of current plant state to modern codes and standards. Condition assessments are to be completed as part of the review of ageing programmes for long-term operation. The AMR must demonstrate that:

- All SSCs that can, directly or indirectly, have an adverse effect on the safe operation of the NPP are evaluated for the proposed period of long-term operation;
- The effects of ageing will continue to be identified and managed for these SSCs during the planned period of long-term operation;
- All safety analyses involving Time Limited assumptions are still valid for the proposed period of long-term operation to ensure that the ageing effects will be effectively managed (i.e., to demonstrate that the intended function of an SSC will remain within the design safety margins throughout the planned period of long-term operation).

Based on the results of the ISR, licensees develop an Integrated Implementation Plan (IIP) for the necessary corrective actions, safety upgrades and other compensatory measures to support LTO.

REFERENCES TO SECTION 5

[5.1] CSA GROUP, Periodic Inspection of CANDU Nuclear Power Plant Components, CSA N285.4, Toronto (2009).
[5.2] CSA GROUP, Periodic Inspection of CANDU Nuclear Power Plant Containment Components, CSA N284.5, Toronto, (2008).
[5.3] CSA GROUP, In-Service Examination and Testing Requirements for Concrete Containment Structures for Nuclear Power Plants, CSA N287.7, Toronto (2008).
[5.4] CSA GROUP, Technical Requirements for In-Service Evaluation of Zirconium Alloy Pressure Tubes in CANDU reactors, CSA N285.8, Toronto (2010).
[5.5] CSA GROUP, Environmental Qualification of Equipment for CANDU Nuclear Power Plants, CSA 290.13, Toronto (2005).
[5.6] CANADIAN NUCLEAR SAFETY COMMISSION, Aging Management for Nuclear Power Plants, Regulatory Document REGDOC-2.6.3, Ottawa (2013).
[5.7] CANADIAN NUCLEAR SAFETY COMMISSION, Reliability Programs for Nuclear Power Plants, Regulatory Document RD/GD-98, Ottawa, (2012).
[5.8] CANADIAN NUCLEAR SAFETY COMMISSION, Maintenance Programs for Nuclear Power Plants, Regulatory Document RD/GD-210, Ottawa (2012).
[5.9] CANADIAN NUCLEAR SAFETY COMMISSION, Reporting Requirements for Operating Nuclear Power Plants, Regulatory Standard S-99, Ottawa (2003).
[5.10] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna (2009).
[5.11] CANADIAN NUCLEAR SAFETY COMMISSION, Life Extension of Nuclear Power Plants, Regulatory Document RD-360, Ottawa (2008).
[5.12] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA Specific Safety Guide No. SSG-25, IAEA, Vienna (2013).

6. CZECH REPUBLIC

6.1. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

The Czech Republic has 4 units VVER 440/213 in Dukovany NPP commissioned from 1985 to 1987 and 2 units VVER 1000/320 in Temelin NPP commissioned from 2000 to 2002. Operating licence is unlimited in the Czech Republic but the State Office for Nuclear Safety (SONS), carrying out supervision and administration at the utilization of the nuclear energy, permits operation of a nuclear power plant always for the following ten years, in accordance with [6.1].

Original design lifetime is 40 years for RPV and 30 years for other major components for Dukovany NPP and also for Temelin NPP. Design lifetime of Unit 1 in Dukovany NPP will expire first in 2015.
Operational permission for 10 years is based on:

- PSR (according to the requirements [6.2 - 6.3]);
- Updated Final Safety Analysis Report;
- Requirements from previous SONS permissions.

Additional SONS requirements for LTO based on IAEA SALTO recommendations have to be fulfilled for operational permission beyond design life time (30 years), e.g. carry out the AMR and launch the Integrated AMP.

6.2. MANAGEMENT OF PHYSICAL AGEING

The physical ageing of all structures and components is managed and the graduated approach is used for this purpose at Czech NPPs. This is assured by plant life management programme (PLIM) [6.4]. According to PLIM programme the power plant structures and components (SCs) are divided into three categories according to:

- Safety importance;
- Technological and economic importance;
- Strategic importance for further operation.

The physical ageing is defined by different procedure in each category:

Category 1, group A - the most important SSCs: Ageing is managed by component specific life management programme.

- Selection criteria:
  - SSCs critical for LTO (non-replaceable);
  - Safety important passive mechanical SCs, active mechanical components fulfilling safety important passive function;
  - SSCs economically important.

- Category 1A Scope:
  - Primary circuit pressure boundary;

   - Containment pressure boundary;
   - Economically important SSCs – RPV internals, high energy pipelines, spent fuel pools, safety cables, cooling towers, turbines, generators, transformers.

Rest of Category 1: Life management is based on preventive maintenance where requested reliability level is defined (on the basis of [6.5]). If the requested reliability level is not maintained the specific AMP is implemented as a remedy.

- Selection criteria:
  - SCs critical for fulfilment of operational-safety targets;
  - SCs important for nuclear and technical safety;
  - SCs replaceable;
  - Usually components with active function.

Category 2: Life management is based on preventive maintenance. Preventive maintenance is optimised with respect to costs (balance repair costs vs. maintenance costs).

- Selection criteria:
  - SSCs important for fulfilment of operational-safety targets;
  - SSCs important for technical safety.

Category 3: Life management is based on corrective maintenance

- Selection criteria:
  - SSCs whose failure to not lead to safety or direct availability impacts or important economic impacts.

6.3. SCOPING AND SCREENING METHOD

The scoping is based upon [6.6 - 6.8] recommendations.

6.3.1. Scoping criteria for LTO.

- Decree No. 132/2008 [6.9] (all SCs important for nuclear safety according to project of the NPP);
- SCs which according to PLIM categorization perform safety function or SCs which failure could impact performance of safety function;
- Economically important non-safety related equipment with long service life (important from viewpoint of LTO);
- Others SCs upon the decision of the operator of NPP:
  - High repair costs;
  - Operation/energy availability factor;
  - Industrial safety and environmental protection.

Scope of the LTO covers about 70 000 SCs.

6.3.2. Screening.

The screening process is based upon [6.6 - 6.8] recommendations. Selected SCs, which are subject to an assessment that demonstrates whether the effects of ageing degradation will be managed for the planned period of LTO so that all relevant license requirements are fulfilled, include passive components (or parts of components fulfilling passive function). Active components or parts of components responsible only for active function are not included. AM of active components is covered by means of maintenance.

6.4. AGEING MANAGEMENT REVIEW FOR LTO

AMR is carried out according to following steps:

- General and specific methodologies for mechanical, electrical, I&C and civil structures and components are elaborated;
- The SCs are grouped into groups according to:
  - Safety class;
  - Required function for LTO;
  - Commodity type;
  - Working environment (temperature, medium, pressure);
  - Type of operation (on line/ stand by);
  - Way of maintenance (maintenance routines, operational procedures);
- Further information for evaluation is collected;
- Real and potential degradation mechanisms and ageing effects are identified for each defined groups;
- AMP controlling corresponding degradation mechanisms are determined;
- The technical evaluation of each AMP is performed (whether the corresponding degradation mechanism is managed in proper way);
- Each AMP is verified with respect to the procedural requirements defined in [6.6 - 6.8];
- TLAA or technical documents limiting lifetime valid for evaluated group of SCs is/are identified;
- The correctness of AM for evaluated group is stated and demonstrated or following suggestions are given:
  - Recommendation for optimization of the existing AMPs scope;
  - Recommendation for improving of the existing AMPs (from both technical and procedural point of view);
  - Definition of missing AMPs;
  - Recommendation for TLAA revalidation (if TLAA or similar document was identified);
- Results of AMR are documented in specific software tool, in excel sheets and reports.

6.5. REVALIDATION OF TLAAs FOR LTO.

For LTO assurance of NPP Dukovany the scope of TLAAs was extended about documents, which limit life time of SCs. Those are Technical specifications, QA documents.

TLAA and further technical documents were identified during AMR. There was identified about 260 TLAAs and time life limiting technical documents. The time schedule of TLAA revalidation was defined and approved.

TLAA are revalidated be means of:

- Demonstration the original TLAA is still valid for period of LTO;
- Re-evaluation of TLAA (new analysis, new calculation);
- Implementation of AMP handling concerned degradation mechanism.

REFERENCES TO SECTION 6

[6.1] Act No. 18/1997 Coll., on Peaceful Utilization of Nuclear Energy and Ionizing Radiation (the Atomic Act).

[6.2] National safety guide BN-JB-1.2, rev. 1 Periodic Safety Review of NPP, State Office for Nuclear Safety of Czech Republic, 2012.

[6.3] Periodic Safety Review of Nuclear Power Plants, IAEA Specific Safety Guide No. SSG-25, IAEA, Vienna, 2013.

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[6.7] Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna, 2009.

[6.8] National safety guide BN-JB-2.1, Ageing management of NPP, State Office for Nuclear Safety of Czech Republic, 2010.

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7. FRANCE

The EDF lifetime management policy for LTO of the NPPs is based on three main principles:

- Regulatory context characterized by 10-year PSR including continuous safety improvement;
- Adequate maintenance policy associated with in-service inspections, and performance improvement to increase operational capacities and availability of the units, in compliance with safety requirements;
- Ageing and obsolescence management process for main NPP safety related components to cope with ageing degradation mechanisms, including operating experience feedback.

The major objective of the AM process is to justify that all the safety related SSCs, concerned by an ageing mechanism, remain within the design and safety criteria, during the whole lifetime of the plants.

The ageing mechanism taken into account may occur during normal operation, including periodic tests and routine maintenance activities.

The EDF AMP procedure, described in a generic guide, is carried out in 4 main steps:

- Selection of Safety SSCs concerned by an ageing mechanism;
- Review of all the couples SSC/degradation mechanism selected by experts and synthetic analyses in ageing analysis sheets (AAS);
- Detailed ageing analysis reports (DAAR) required for some “sensitive” components (such as reactor pressure vessel, reactor internals, civil works, I&C or electrical cables);
- Unit ageing analysis report (UAAR) required for each unit preparing the 10-year PSR from the 3rd one.

The three first steps, are implemented at the corporate level in a generic approach, available for a fleet of similar units. The 4th one is implemented at the unit level.

7.1. SELECTION OF STRUCTURES, SYSTEMS AND COMPONENTS

This selection is based on a systematic review of SSCs important to safety according to the final safety analysis report (FSAR) that defines the rules in terms of safety importance.
About 15000 components are concerned:

- Mechanical components of all safety classes including active ones;
- Electrical components;
- Civil structures connected to safety.

That list has been extended to non-safety related SSCs having a significant impact in Probabilistic safety analyses and non-safety related SSCs that might affect a safety related SSC as a result of an ageing degradation.

7.2. AGEING ANALYSIS SHEETS (AAS)

A review of the different ageing mechanisms that can affect a part of the above mentioned list of components and structures is carried out by experts. As a result, all the relevant couple's SSC/ageing mechanism are selected to be described in a specific AAS.
The information provided in an AAS is the following:

- The consequences of the ageing mechanism (potential or already encountered in a French plant or of a similar type in another country) on the SSC behaviour and its required safety functions;
- The capability of the routine maintenance programme as well as of the inspection procedures to detect the ageing mechanism in a given location;
- Difficulties in repairing or replacing the component, taking into account the obsolescence issues.

According to the criteria indicated in table 1, a level of category (0, 1 or 2) is attributed to each AAS:

TABLE 1. CRITERIA FOR THE ATTRIBUTION OF THE AAS CATEGORY

Criteria	**Encountered mechanism**			**Potential mechanism**		
Maintenance And operation	**Adapted**	**Adaptable**	**Difficult to adapt**	**Adapted**	**Adaptable**	**Difficult to adapt**
Difficult to repair and to replace	**2**	**2**	**2**	**0**	**1**	**2**
Easy to repair or to replace	**0**	**1**	**2**	**0**	**1**	**1**

Category 0: Ageing is under control, without any additional information
Category 1: Temporary state – A complementary instruction is needed
Category 2: A DAAR is required.

7.3. DETAILED AGEING ANALYSIS REPORTS (DAAR)

For each component with at least one AAS affected to category 2, a detailed report is required to justify continuation to operate to the end of life of the plant.
On the basis of references, this report has to collect knowledge as follows:

- Introduction: objective;
- Description of the component: design, materials, manufacturing process;
- Design basis: regulation, codes & standards, specification and guidelines;
- Operating experience;
- Ageing mechanisms (especially category 2 AAS);
- In service inspection, monitoring, leak detection;

– Mitigation, repair, replacement including industrial capacity and obsolescence;
– R&D programmes in support;
– Synthesis of AMP and recommendations.

As an example, DAARs have been produced for 12 main components or structures of the 3-loop NPPs, such as Reactor Pressure Vessel, pressurizer, main coolant pump, electrical cables, I&C, containment and civil structures.

7.4. UNIT AGEING ANALYSIS REPORTS (UAAR)

The information provided in an UAAR is:

– Relevant plant construction and equipment manufacturing and erection particularities related to ageing;
– Relevant operation events connected with ageing;
– Analysis of each generic DAAR in comparison with the unit situation (maintenance and inspections conclusions, etc.);
– Analysis of each AAS in comparison with the unit situation, (maintenance and inspections conclusions), and possibly AAS creation for unit specific SSC (e.g. part of heat sink).

As a conclusion of these analyses, an additional AMP, specific for each unit, is established.

All these reports have to be prepared in agreement with the French regulation, as the decree for surveillance of primary and secondary system [7.1], French Codes & Standards, as RCC-M Code for Design and Construction of French PWRs [7.2] and RSE-M Code for Surveillance in operation of French PWRs [7.3] and the corresponding plant Final Safety Analysis Report. .

They are issued by the operator and submitted to the Nuclear Safety Authority.

The French procedure is globally consistent with IAEA Safety Guide NS-G-2.12 on Ageing Management for Nuclear plants [7.4], according to the comparison recently carried out by EDF.

REFERENCES TO SECTION 7

[7.1] REPUBLIQUE FRANCAISE, Arrêté du 10 Novembre 1999 Relatif à la Surveillance de l'Exploitation du Circuit Primaire Principal et des Circuits Secondaires Principaux des Réacteurs Nucléaires à Eau Sous Pression, Paris (1999).
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[7.3] AFCEN, Règles de Surveillance en Exploitation des matériels Mécaniques des îlots nucléaires REP, édition 2010, Paris la Défense (2010).
[7.4] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna (2009).

8. GERMANY

8.1. APPROACH TO AGEING MANAGEMENT OF GERMANY

The Fukushima Accidents have led to fundamental changes in the usage of nuclear power in Germany. On August 1, 2011, an amendment of the German Atomic Energy Act came into force. It consists basically of an accelerated step-by-step phase-out until 2022. Eight older NPPs were shut down immediately. The remaining NPP will be stepwise shut down so that the last one will stop commercial operation at the end of 2022.

Against this background, long-term operation is not an issue anymore in Germany. However, for the NPPs in operation it is necessary to ensure the required quality of safety-related SSCs by an AM process, though the specified operational lifetime is not enlarged. The new nuclear safety standard KTA 1403 [8.1] was established and issued in December 2010 [8.1] specifies the German Reactor Safety Commission's recommendation on AM of 2004 [8.2] and is also considered to fulfil the related IAEA guidelines and WENRA safety levels [8.3].

[8.1] applies to the procedures of AM regarding the safety-related SSCs – including the respective auxiliary and operating media – that are specified in the licensing documents and operating instructions of German light water reactors in operation. Special emphasis is placed on physical ageing with consideration of newer findings with respect to ageing processes. [8.1] applies, furthermore, to the procedures of AM regarding the basic qualification and maintenance of competence and know-how of the personnel and, also, to the documentation and the data from information and operation management systems.

[8.1] specifies requirements for AM that encompass the technical and organizational measures with respect to an early detection of ageing phenomena relevant to the safety of nuclear power plants and to maintaining the actually required quality condition. The utility operating the nuclear power plant is to install a systematic and knowledge-based AM that is to be organized, documented, assessed and updated. Hereby, the following basic requirements are to be translated into practice:

- The scope of SCCs which are subject of AM are to be defined and documented;
- The procedures of AM are to ensure that safety-related relevant degradation mechanisms are identified;
- The causes and/or effects of these degradation mechanisms are to be mitigated by proper measures;
- The development of SOAR regarding ageing-related findings is to be pursued and assessed;
- The measures taken with respect to AM and the respective results are to be documented and assessed. A plant specific basis report is to be drawn up. Furthermore, status reports are to be drawn up in yearly intervals;
- Concerning SCCs, the Basis Report is normally to comprise information regarding the following aspects:
    - o Description of the technical and administrative procedures;
    - o Structure of the knowledge base;
    - o Pursuing and evaluating ageing-related findings (state of science and technology, experience feedback);

- o AM of the SSCs including auxiliary and operating media (scope and classification of SSCs, potential degradation mechanisms, measures to control these mechanisms, effectiveness monitoring).

– A status report is normally to contain quantitative and qualitative information gathered within its respective reporting period on ageing-related activities and measures as well as findings and results from in-plant surveillance and from external sources. This includes e.g. special examinations performed, insights gained from information notices and from modifications of standards. A status report is to contain a summarizing assessment of the effectiveness of AM and of the quality or changed quality of the SCCs. Any modifications of the AM are to be documented;

– AM is to be continuously optimized based on the performed assessments. Impermissible deviations from the required quality condition are to be eliminated;

– The AM is to be translated into practice in a process-oriented way and is to be integrated into the operational procedures. It is to be part of an integral management system. The processes involved (e.g., in-service inspections, maintenance), the intertwined activities as well as the mutual interactions are to be identified, directed and controlled. This overall process is to be designed in accordance with the principles of a PDCA-cycle;

– The AM is to be performed on the basis of a structured knowledge base. This knowledge is to contain sufficient information on the design, on the ageing-related requirements in codes and standards, on the design and manufacture as well as operating history of the SSCs, on the potential relevant degradation mechanisms and, with respect to the relevant degradation mechanisms, the monitoring, examination and mitigation measures including assessment of the results;

– In case certain ageing effects are detected in non-safety-relevant SSCs that are applicable to similar SSCs considered within AM, these findings are normally, e.g. within the framework of the internal experience feedback, to be integrated into the AM.

REFERENCES TO SECTION 8

[8.1] NUCLEAR SAFETY STANDARDS COMMISSION, (Kerntechnischer Ausschuss - KTA) Ageing Management in Nuclear Power Plants, KTA Standard 1403, KTA, Germany (2010).

[8.2] REAKTOR-SICHERHEITSKOMMISSION (RSK)-Recommendation: Management of Ageing Processes at Nuclear Power Plants, of 22.07.2004 (374th Meeting), RSK, Germany (2004).

[8.3] WESTERN EUROPEAN NUCLEAR REGULATORS' ASSOCIATION (WENRA), WENRA Reactor Safety Reference Levels, WENRA Reactor Harmonization Working Group, WENRA (2001).

9. HUNGARY

9.1. NATIONAL REGULATORY REQUIREMENTS FOR LONG TERM OPERATION AND AGEING MANAGEMENT

9.1.1. Bases of nuclear regulation.

The national requirements for nuclear safety form a pyramid of legal documents, the first three levels are mandatory of them:

- The Atomic Energy Act (CXVI. 1996) [9.1];
- Government Directives (118/2011 [9.2] and 37/2012 [9.3]);
- Nuclear Safety Regulations (NSR) (as annexes to 118/2011) [9.4];
- HAEA Regulatory Guidelines;
- Internal documents of the HAEA and licensee.

9.1.2. Licensing process for LTO.

A basic feature of the Hungarian nuclear safety regulations is that the license for NPP operation is valid for a limited time, issued for the design lifetime of the plant. For Paks NPP this is 30 years, although some structures and components have design lifetime longer than this.

The Hungarian legislation for LTO was developed through adopting the relevant requirements and guidance of the IAEA and international best practice. The HAEA adopted some basic elements of U.S. NRC 10 CFR Part 54 [9.5] for the regulation of licence renewal (LR). According to Volume 1 of the NSR, the operation can be continued beyond the licensed term – i.e. the design lifetime – if the licensee obtains an operating license for the term of extension of the operation.

In the Hungarian regulatory framework, control of compliance with the current licensing basis is maintained via:

- FSAR, and its annual update;
- PSR every ten years;
- Other regulatory tools, including the maintenance effectiveness monitoring (MEM), inspections, review of AM activities etc.

Regulatory guidelines related to LTO in general are:

- Guideline 1.28 on regulatory process of the license renewal [9.6];
- Guideline 4.14 on preparation of the long-term operation [9.7].

License renewal itself is a two-step process:

Step one is the development of the LTO programme (on the base of Guideline 4.14.) [9.7]. The LTO programme has to be submitted to the regulator at least four years before the design life is due to expire, but not earlier than 20 years of operation left.

The second step is the formal license application (on the base of Guideline 1.28) [9.6]. This has to be submitted one year before the design lifetime is due to expire.

As in many other European countries, the PSR is an important element of Hungarian regulation, but it is not part of the Hungarian LTO licensing process. The PSR is a self-assessment and reporting obligation of the licensee. It is performed every 10 years primarily to assess the overall ageing of the plant SSCs on a time scale broader than the routine daily or even yearly checks. The broader time scale allows the reviewers to better take into account the development of science and technology in relation to safety and ageing. PSR is considered the main method for identifying the need for any safety upgrade measures.

9.1.3. Regulation of Ageing Management.

Activities related to AM are determined by the NSR and the accompanying regulatory guidelines. These requirements are in line with the international practice and guidelines (e.g. NUREG 1801). Regulatory Guidelines related to AM in general are:

- 1.26. Regulatory supervision of ageing management [9.8];
- 3.13. Ageing management issues in the design phase of a NPP [9.9];
- 4.12. Ageing management during the operation of a NPP [9.10].

The licensee has to ensure the required condition of the plant and the intended safety functions via plant programmes, i.e., maintenance, AMPs, programmes maintaining the qualified status of equipment, scheduled replacements and reconstructions.

The licensee has certain freedom and flexibility in application of these programmes. The licensee should continuously demonstrate the ability of SSCs to fulfil required safety functions is maintained. The demonstration of fulfilment of safety functions may be through safety analysis (e.g. TLAA), environmental qualification (EQ), AM or MEM, or by a combination of them.

The basic objective of AM is to maintain the safety of the passive SSCs with safety function by managing ageing phenomena. For SSCs subject to ageing effects, this is realized by identification of degradation mechanisms, detection of ageing effects, evaluation and trend analysis, and introduction of preventive measures or retarding actions. When developing an AMP, IAEA NS-G-2.12 [9.11] was taken into account, as well as US GALL Report [9.12], with ten generic attributes for AMP reviews.

According to Guidelines 1.26 AM should be implemented as minimum for:

- High priority mechanical components (e.g. RPV and internals, pressurizer, SG, MCP, etc.);
- Other mechanical components (e.g. feed-water lines, ECCS hydro-accumulators, HP ECCS pumps, sprinkler system pumps etc.);
- Building structures (e.g. reinforced concrete in the hermetic containment compartments, shafts, machine bases, metal support structures etc.);
- Cables and certain electrical components.

9.1.4. Regulatory bases for Time Limited ageing analyses.

TLAAs are plant-specific safety analyses based on an explicitly assumed period of plant operation. They are an essential part of the LTO evaluation. The review and validation of TLAAs for the extended period of operation is a required element in the justification for license renewal. According to Hungarian regulation, TLAAs are analyses which:

- Are necessary to maintain the safety of the installation, and/or to demonstrate the maintenance of function of SCs in accordance with the legal and regulatory requirements;
- Demonstrate for a given SC that its required safety functions and performance can be ensured (for a specific limited time) under stresses that could occur during normal operation, anticipated incidents and design basis accidents.

According to Guideline 1.28, the applicant for LTO has to demonstrate that:

- The analysis remains valid for the period of LTO;
- The analysis has been projected to the end of the period of LTO; or
- The effects of ageing on the intended function(s) will be adequately managed for the period of long-term operation.

Existing TLAAs need to be reviewed and revalidated with the assumed new (extended) period of plant operation. The evaluation of each identified TLAA should demonstrate that the safety function of the SC will remain within design safety margins throughout the period of LTO.

9.1.5. Scoping and screening for AM and LTO.

9.1.5.1. Methodology for scoping SSCs for LTO/LR

According to the regulatory requirements, the scope of LTO/LR (licensing renewal) include Safety Class 1-3 components, and non-safety class components (“SC+”) whose failure may occur due to unmanaged ageing and which may jeopardize safety class components.

The first step of determining the LR scope is the system-level scoping process. The next step of component-level scoping is based on technological schemes, and tables for each mechanical technological system. The component lists are compared with the LR scope components in the technical database. The non-safety class components within the scope are verified by walk-down.

The basic method for determining cables in the LR scope is the analysis of data from the cable database. This database contains the main data, paths and connected equipment for the cables. Cables are assigned to safety systems according to their designations and the connected equipment. The safety function of cables is determined through fire and electrical circuit analysis.

To determine the LR scope of buildings and structures, the base map of the plant showing all the buildings is used, and safety classification assigned to each building and structure is the base to scope.

9.1.5.2. Selection of components to be managed by AM, EQ and MEM

In accordance with regulatory requirements, the availability of the SSCs to fulfil the safety function should be ensured and demonstrated for components within the LTO/LR scope. According to the regulation the licensee may choose the method of ensuring the intended safety function and the demonstration of performance. There is a basic rule, i.e., the method selected depends on whether the SSC fulfils its intended safety function in active or passive way. The maintenance and MEM is only used for active components, while AM is used for the passive ones. EQ can be applied to both active and passive components, and, in case of harsh environment it is an essential mean of demonstration.

9.1.6. Ageing management programmes.

To comply with Guidelines 4.12, Paks NPP should have an integrated AMP. Since the number of SSCs is very large and the ageing mechanisms are also numerous, the AMPs are be structured for ensuring the proper management of the activities.

9.1.6.1. Types and contents of the AMPs

In case of mechanical components there are two types of programmes: degradation-type programmes and component-specific programmes.

In case of civil structures practically the same idea is applied. However the basic programmes (called A-type programmes) are developed either for typical structural elements, members or degradation mechanism. Ageing of complex civil structures that are composed from different structural elements are managed via frame programmes (called B-types programmes) built up from the basic programmes.

AMPs for mechanical components: The degradation type ageing management programmes (DTAMPs) define the way, how to manage the ageing caused by the degradation mechanism. These programmes also comprise the fundamentals of the degradation mechanism, the available scientific results related to the mechanism, a summary of national and international experience.

DTAMPs are developed for 19 degradation mechanism of mechanical components, listed in Guidelines 1.26, e.g., for low-cycle fatigue, thermal ageing, irradiation damage, stress corrosion, boric acid corrosion, wear, irradiation-assisted stress corrosion, swelling, erosion-corrosion, microbiological corrosion etc.

Component specific ageing management programmes (CSAMPs) are developed for mechanical components (e.g. RPV, Pressurizer, SG, MGV, MCP etc.) or commodity groups of mechanical components, cables and certain electrical components selected on the base of Guideline 1.26. CSAMPs based on DTAMPs and contain 10 attributes of AMPs.

Commodity groups are based on the approach (according to guideline 1.26.), that during the development of the AMPs, it is permissible to group components within the scope of AM if it can be justified, that the ageing of the components in the group is similar. The grouping is based on a characteristic of the components (e.g. material, environment, operating parameters or construction). Passive mechanical components in the scope of AM are grouped as heat exchangers, vessels, pipeline elements, appliances, pumps, valves, filters and special equipment.

AMPs for civil structures: AM of civil structures at Paks NPP is based on two types of AMP. Basic programmes (type "A") are used for the typical structural elements, members (structural commodities) from which the complex buildings or structures of the plant are built, or for some general ageing processes such as settlement. These programmes are developed through the identification of the structural elements, ageing mechanisms and locations (similar to DTAMPs for mechanical components).

AMPs of type "B" are used for complex buildings and structures of the plant. These identify the ageing effects and mechanisms to be managed, and give lists and details of the proper application of type "A" AMPs to be used, while managing the ageing of the given building. The type "B" AMP also contains logistical information, how to perform the actions defined by the programmes, e.g., the accessibility of certain buildings (similar to CSAMPs for mechanical components).

AMPs for cables: Environmental qualification and/or AM is clearly an essential task regarding safety functions of cables. The basic approach for justifying, that cables are operable over the extended 20 years of operation is the environmental qualification. In some cases environmental qualification is not possible for a group of cables, because of the cables' allowable operational parameters. In these cases AMP is implemented.

AMPs for electrical components: For some electrical-related equipment and structures AMPs are introduced for:

- The holding frame and casing of cabinets, relay panels and other E&IC boxes;
- Cable trays and supporters;
- Base structures of rotating machines;
- Fire barriers between the cable rooms;
- Phase buses and insulators of distribution cabinets (several programmes for different types);
- PVC insulated cables (also the target of EQ);
- Other types of cables (fibre optic, XLPE, etc.)

According to Hungarian regulations AMPs are developed to cover each of these commodities, following the 10 attributes of AMPs.

9.1.6.2. Ageing management monitoring system

The AM of high priority mechanical components requires handling data from many sources related to different aspects of design, operation, maintenance and inspection. The concept of the Data Acquisition and Analysis System for Ageing Management (DACAAM) is based on the concept of providing the most frequently used data from the AM activities to operational personnel in a structured form and facilitating its retrieval for further processing and assessment.

The objectives of the DACAAM application are derived from the basic requirement of the AMP to assess and evaluate data in order to justify LTO. These data need to be retained for the life of the plant. The DACAAM system has also been developed to provide easy-to-use data collection and record-keeping tools required by AM activities.

AMPs of commodity groups are supported by plant technical database, based on enterprise asset and work management system (Asset Suite).

Review of AMPs for LTO: The plant's AMPs may be credited for use in LTO provided that they meet the evaluation criteria for the adequacy of plant programmes regarding LTO/LR. These programmes have to be reviewed and the adequacy of each has to be demonstrated, along with the adequacy of the whole system of programmes, its acceptability and completeness.

The review and qualification of the AMPs is made according to the standard '10 attributes'. The conclusions of the review are documented in the documentation for justification of the application for LR.

Preliminary review of AMPs was performed while developing the Programme for LTO. Some existing programmes were qualified as adequate, and requirements for modifications or development of new programmes were identified. These modifications or new programmes were implemented during the Programme for LTO. The full-scope and comprehensive AMP review is completed for the LR application, taking into account recent achievements and experiences.

Management of obsolescence: Conceptual (design) aspects of obsolescence are subject of PSR. The information or indicators for different aspects of obsolescence (moral ageing, difficulties in spare part managements) are collected from the experience gained while performing maintenance and MEM, or implementing other plant programmes.

The obsolescence issue is managed by scheduled replacement and reconstruction programmes.

Examples are the replacement of reactor protection system, high-pressure preheaters, turbine condensation tubing, etc. Example for management of the preparation of scheduled reconstruction is the preparation of process control reconstruction. The need for reconstruction has been identified via collecting and analysis of operational and maintenance data. The preparatory work has been made and managed by dedicated group of experts, that has been overseen by I & C Expert Board.

Paks NPP performed during last twenty years several safety enhancement projects that involve also replacement of obsolete systems and equipment.

Although the obsolescence issue is part of scheduled replacement programme and related mainly to the active replaceable systems and components, some aspects of obsolescence have already been accounted in the AMPs. Procedures connected to AMPs are in place to provide for the availability of:

- Documentation to support SSC maintenance and replacement;
- Required technical support;
- Sufficient spare parts.

9.1.7. Revalidation of time limited ageing analyses for LTO.

9.1.7.1. The scope of the TLAAs

The scope of TLAAs can be derived from the Guidelines related to LR: Guideline 1.28 on the licensing procedures for LTO and Guideline 4.14 on the activities to be implemented by the operating organization to support LTO and LR. Guideline 4.14 provides a minimum scope for TLAAs.

The scope of the TLAAs is identified according to Guideline 4.14, i.e. taking into account the requirements of the CLB analyses needed for ageing processes that may limit the intended safety function, or that are relevant in determining safety.

9.1.7.2. Methodology for revalidation of TLAAs

According to the Guideline there are three possibilities for validation of the TLAAs:

– To extend the validity of the existing TLAAs;
– To replace the conservatism used in the original TLAA analysis by less conservative assumptions and methods for analysis. (This practically means performing a new analysis.);
– To demonstrate that measures will be introduced during the extended service life that will control the ageing processes and assure the intended safety function.

In the LR application all TLAA analyses are revalidated for 30+20 years of operation with 10 years reserve.

REFERENCES TO SECTION 9

[9.1] Hungarian Parliament: The Atomic Energy Act (CXVI. 1996).
[9.2] Hungarian Government Directive 118/2011.
[9.3] Hungarian Government Directive 37/2012.
[9.4] Hungarian Government: Nuclear Safety Regulations (NSR) (as annexes to Government Directive 118/2011).
[9.5] 10 CFR Part 54, Office of the Federal Register, National Archives and Records Administration (2009).
[9.6] HAEA Guideline 1.28 Regulatory process of the license renewal (2013).
[9.7] HAEA Guideline 4.14 Preparation of the long-term operation (2013).
[9.8] HAEA Guideline 1.26. Regulatory supervision of ageing management (2007).
[9.9] HAEA Guideline 3.13. Ageing management issues in the design phase of NPP (2007).
[9.10] HAEA Guideline 4.12. Ageing management during the operation of NPP (2013).
[9.11] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna (2009).
[9.12] UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned (GALL) Report, NUREG-1801, Revision 2, USNRC, December 2010.

10. INDIA

10.1. RATIONALE FOR AGEING MANAGEMENT

AM deals with the identification of age related degradation and corrective measures to ensure safety. Considerations for AM of NPPs starts right from siting and continue through the stages of design, construction and commissioning. Implementation of AMP enables acceptable safety performance during operating phase and extended phase of operation. Special attention is required during the extended phase of operation such as time limited ageing assessment and corrective actions.

Existing programmes relating to various activities and management of NPP (operation, maintenance [10.1], in-service inspection [10.2], surveillance [10.3] and radiological protection) for safe operation are detailed in safety guides. AM addresses issues like understanding, predicting and detecting effects of ageing and corrective/ mitigatory actions for age related degradations. It provides feed back to the designers, manufacturers, and operating organization regarding the need for effective AM of SSCs and related improvements at different stages of NPP life cycle.

Considerations in formulating the AMP of NPP include:

- Degradation of plant SSC caused by a combination of ageing mechanism and premature degradation during various phases of plant life;
- Understanding the role of service environment and various degradation mechanisms in causing premature ageing and improving Operation and Maintenance practices for minimizing degradation;
- Up-gradation of safety levels to the extent feasible with increase in knowledge and improvement in technology.

10.2. REGULATORY APPROACH

In India the regulation of issues related to continued safe operation and ageing of SSCs of NPPs as well as safety upgrading/improvements is addressed through the instrument of PSRs introduced in the year 2001. A PSR is carried out once in ten years as per safety guide on renewal of authorization for operation of NPPs [10.4, 10.5] during design lifetime. Well before (at least 5 years) the end of design life, a license renewal for further period of operation (beyond design life) is to be applied as per guidelines given in this safety guide.

The basic objective of review of AM in PSR is to determine whether ageing in a nuclear power plant is being effectively managed so that required safety functions are maintained, and whether an effective AMP is in place for future plant operation.

The review of AM as part of PSR aims to establish whether:

- For each SSC important to safety, all significant ageing mechanisms are identified;
- There is thorough understanding of the relevant ageing mechanisms and their effects;
- Ageing behaviour of SSCs over period of operation is consistent with the predictions;
- There are adequate margins in respect of ageing, to ensure safe operation for at least

the period until the next PSR;
- There is an effective AMP in place for future long term plant operation.

Regulatory documents on AM of NPPs are listed below and are available at website (www.aerb.gov.in):

- AERB/SG/D-1;
- AERB/SG/O-7;
- AERB/SG/O-14;
- AERB/SG/O-12;
- AERB/SM/CSE-1;
- AERB/SM/CSE-2;
- AERB/NF/SM/CSE-3.

10.3. AGEING MANAGEMENT PROGRAMME

The AM activities of an NPP are carried out in two distinct phases:

- Pre-operational phase includes siting, infrastructure development at site, design, manufacture of equipment and components, construction and commissioning. Pre-operational tests of all SSC including initial failures and corrective actions form base-line data for life management;
- Operational phase has a life span of 30 to 40 years and may be extended for further maximum period of 20 to 30 years in phases of 5 years based on appropriate life extension programme, regulatory review and license renewal.

The AERB Safety Guide on Life Management of NPPs [10.6, 10.7] recommends an approach considering safety classification and seismic categorization of SSCs as outlined in AERB Safety Guide [10.8]. The criterion for selection of SSCs for AMP considers their importance to safety besides production reliability and overall economics. The SSCs or group of SSCs short listed based on their importance to safety are further assessed/reviewed, to cover the following aspects: (i) Understanding ageing; (ii) Monitoring ageing; (iii) Management/ mitigation of ageing effects.

To realize objectives of LTO, the AMP of NPPs addresses the following:

- Understanding and development of knowledge of ageing-related degradation mechanisms and relating the consequences of damage mechanisms in terms of behaviour of materials and SSCs;
- Ability to predict/ extrapolate SSC behaviour up to a defined timeframe;
- Methods for detection and surveillance of ageing degradation;
- Measures for mitigation, repair and replacements;
- Optimization of AMP based on current understanding and knowledge;
- Documentation to facilitate periodic review & assessment based on new information.

REFERENCES TO SECTION 10

[10.1] AERB Safety Guide No. AERB/NPP/SG/O-13: Operational safety experience feedback on nuclear power plants, Mumbai (2006).

[10.2] AERB Safety guide No. AERB/NPP/SG/O-2: In-service inspection of nuclear power plants, Mumbai (2004).

[10.3] AERB safety Guide No. AERB/SG/O-8: Surveillance of items important to safety in nuclear power plants, Mumbai (1999).

[10.4] AERB Safety Guide No. AERB/SG/O-12: Renewal of authorization for operation of nuclear power plants, Mumbai (2000).

[10.5] IAEA Safety Standards Series No. NS-G-2.10: Periodic safety review of nuclear power plants, Vienna (2003).

[10.6] AERB Safety Guide No. AERB/NPP/SG/O-14: Life management of nuclear power plants, Mumbai (2005).

[10.7] IAEA Safety Standards Series No. NS-G-2.12: Ageing management for nuclear power plants, Vienna (2009).

[10.8] AERB Safety Guide No. AERB/NPP-PHWR/SG/D-1: Safety classification and seismic categorization for structures, systems and components of pressurized heavy water reactors, Mumbai (2003).

11. JAPAN

11.1. INTRODUCTION

In response to the accident at Fukushima Daiichi NPS, the Nuclear Regulation Authority (NRA) was established in September 2012, integrating nuclear regulation functions regarding nuclear safety, security, safeguards, radiation monitoring and radioisotopes, and the Reactor Regulation Act was revised for the purpose of introducing new regulations based on 'lessons learned' availability of the latest technical knowledge, as well as trends of overseas regulations, including requirements developed by international organizations such as the International Atomic Energy Agency (IAEA). The main points of the revision include:

- Strengthening countermeasures against severe accidents and terrorism;
- Back-fitting: NRA can issue an order to comply with new regulatory requirements even to existing nuclear plants without exception;
- Limit of the plant lifetime: Up to 40 years one time extension up to 20 years.

As of 1st September, 2013, the number of the units in service is 50, 26 units for BWR and 24 units for PWR. 17 units of them are in LTO beyond 30 years, and 3 of them, one BWR and two PWRs, are in LTO beyond 40 years.

11.2. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

To strengthen the nuclear safety regulation, the Act [11.1] and the Rule [11.2] were revised. The NRA was officially inaugurated on 19 September, 2012. The new nuclear safety regulations including Guide for Pre-service inspection, Facility Periodic Inspection and Periodic operator's inspection [11.3], Guide for an approval system for the extension of operational periods [11.4] and Guide for Ageing Management Implementation [11.5] by the NRA went into effect on 8 July, 2013. The operating life of power reactors was set at 40 years, but subject to approval, this can be extended once only for a further maximum 20 years (Operational period extension approval system). Furthermore, it was decided to require the maintenance programme for the extended period to be included in application of the extension of operational periods, paying particular attention to preventative measures against ageing. Regarding commercial power reactors which have been in operation for thirty years or more, decennial ageing management technical evaluation (AMTE) and preparation of a long term maintenance programme (LTMP) are already required, based on the Reactor Regulation Act [11.1] and Rule [11.2] (Ageing management system). This has been one of the requirements for approval of safety measures (system for responding to facility ageing). These two systems are applied to nuclear power plants to be 40 years after commissioning integrally.

11.3. REVIEW FOR THE EXTENSION OF OPERATIONAL PERIODS

Operational period extension approval system was introduced on 8 July, 2013. This system is to set the original operational period of nuclear power reactors to be 40 years after commissioning and to permit extension of the period only once when it is approved by NRA before expiration of the 40-years period. The maximum extension period is 20 years, and the specific extension period for each reactor is determined by the results of NRA's review. New requests in the new system are as follows:

- Back-fitting: At the time of the approval for operational period extension, all the structures, systems and components (SSCs) shall meet the effective technical standards specified by the ordinance of the NRA;
- Special Safety Check: Special safety check is required to understand the condition of the SSCs important to safety which have not been inspected or of which only a representative location or part have been checked so far in terms of ageing effect within the maintenance programme. The SSCs in scope are examined with the method that can directly detect or observe ageing effects or indications.

11.3.1. Examples of special safety check on PWR and BWR.

- PWR
  - RV; Ultrasonic Test (UT) of core belt zone (100% of Weld and Base metal)- PT or ECT of Primary water Nozzle corner, MVT-1 of BMI (Outside), ECT of BMI (Inside);
  - PCV; Visual Test (VT-4) of Steel surface- Core sampling of pre-stressed concrete (Check strength, Effect due to radiation irradiation (neutron, gamma-ray), Salt penetration and Alkali-aggregate reaction, High-temperature, Carbonation, etc.);
  - Civil structures; Core sampling of concrete (check strength, effect due to radiation irradiation (neutron, gamma-ray), Salt penetration and Alkali-aggregate reaction, High-temperature, Carbonation, etc.)
- BWR
  - RPV; UT of core belt zone (in accessible area of Weld and Base metal)- MT or PT or ECT of Primary water Nozzle corner, MVT-1 (Outside) and PT or ECT (Inside) of CRD Stub tube, CRD housing, ICM, housing, DP/LC Nozzle;
  - PCV; Visual Test (VT-4) of Steel surface- Core sampling of RCCV concrete (Check strength, Effect due to radiation irradiation (neutron, gamma-ray), Salt penetration and Alkali-aggregate reaction, High-temperature, Carbonation, etc.);
  - Civil structures; Core sampling of concrete (Check strength, Effect due to radiation irradiation (neutron, gamma-ray), Salt penetration and Alkali-aggregate reaction, High-temperature and Carbonation etc.)
- Review of ageing management: It is required to carry out an AMTE to ensure the implementation of appropriate AM through the period of extended operation. In addition, development of a LTMP based on the AMTE is required for extended operating period for approval of the standard technical specification.

11.3.2. Review of ageing management for LTO.

AM system in Japan is to re-evaluate reactor facilities which are passing through 30 years after operation subject to SSC's degradation evaluation and making the LTMP to be submitted the NRA for approval and implementing this maintenance programme based on the standard technical specification.

Due to the enforcement of revised Act [11.2] on 8 July, 2013 and the revision of Safety standards related to AMTE, the NRA revised AM implementation guide for nuclear power generation equipment and the review guideline for AMTE. In response to these revisions, the Japan Nuclear Energy Safety Organization (JNES) revised AMR manuals for AMTE [11.6]. It defines the point and the procedure of JNES's review on AMTE report which describes technical bases of LTMP in applicant's AMPs. The manual consists of the parts on the six major ageing mechanisms (low-cycle fatigue, neutron irradiation embrittlement, irradiation assisted stress corrosion cracking, thermal ageing embrittlement of cast austenitic stainless steel, insulation degradation of electric and instrumentation equipment, reduced strength and shielding performance of concrete) and safety review of seismic and tsunami.

Seismic safety evaluation and Tsunami resistant safety evaluation were consolidated as follows:

- Seismic safety evaluation: Seismic safety of SSCs is evaluated by using the seismic forces corresponding to the seismic importance class in consideration of ageing mechanisms/effects of components and structures subject to evaluation;
- Tsunami resistant safety evaluation: Tsunami resistant safety is evaluated for the structures and components installed to protect facilities from Tsunami, such as tide embankments, tide barriers and water tight doors, by using the forces (inundation height, wave power, etc.) caused by the design basis Tsunami in consideration of ageing mechanisms/effects of components and structures subject to evaluation.

In an AMTE report, ageing effects or mechanisms that should be considered in the AM during LTO are identified by an applicant in reference to the set of summary sheets of ageing mechanisms [11.7], which has been compiled based on the latest findings, knowledge and operating experience obtained from the 17 units that had completed the AMTE by October 2009, and is comprehensive lists of specific ageing mechanism or effect expected to occur in each SSC in nuclear power plants.

Progress of ageing effects on each SSC, at least for the six mechanisms specified in NRA guide and JNES manual mentioned above, are evaluated for the period of extended operation, and LTMP is developed to be incorporated into maintenance programme. Other ageing effects than the six that can be properly managed in the maintenance programme are not necessary to be subject to the evaluation.

In the second and subsequent AMTE (i.e., AMTE at 40 and 50 years), the evaluation in terms of the following items is required to be carried out.

- Verification and comparison between the results of the ageing evaluation at the previous AMTE and operating experience after the AMTE & the latest technical knowledge/safety study;
- Evaluation of the effectiveness of the LTMP developed based on the previous AMTE.

11.3.3. Management of obsolescence.

For obsolescence of the AM system, it was decided to be reflected in the existing all facilities without exception to the latest regulatory requirements by the back-fitting requiring compliance with regulatory guides even existing nuclear plants without exception. In addition, to achieve improved safety of nuclear facilities continuously, it was required that NRA conducts a safety comprehensive assessment (Final Safety Analysis Report; FSAR). The operator shall publish and deliver a FSAR to the NRA from end of 2013.

11.3.4. Basic strategy for ageing management.

The Japanese basic strategy to keep safety and reliability of nuclear power plants for LTO is based on major safety research fields as follows:

- Establishment of information basis for AM;
- Verification for evaluation methodologies of ageing mechanism, inspection techniques, and repair or replacement technologies;
- Consolidation of codes and standards;
- International collaboration.

Continuous revision of Strategy Maps [11.8] for AM and Safe LTO has been performed to promote safety research activities effectively and efficiently. Systematic establishment of the information basis for database and knowledge-base has been performed in addition to the consolidation of codes and standards through the intensive domestic safety research collaborations and international collaboration. Since LTO is the operation beyond the initial design, the technical base for safe continued operation against ageing has to be established through safety research. The safety researches on ageing endorsed by the government were started in 1980s, scaled-up in 1990s, sophisticated on the 'Research and Development for AM for Safe LTO' coordinated with industries, research organization and regulatory institutes from 2005 to 2010 for enhancing technological information infrastructure in the 'National Project on Ageing Management and Maintenance of Nuclear Power Plants', and from 2011 to 2015 for 'Japan Ageing Management Programme on System Safety of Nuclear Power Plants'. The government requested licensees intending LTO to make comprehensive technical review of ageing based on these safety research results to establish LTMP.

REFERENCES TO SECTION 11

[11.1] The Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166 of 1957).

[11.2] The Rules for Commercial Nuclear Power Reactors concerning the Installation, Operation, etc. (Ordinance No.77 of the Ministry of International Trade and Industry, 1978).

[11.3] Guide for Pre-service inspection, Facility Periodic Inspection and Periodic operator's inspection on the Rules for Commercial Nuclear Power Reactors concerning the Installation, Operation, etc. (No.13061923, 19 June, 2013).

[11.4] Guide for an approval system for the extension of operational periods on the Rules for Commercial Nuclear Power Reactors concerning the Installation, Operation, etc. (No.1306197, 19 June, 2013).

[11.5] Guide for Ageing Management Implementation on the Rules for Commercial Nuclear Power Reactors concerning the Installation, Operation, etc. (No.1306198).

[11.6] Japan Nuclear Energy Safety Organization (JNES), Review Manual for Ageing Management Technical Evaluation, JNES-RE-Report Series, JNES-RE-2013-0000.

[11.7] Atomic Energy Society of Japan (AESJ), AESJ-SC-P005E:2008, Code on Implementation and Review of Nuclear Power Plant Ageing Management Program:2008.

[11.8] Japan Nuclear Energy Safety Organization (JNES), Technological Strategy Map for Ageing Management 2009.

12. MEXICO

12.1. APPROACH TO AGEING MANAGEMENT OF MEXICO

Comision Federal de Electricidad (CFE) is the Mexican Federal Government company responsible for the construction and operation of nuclear power plants, has two 810 MWe BWR-5 units. Unit 1 has been operating since July 1990 and Unit 2 April 1995; both units were designed by General Electric (GE) the Nuclear Steam Supply System (NSSS) and turbo group by Mitsubishi, the architect engineer was EBASCO (now URS International). Laguna Verde Plant is located in Veracruz State at 72 kilometres from Veracruz City and 380 Km from Mexico City and was designed under ASME code and standards from the NSSS origin country which is United States of America, so the applicable regulation to Laguna Verde is from that country.

The original power licensed was 670 MWe and in 1998 there was a first power up rate increasing 5% from the original power and during 2007 to 2011 was prepared and performed the extended power up rate increasing 15% more, to obtain a 20% from the original power, during that work were replaced some major equipment and re-evaluated the NSSS portion.

Pursuant the American regulation (10 CFR 50) the operation license should be issued for 40 years, however both units were licensed for 30 years, with this situation Laguna Verde 1 will reach the end of its license in 2020, because of that, LV has started the process for applying the License Renewal evaluation. Also partial PSRs using the IAEA safety guide NS-G-2-10 has been conducted for both units (one per unit) as was required for the Mexican Regulatory Body CNSNS (Comision Nacional de Seguridad Nuclear y Salvaguardas).

For safety related systems and other connected systems, AM has been established through the operational life of the plant, mainly for the standards and regulatory requirements, like the inspection programmes based on ASME code, surveillances and monitoring requested by BWRVIP programme, and some special programmes for vessel internals stress corrosion cracking mitigation (SCC) through chemistry and inspection programmes, flow accelerated corrosion for high energy systems (FAC), erosion-corrosion of low energy and service water systems, microbiologically influenced corrosion (MIC) for secondary cooling systems. Regarding the obsolescence issue Laguna Verde has an ongoing programme to replace and refurbishment the obsolete equipment as meteorological monitoring system, rad-waste system, simulator and process information system, process buildings elevators, main switchgear electrical protections, etc. previous evaluation and prioritization process [12.2, 12.3, 12.4, 12.5].

As was mentioned before, Laguna Verde is in a process of preparation for license renewal. Actually the first phase of the work has been done and components and structures in a scope of license renewal have been determined. This scoping was performed based on 10CFR54.4 (a) (1), (2), and (3) criteria [12.1, 12.10, 12.11] which means:

- 10CFR54.4 (a) (1): All safety related components and structures as is defined by regulation;
- 10CFR54.4 (a) (2): Non Safety Related components and structures whose failure could prevent the safety related function of components determined before;

- 10CFR54.4 (a) (3): Components and structures to perform functions in compliance with any of following regulatory requirement: Fire Protection (FP), Environmental Qualification (EQ), Anticipated Transient Without Scram (ATWS) and Station black out (SBO).

The AMR is currently in process for those components and structures selected and the AMPs required. A comprehensive review of the existing activities for ageing control and the internal operation experience, is being started in order to establish which of them meet the GALL criteria and which should be enhance or generated as a new programme and if there is a specific ageing effect that should be addressed by plant specific programme [12.5, 12.7,12.8, 12.9].

Additionally it is being started the Current Licensing Basis documents review for identifying the specific Laguna Verde TLAA [12.8, 12.10, 12.11], and evaluate their applicability during the extended operation term. The license renewal work is expected to finish at the end of 2014 and submitting the License Renewal Application at the beginning of 2015 and the AMPs totally implemented during the following 5 years period.

REFERENCES TO SECTION 12

[12.1] 10 CFR 54 Requirements for Renewal of Operating Licenses for Nuclear Power Plants. Washington, D. C.: Nuclear Regulatory Commission.

[12.2] Guide for Prediction Long-Term Reliability of Nuclear Power Plants Systems. Structures and Components. Palo Alto, California; USA: Electric Power Research Institute. (December 2002).

[12.3] Plant Support Engineering: Obsolescence Management. Program Ownership and Development. (1016692). Palo Alto, California; USA.: Electric Power Research Institute. (November 2008).

[12.4] Safety Systems Obsolescence and Maintainability. Electrical Power Research Institute. Palo Alto, California, USA: EPRI. (May 2001).

[12.5] Life-Limiting Issues for Long-Term Operation of Nuclear Power Plants (1021115). Palo Alto, California, USA: Electric Power Research Institute. (November 2010).

[12.6] Non Class 1 Mechanical Implementation Guideline and Mechanical Tools R4 (1010639). Palo Alto, California; USA-: Electric Power Research Institute. (December 2009).

[12.7] Plan Support Engineering: License Renewal Electrical Handbook R1 (1013475). Palo, Alto California; USA: Electric Power Research Institute. (February 2007).

[12.8] NUREG-1801 Generic Aging Lessons Learned Report. Washington, D. C.: Nuclear Regulatory Commission, . (September 2005).

[12.9] Class 1 Structures License Renewal Industry Report R1 (TR-103842) Palo, Alto California; USA: Electric Power Research Institute. (July 1994).

[12.10] NUREG 1800 R2 Standard Review Plan for Review License Renewal Applications for Nuclear Power Plants, Nuclear Regulatory Commission, December 2010.

[12.11] NEI 95-10 R6, Industry Guideline for Implementing the Requirements of 10CFR54-License Renewal Rule, Nuclear Energy Institute, June 2005.

13. RUSSIAN FEDERATION

13.1. APPROACH TO AGEING MANAGEMENT OF RUSSIAN FEDERATION

The operational organization in the Russian Federation is the JSC ‘Concern Rosenergoatom’. It is responsible for all stages of life time of NPPs from choice of site for new units to their decommissioning. There are 33 power units of the NPP under operation in the Russian Federation. Useful life defined by design for these units was typically 30 years. After 30 years of operation, the prolongation of the useful life is carried out if it is economically rational.

The Russian regulatory body ‘Rostechnadzor’ (RTN) issues licenses for the power units operation within design defined term as well as beyond it. The basic document of RTN relating to the prolongation of the operation term is NP-017-2000 ‘Basic requirements to the prolongation of operation term for a power unit of NPP’.

The number of Standards of the operational organization (STO) was developed to support NP-017-2000. Recommendations of IAEA were also taken into account.

The arrangement of works for LTO is carried out according to the STO 1.1.1.01.006.0327-2008 ‘Prolongation of operational term for a power unit of NPP’. It determines the irreplaceable and non-restorable elements which determine service life of the power unit, namely:

- Mechanical components from the first on the fourth class of safety according to document of RTN NP-001 (OPB-88/97) ‘Common requirements for safety assurance of NPP’;
- Other elements from the first to the third class of safety according to NP-001 (OPB-88/97) which resource characteristics are not restored, are not supported or not supervised within the framework of existing maintenance system;
- Buildings and constructions important for safety;
- Graphite stacking and metal constructions of the reactor installations.

The standard describes performance of works in two stages. The first stage includes a complex of works for the estimation of the technical feasibility and economic reasonability of term prolongation. First stage begins eight to ten years before the expiration of the design defined term and includes the following basic works:

- Complex inspection of the unit;
- Estimation of safety of the unit;
- Making a volume and nomenclature of works on preparation of the unit to prolonged term of operation;
- Making an investment project of the unit LTO.

Based on results of the first stage, on the basis of the investment project, the operational organization makes a decision on preparation of the unit for LTO at least five years before the expiration of the design defined term.

The second stage includes a complex of works on the preparation of the unit to LTO. Second stage includes the following basic works:

- Development of the programme for preparation of the unit to LTO;
- Modernization of systems and equipment of the unit;
- Substantiation of term prolongation for non-restorable and irreplaceable elements;
- Profound (in-depth) estimation of the power unit safety.

A decision on operation beyond design defined term is made by results of the specified works (new term of unit operation is established). Results of works on prolonged term of operation are represented to RTN for getting the license for the further operation. The important part of works on LTO is the complex inspection of the unit.

Within the framework of the complex inspection it is carried out:

- The tentative estimation of a residual life of elements;
- Making a nomenclature of additional works according to the technical condition and residual life of elements;
- Making a list of programmes of management defined by resource characteristics of elements which are necessary for developing or modifying (if necessary);
- The technical feasibility estimation of the replacement of elements.

The tentative estimation of a residual life of elements is carried out on the basis of the analysis of the history of operation, requirements of the design documentation and the modern materials science. The specified analysis has to show that:

- Mechanisms of ageing are determined for all tested elements;
- Ageing management programmes are implemented (or there is an opportunity of its implementation);
- Ways of mitigation of ageing mechanisms are determined, if it is possible.

Additional works for maintenance of prolonged term for non-restorable and irreplaceable elements have to be focused on:

- Mitigation of damaging factors influence;
- Partial resource restoration for elements;
- Researches of the actual materials properties;
- Researches of the actual condition of critical zones of elements;
- Monitoring of the elements condition;
- Realization of calculations on durability (according to requirements of normative and methodical documents);
- Estimation of the residual operation life of elements.

The specified additional works have to be included in an investment LTO project and carried out at the second stage of a unit operation term prolongation.

Management of operating life characteristics of elements during LTO is carried out within the preventive scheduled maintenance service and repair.

14. SLOVAKIA

Slovakia has currently two nuclear power plants in operation. Bohunice 3&4 which were commissioned in 1984 and 1985 and Mochovce 1&2 commissioned in 1998 and 2000. Both plants are of a standard WWER-440 design, V-213 type.

14.1. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

Slovakia is a member of the IAEA, EU, OECD and other international organizations. Country's National Council approved the Act 541/2004 on peaceful use of nuclear energy (Atomic Act) on 9 September 2004 [14.1]. Requirements for AM are given by national safety guide BNS I.9.2/2001 'ageing management for the Slovak Regulatory Authority [14.3]. After issuing of country's nuclear authority safety guide No.II.5.X/2001 'Ageing management of nuclear power plants. Requirements.' in 2001, a project called 'Ageing management and lifetime optimization of nuclear power plants with WWER 440 units' had been introduced and, in collaboration with the research institute (VUJE) it has been completed within the period of 2002-2005.

LTO requirements are defined in Regulation No.33/2012 on PSR issued by UJD [14.2]. The regulation is in legal force since 1 March 2012. The objective of LTO licensing programme is to demonstrate that the relevant SSCs shall perform their safety functions in compliance with all the requirements throughout the entire LTO period which has been set forth to 60 years. All the documents required by the relevant legal basis [14.2] are to be submitted to the authority by 31 July 2013.

14.2. MANAGEMENT OF PHYSICAL AGEING

An AMP has begun to be systematically implemented under provisions of the NPP Bohunice environment since 1996, when the Safety Analysis Report after 10 years of Unit 3 & 4 operation had been submitted to the authority. Till then, the effects of known degradation mechanisms, of which various equipment and components are prone to, were assessed through the use of the existing particular programmes; e.g. RPVs' irradiation embrittlement was being monitored and evaluated by the use of standard design-built surveillance specimen programme me and by the use of neutron dosimetry, then fatigue of main primary components in critical locations as well as the evaluation of flow accelerated corrosion on wall thinning of secondary piping.

The basic document for AM in NPP is methodical guide 'Ageing management of systems, structures and components of NPP'. This document describes the entire AM process and shows how to manage the individual AMPs.

14.2.1. Objectives of AMP(s).

- Safe and reliable plant operation;
- Failure-free SSCs with to minimize the unplanned outages and maximize the maintenance efficiency;
- Maximal cost efficiency of electricity production;

- To build up environment and conditions for continued LTO (60 years) of the plant.

14.2.2. AMP Principles.

- Continuous monitoring of actual conditions of all safety relevant SSCs;
- Plant must be managed in a ‘gentle’ way to assure long term integrity of non-replaceable SSCs;
- Manage life, maintenance programmes and operating conditions of SSCs to optimize their remaining technical lifetime under lower bound of safety margins.

14.2.3. Performance of AMP(s).

1. Specification (list) of SSCs, which are necessary to be covered by AMPs;
2. AMP preparation, management, update including:

   - Basic description of SSC;
   - Identification of (ageing) degradation (mechanism);
   - Data collection and record keeping;
   - Assessment of a current condition of a SSC;
   - Corrective actions, operational feedback;
   - AMP update.

14.2.4. Management of obsolescence.

Management of obsolescence for AMP is performed by:

- Update of safety analysis report;
- Use of state-of-the-art knowledge about potential ageing degradation issues known/observed worldwide;
- Review of codes and standards;
- Identification of newly developed techniques, materials, designs.

14.3. SELECTION OF SYSTEMS, STRUCTURES AND COMPONENTS FOR LTO ASSESSMENT

Selection of SSCs for LTO is a very important process. It determines which plant SSCs will be included into scope for LTO assessment. The relevant list of SSCs shall strictly follow all the safety requirements of licensing authority (UJD) and IAEA recommendations.

The result provides the utility with list of short and long lived SSCs. Short lived SSCs are subject of relevant plant programmes (maintenance, EQ, etc.). Long lived SSCs are subject of relevant AMPs and time limited ageing analyses (TLAAs).

Safety classified SSCs or their parts in Slovak NPPs are divided into safety classes depending on their safety relevance and function in/of the system they are part of; and in accordance with a severity of their potential defect. The SSCs within the scope of LTO are those that perform the following safety functions:

- All SSCs important to safety that ensure the integrity of the reactor coolant pressure boundary;
- All SSCs important to safety that ensure the capability to shut down the reactor and maintain it in a safe shutdown condition;
- All SSCs important to safety that ensure the capability to prevent accidents that could result in potential off-site exposure or that mitigate the consequences of such accidents.

Other SSCs within the scope of LTO are those whose failure may impact upon the safety functions specified above.

All SCs within the scope of LTO and not subject to replacement based on a qualified life or specified time period are identified and included for further reviews for LTO.
Taking into account the above listed classification, the scoping follows the decision making process in which long lived SCs enters the screening process. The purpose of screening is to identify SCs whose degradation is managed by AMPs and evaluated by TLAAs.
Screening shall result in development of:

- List of AMPs that shall be verified;
- List of SCs for whose AMPs shall be developed;
- List of TLAAs whose validity shall be reviewed;
- List of SCs with no ageing effects identified (no TLAA needed).

14.4. REVALIDATION OF TIME LIMITED AGEING ANALYSES FOR LONG LIFE STRUCTURES AND COMPONENTS

Time limited ageing analyses (TLAAs) are plant specific analyses for the explicitly determined (or considered) time period. Time period does not always mean a direct service period; it may be represented by the limited number of loading cycles or duration of a specifically defined event. If the original designed life of a SC which is subject of the corresponding TLAA is at its end (or beyond) at the end of intended LTO timeframe, then such TLAA shall be reviewed and revalidated with respect to LTO. Obviously, number of new TLAAs which are to be initiated by the plant may emerge as a result of the review of the existing conditions. New analyses shall be performed in specific cases, or eventually it can be demonstrated that ageing effects on required SC functions are adequately managed throughout the entire LTO period. It is necessary to verify whether LTO do not generate the new TLAAs, which will have to be performed. All the steps of TLAA revalidation process are subject of the methodical guidance, which will be developed for that purpose.

14.4.1. New TLAAs.

In this specific case the review process shall identify measures that are needed to take for development of new analyses. The integral part of new TLAAs shall be the verification whether they will be effective and valid throughout the entire LTO period. In case of the unfavourable results of the review, corrective action(s) shall be proposed to ensure that the effects of ageing on the intended SC functions will be adequately managed throughout the entire LTO period, thus (demonstrably) assuring that the concerned TLAA is valid until the end of plant operating life.

14.4.2. Revalidation of existing TLAAs.

The existing TLAAs will be reviewed in two phases.
The objective of the review in the first phase is to determine whether all the existing analyses are valid until the end of plant design life. If it is shown that under existing conditions it is not possible to assure a safe operation of a particular SC by the end plant design life, then corrective action(s) shall be proposed to resolve a specific problem.

The objective of the review in the second phase is to determine whether all the existing analyses are effective and valid throughout the entire LTO period. Thus it must be determined that:

- Results guarantee the concerned SC availability (continuous performance of the intended safety functions) throughout the entire LTO period;
- The validity of original analysis can be extended to the intended plant LTO period.

In case of the unfavourable results which were obtained from the review of the existing TLAAs, corrective action(s) shall be proposed to ensure that the effects of ageing on the intended SC functions will be adequately managed throughout the entire LTO period, thus (demonstrably) assuring that the concerned TLAA is valid until the end of plant operating life.

14.4.3. Review of AMPs for long lived structures and components.

The purpose of the AMR is to verify whether the concerned SCs will meet the current design requirements throughout the entire LTO period.

Review of the AMPs shall be carried out in the following steps:

- Evaluation of actual conditions of all the concerned SCs which are managed by AMPs;
- Identification of ageing degradation and effects and their impact on SCs availability (i.e. their ability to perform the required safety functions throughout the entire LTO period);
- Evaluation of the existing and proposed AMPs by ten criteria (see further text below) with the aim to verify whether the concerned AMPs are adequate and effective. If any shortcomings are found, the existing AMPs shall be modified accordingly. If the existing AMPs are found to be not effective enough, or some relevant AMPs are missing, then new AMPs shall be developed;
- Verification (and documentation) if the existing, modified or new AMPs provide availability of all the concerned SCs throughout the entire LTO period.

REFERENCES TO SECTION 14

[14.1] 541/2004 Collection of Laws ACT of 9 September 2004 on peaceful use of nuclear energy (the Atomic Act) and on changes and amendments to certain laws.
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[14.3] NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC, Ageing management of Nuclear power plants – requirements, BNS I.9.2/2001, 2002.
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15. SPAIN

15.1. INTRODUCTION

The plant lifetime or AMR programmes in Spain started in the mid 1980´s with a joint programme shared by all Spanish utilities through their common organization UNESA, developing a methodology to be applied to two plants (an old BWR, Sta. M. de Garoña, and a modern PWR, Vandellós 2) which acted as pilot projects.

The development of the methodology was based mainly in the existing technical documents from IAEA, as TECDOCs 338, 540, 547 and 670,[15.1][15.2][15.3][15.4] and in some instances from EPRI documents (i.e. Monticello NPP [15.5] and Surry NPP [15.6]), as well as in the international experience available.

The application of this UNESA methodology included: (a) scoping and screening of systems, structures and components (SSC) taking into account safety, availability, replacement and/or cost criteria; (b) study of potential degradation mechanisms affecting these SSC, that were previously grouped in different categories due to their singular components (i.e. vessel, steam generators, turbine-generator set, containment, etc.), or depending on their typology (families or commodities); (c) evaluation of the existing plant maintenance practices versus ageing mechanisms, classifying the SSC as high, medium or low in terms of risk of degradation: and (d) the establishment of improvements in maintenance practices (in broad sense: predictive, preventive and corrective maintenance histories, in-service inspection and erosion-corrosion programmes, in-service testing, environmental and seismic qualification programmes, TS surveillance tests, etc.). The main objectives of the UNESA methodology were:

- The plant, as a set of SSC, can reach his design lifetime (40 years) in good safety and availability conditions;
- The choice for extending the Operation License and the extension of the initial design lifetime beyond the 40 years, that is LTO, is preserved.

The aforementioned general methodology defined by UNESA has been followed by all the Spanish plants since 1987 up to mid-1990´s. At that time, Spanish NPPs AMPs evolved to the USNRC rulemaking on license renewal (10CFR54) and related reports NUREG-1800 [15.7], NUREG-1801 [15.8] and NEI 95-10 [15.9] guideline, modifying as needed the previous work carried out under UNESA methodology.

15.2. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

Since December 1995 CSN issued the Safety Guide 1.10 on "NPP Periodic Safety Revisions", regulating the PSR process (content, frequency, etc.), based on the IAEA NS-G-2.10 (2003) [15.10].

The process of renewing plant Operation Licenses following the performance of PSRs every 10 years constitutes a reasonable guarantee that safety conditions will be maintained throughout the next 10 years period.

The USNRC rulemaking (10CFR54) [15.11] as well as the IAEA safety Guide on ageing management, NS-G-2.12 (2009) [15.12] and the recommendations ('reference levels') from European WENRA harmonization of requisites and regulatory practices has been used, by CSN, as references for developing the national rulemaking on AMR and long-term operation of Spanish plants. The CSN regulation is called 'Instruction on safety requirements for the management of ageing and long term operation of nuclear power plants', IS-22 [15.13], in force since July 1st 2009.

This regulation is currently in revision, and will be complemented thorough a Safety Guide on 'Ageing management programmes and long term operation of nuclear power plants', scheduled to be issued by end of 2013.

Based in the yearly information provided by the utilities according to IS-22 requirements, assessments reports on the status of its AMR are issued periodically by CSN staff for each NPP, in order to have an updated version of the assessed programme.

Additionally, regulatory monitoring on the AMR is carried out by CSN inspectors on each NPP, via periodic formal inspections that are included in the corresponding CSN 'Basic Inspections Programme'. In these inspections, performed every 2 years, the information contained in the periodic reports submitted by the licensee, according to IS-22, are taken into account.

The above CSN activities are ruled by two internal regulatory procedures applying to the inspection and assessment of SSC AM activities.

15.2.1. Management of physical ageing.

The physical ageing of SSC is ruled by the *'Instruction on safety requirements for the management of ageing and long term operation of nuclear power plant'*, IS-22 of CSN, and developed in the new Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'*.

15.2.2. Management of obsolescence.

The obsolescence aspects are not ruled currently by the CSN Instruction IS-22, but some aspects (replacement of SSC, commercial grade dedication processes, etc.) are covered through plant quality assurance and control programmes.

The new version of Instruction IS-22 as well as the new Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'* will contain a chapter dedicated to technical obsolescence.

Scoping and screening of SSCs for ageing management and LTO (passive and active components, long term and short term components)

CSN Instruction IS-22 as well as Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'* rules the scoping and screening process, following 10CFR54 and NS-G-2.12 criteria. As a final result of the screening process, only passive and long lived components and structures are considered.

In Spain, as referred in CSN Instruction IS-22, active and short lived equipment are covered through Maintenance Rule regulation (10CFR50.65) [15.14] as well as by other plant maintenance and surveillance programmes, applicable not only to LTO but also during the design life (usually 40 year period).

15.2.3. Ageing management review for LTO.

CSN Instruction IS-22 as well as Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'* rules the AMR process, in a similar manner as described in 10CFR54 and NS-G-2.12, determining for structures and components in scope, its applicable materials, internal/external environments and grouping of systems, structures and components, determining for each group the significant ageing mechanisms and effects and finally defining the AMPs, and TLAAs. IGALL tables will be considered as a valuable reference.

In Spain, the AMR process is applicable not only to LTO but also during the design life period.

15.2.4. Review of ageing management programmes for LTO.

When the period of an Operating License exceeds the lifetime considered in the original initial design of the plant (40 year), the PSR process remains valid, but it must be supplemented with additional information regarding an AMR.

CSN Instruction IS-22 as well as Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'* rules the preparation of a specific AMR containing all the AMPs and TLAAs applicable to LTO, as part of PSR dossier. These documents shall be submitted to CSN for assessment and approval, three years before entering the LTO phase.

During LTO period, these AMPs must be reviewed and updated periodically in view of its results, operating experience, design changes in the plant, new regulations, etc.

15.2.5. Revalidation of TLAA for LTO.

CSN Instruction IS-22 as well as the Safety Guide on *'Ageing management programmes and long term operation of nuclear power plants'* rules how to perform TLAA with similar criteria of 10CFR54 and NS-G-2.12.

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16. SWEDEN

16.1. APPROACH TO AGEING MANAGEMENT OF SWEDEN

Since the adoption of the 1997 act of parliament concerning the abolishment of nuclear power in Sweden, plant lives are no longer limited until 2010 as they were following the referendum in 1980. Therefore the Swedish Nuclear Power Inspectorate (SKI) in its general regulations from 2004 introduced general requirements for nuclear power plants to develop AMPs which should have been in place by the end of 2005. These requirements are unchanged in the current regulations of the Swedish Radiation Safety Authority (SSM), SSMFS 2008:1 [16.1]. The authority's regulatory strategy is not to provide detailed regulations but to ensure that the licensees take the full responsibility for the safety of their plants the detailed contents of the programmes have not been stipulated by SSM.

SSM considers that an AMP should coordinate, and where necessary, extend, the plant efforts in other programmes such as maintenance, monitoring, inspection, environmental qualification, chemistry, periodic testing and surveillance programmes all of which should already exist. In this way an integrated and long term approach to these issues can be ensured and become a natural part in the overall management of the plant. To this end it is important that the AMP, as all other central programmes and processes, is documented in the quality assurance system, overall management system and is included in the underlying safety analysis report of the plant. The AMPs will be assessed through a combination of inspection and document reviews as part of the normal supervision process of SSM. Thereafter it is anticipated that the major regulatory effort will be concentrated to the assessment of the PSRs to determine the effectiveness of the programmes and whether further specific regulatory action is required. This will become particularly important for reactors that are planning for LTO. SSM will also continue its active involvement in national and international research efforts to improve the understanding of ageing and degradation mechanisms.

In April 2010, SSM obtained a task from the Government that in July 2010 resulted in the start of a project at the authority that analyses the long term safety development in Swedish nuclear power plants. The project was finalized and reported in June 2013 [16.2]. The four sub-projects included in [16.2] are:

- Analysis of safety improvements related to modernizations to meet the SSM's back-fitting regulations which came into force in 2005;
- Analysis of the present Swedish regulatory approach. Input has been provided from the Integrated Regulatory Review Service (IRRS), compared to IAEA-standards, and co-operative research on different regulatory strategies has been initiated;
- Analysis of operation times longer than those analysed/designed;
- A Fukushima-analysis for Swedish purposes was added.

During 2012, the sub-project on operation times longer than those analysed/ designed shall supply an assessment of the state-of-the-art conditions for Swedish LTO. Also, a judgment will be supplied regarding which main conditions that will decisive on whether a reactor can be operated during long times with maintained safety. An assessment of the validation of today's inspection programmes will also be supplied. Based on these results the need for firmer regulations will be decided.

REFERENCES TO SECTION 16

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17. SWITZERLAND

Switzerland has four NPP sites with five operating reactor units. The first reactor unit has been operating since 1969, and three of the five reactors have already exceeded their initially planned operating period of 40 years.

17.1 NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

The safety-relevant aspects of material ageing have to be taken into account for all classified SSCs in Switzerland, which was one of the first countries to introduce a systematic AMP. All licencees have started their plant specific AMPs in 1992. Within the current guideline ENSI-B01 [17.1] (issued 2011) which superseded the guideline HSK-R51 [17.2] (issued in 2004), the regulatory expectations for the AMP in Switzerland are provided. The guideline ENSI-B01 is based on the legal framework in Switzerland (Nuclear Energy Ordinance [17.3] and Nuclear Energy Act [17.4]) and in the guideline reference is made to requirements according to IAEA Safety Guide NS-G-2.12 [17.5] related to material ageing issues.

17.1.1. Management of physical ageing and review of ageing management programme.

An AMP according to guideline ENSI-B01 [17.1] is mandatory for the operation of Swiss nuclear installations and covers all classified SSCs according to Swiss guideline ENSI-G01 [17.6]. Information from manufacturers, knowledge gained from maintenance, operational experience, root cause analysis of international reportable events and the current state of science and technology have to be considered when implementing and maintaining the ageing monitoring programme. The documentation of the AMP comprises:

- Technology-specific assessment of the potential possible ageing mechanisms;
- Plant-specific or generic guidelines;
- Fact sheets (in Switzerland called ‘Steckbrief’) on AM with structural-element-specific/ component-part-specific or component-specific categorization of the relevant ageing mechanisms and their adherence with the respective maintenance programmes;
- Annual status reports which include a compilation of [17.7]: updated fact-sheets and complementary measures; evaluation of ageing relevant internal and external operating experience and current state of science and technology; assessment of the effectiveness of the applied AMP and the complementary measures taken.

17.1.2. Scoping and screening of SSCs for ageing management and LTO.

The AMP covers the areas of mechanical, electrical and civil engineering SSC:

- Electrical equipment (safety system = 1E and safety related system = 0E):
  - Class 1E power supply systems and Class 1E components, e.g. cables (low and medium voltage), penetrations, SOVs, capacitors, inverters, converters, signal recorders, control equipment, relays, RTDs, thermocouples, level- , pressure- and H2-measurements, batteries e.g. 24 V and 120 V, connectors, fuses, motors, MOVs, closed loop valves, switch gears (medium and low voltage);
  - For 0E classified equipment (e.g. plant information systems) a so called ageing dossier on system level instead of fact sheets can be prepared.

- Civil engineering components and structures:
  - Building Class (BC) I: buildings in which mechanical equipment with Safety Class (SC) 1 – 3 and electrical equipment with class 1E is installed (reactor buildings, auxiliary buildings, electrical buildings, special emergency buildings, pump houses, intake structures, diesel generator buildings, emergency feed-water buildings, fuel buildings);
- Building Class (BC) II: buildings in which mechanical equipment with Safety Class (SC) 4 installed (decontamination buildings, service buildings, turbine buildings).
- Mechanical components:
  - Pressure vessels and piping classified in Safety Classes (SC) 1 – 3, including their supports and pressure-retaining equipment, RPV internals, emergency diesel and nuclear cooling systems;
  - Additional equipment identified by probabilistic safety assessment criteria (PSA).

There are specific requirements for the individual implementation of AMP for electrical and I&C systems, mechanical systems and civil structures. This reflects the individual necessities based on the different physical ageing mechanism and the respective maintenance strategy.

The guideline ENSI-B01 provides for example for mechanical equipment a procedure for fatigue monitoring under consideration of environmental effects and a procedure for assessment of the RPV brittle state due to neutron irradiation.

For electrical and I&C equipment the forecast of potential ageing effects can be based on different methods. The regulator accepts the following methods:

- Accelerated ageing test in a test environment (e.g. in a heat box): The model calculation necessary for the test evaluation is then carried out by means of the Arrhenius equation or the n-k rule;
- Examination of disassembled components with known conditions of use;
- Storage and subsequent testing of cables or components in the containment under extreme environmental conditions (temperature, humidity, radiation etc.), see also IAEA-TECDOC-932 [17.8].

An example of a fact sheet for electrical and I&C systems can be found in the IAEA-TECDOC-1402 [17.9] (contains a full example for a pressure transmitter in Annex A).

17.1.3. Complementary measures initiated by ageing management programmes.

AMPs provide essential information for the qualification process of the respective in-service inspection programmes (ISIs) for mechanical components and are also considered for a verification of maintenance programmes already in place. The maintaining (updating) process of the AMP ensures that the relevant ageing mechanisms for all safety-relevant components and structures are identified and that appropriate complementary measures are initiated if any divergences or gaps are discovered.

The complementary measures initiated are one key issue of the AMP. They cover for example the following topics:

- Studies for specific material degradation issues (e.g. material degradation susceptibility under specific conditions, root cause analysis of flaws);
- Modification/adjustment of in-service inspection programmes (temporarily or permanently);
- Mitigation techniques;
- Studies on efficiency of the inspection techniques;
- Modification or replacement of affected SSCs;
- Refurbishment of reinforced concrete structures due to carbonated concrete or concrete damaged by salt solutions.

17.1.4. Management of obsolescence.

A review of the management of obsolescence is an integral part of the regular PSRs. The regulatory requirements for the assessment whether a nuclear power plant has been brought up to the state of the art in back-fitting technology are addressed the current guideline HSK-R48 [17.10] which will be superseded with the new guideline ENSI-A03 (to be published).

The state of the art in back-fitting technology is an important part of the PSR. Typically the following aspects of conceptual obsolescence have to be re-assessed by the licensee during PSR:

- The redundancy level, functional independence and physical separation of safety systems;
- Safety against earthquakes and aircraft crashes;
- Provision against incidents in excess of design specifications.

Additionally within the PSR other aspects of obsolescence, e.g. related to knowledge, organizational and supply issues need to be evaluated.

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18. UKRAINE

18.1. APPROACH TO AGEING MANAGEMENT

The national requirements for LTO of NPP's include four levels documents:

- I level - The Atomic Energy Act [18.1-18.2];
- II level - Government Directives [18.3];
- III level - Documents of the Nuclear Regulatory Inspectorate of Ukraine (NRI) [18.4-18.5];
- IV level - Documents of the Utility approval by the NRI [18.6-18.8].

NP 306.2.141-2008 'Basic provisions of the nuclear plants safety' [18.4].

This document establishes the basic criteria, requirements and conditions of the NPPs safety ensuring, and also basic principles and technical and organizational measures for safety ensuring, including:

- Main terminology and determination in the sphere of nuclear energy use;
- Classification of the NPP systems and elements;
- Safety principles, used in NPP design;
- Basic requirements for quality assurance and forming of safety culture.

This document provisions, including presented above, generally meet the IAEA requirements and recommendations.

In terms of lists of SSC for AMP the following provisions should be noted: 'Systems (elements) important for safety - safety systems and elements, and normal operation systems (components) whose failures, considering failure of active or passive element of safety system which has mechanical moving parts or one personnel error independent of this failure, can result in an accident'.

The classification of systems and components according to their effect on safety is established. Based on this classification, the SSC lists are developed for AM.

- Class 1: This includes fuel elements and NPP elements, whose failures are the initiating events leading, at design operation of safety systems, to damage to the fuel elements with excess of the limits established for design basis accidents;
- Class 2: This includes the elements whose failures are the initiating events leading to damage to the fuel elements damage within the limits established for design basis accidents, at design operation of safety systems, taking into account the number of failures in them rated for design basis accidents; elements of safety systems whose failures lead to non-fulfilment by these systems of their functions;
- Class 3: This includes: the elements of the systems important to safety, which are not included in classes 1 and 2; the elements performing the functions of radiation protection of personnel and public;
- Class 4: This includes elements of normal plant operation, which are not influence safety and are not included in Classes 1, 2, 3.; NP 306.2.099-2004 'General requirements for the extension of NPP units operation according to the results of the periodic safety reassessment' [18.5].

This document establishes regulative requirements on 'extension of NPP units operation…and periodic safety reassessment'. The requirements on safety reassessment and content of the corresponding safety analysis report are obligatory, even for periodic safety assessment (not rarely than one time in 10 years), not related to extension of NPP operation beyond its design lifetime.

The basic management directive of the operator in terms of AM is *PM-D.0.08.222-06 'Standard ageing management programme for NPP unit's elements'* (Umbrella AMP) [18.7].

This document establishes the requirements for the organization and procedure of SSC AM system introduction and implementation at NPP units and defines the scope and sequence of technical measures to control ageing. The document contains a separate section that contains the requirements for compiling the lists of SSC subjected to AM.

The goal of the work performed in frame of NPP SSCs AM is ensuring required level of safety for unit life time extension and the maximum operational efficiency. The goal is ensured by implementation of measures aimed to the early detection of SSC ageing degradation and keeping of degradation in acceptable limits to guarantee SSC integrity and functionality.

Result of this activity is design and implementation of technically and economically efficient measures to prevent NPP SSCs malfunction caused by their ageing degradation.
The AM of NPP units consists of following basic activities:

- Elaboration of AMP of NPP unit SSCs;
- Elaboration of the list of equipment which are the object of AM;
- Technical status assessment of NPP unit SSCs;
- Identification and study of NPP unit equipment ageing processes;
- Reassessment of technical lifetime of NPP unit SSCs;
- Elaboration and implementation of measures mitigating ageing processes;
- Elaboration and implementation of unit SSCs ageing process monitoring;
- SSCs reliability maintenance in accordance to technical documentation requirements;
- Comparison of expenditures (costs) necessary for equipment replacement to expenditures for their operation time extension;
- Timely SSCs replacement when they reach the end of design lifetime;
- Equipment qualification realization;
- Documentation (administration control) and elaboration of effective information system for NPP unit SSCs AM.

On the basis of NPP unit SSCs technical status assessment results it is necessary to suppose elaboration of appropriate measures for ageing mitigation that has to be implemented in frame of:

- Maintenance;
- Refurbishment;
- Replacement;
- Change of operating conditions.

Requirements on NPP SSC AM monitoring are briefly:

- Monitoring of dominant ageing mechanism-monitoring systems, diagnostics, destructive and non-destructive tests, special measurement, in-service inspection, tests and measurement in frame of maintenance activities etc.;
- Preferring non-destructive methods and continuous operational monitoring;
- Determination and monitoring of parameters decisive with regard to ageing;
- AMP IS utilization for continuous monitoring of NPP unit equipment;
- Operational feedback and correction of monitoring system.

MT–T.O.03.303–12 'Methodology for Selection of NPP Unit Components to be addressed in the Ageing Management Program' [18.8] - This document establishes the main requirements for the organization and procedure scoping and screening of SSCs for AM and LTO is the methodology applied to the systems and components important to safety (Classes 1, 2 and 3), and having no impact on safety (Class 4), whose failure or damage can affect the safety functions to be performed by the Classes 1, 2, 3, systems and components, as per НП 306.2.141-2008. The Methodology should apply to the following equipment of SE NPP:

- Mechanical equipment and pipelines;
- Electrical equipment, I & C components;
- Buildings, structures, basements and foundations.

ПМ-Д.0.03.476-09 'Programme of Equipment Qualification for NPP's' [18.9];
This document establishes the main requirements for the organization and procedure Equipment Qualification.

EQ activities for NPPs envisage a successive implementation of the following stages:

- Elaboration of the NPPs equipment qualification programme and its approval by the
- NRI;
- Preparation of initial design data;
- Upgrading of the equipment qualification;
- Development of measures required to preserve the equipment qualification.

According to НП 306.2.099-2004 [18.5] for the complex analysis of influence on safety of the power unit upgrades of systems (elements), ageing of the equipment and building designs, infringements in work of the power unit, changes of technological parameters or technological and natural external influences etc. operation organization carries out periodic revaluation of safety of each block. The purpose of periodic revaluation of safety is definition of conformity of level of safety of the power unit of the nuclear power plant to effective standards and rules on NRS, and also the design and operational documentation, the Safety Analyses Report (SAR) and other documentation specified in the license for operation. On the basis of a periodic estimation of safety the analysis of sufficiency of the existing conditions providing maintenance of appropriate level of safety of the power unit of the nuclear power plant on following revaluation or to term of the termination of its operation is carried out. Also the list and terms of introduction of actions for increase of safety of the power unit, necessary for elimination or easing of the lacks revealed as a result of spent revaluation is defined.

For LTO of the power unit of the nuclear power plant in prolongation period term by modification of the license for the right realization of activity ‘Nuclear facility’, operation organization submits in State Nuclear Inspectorate the PSR of Nuclear Power Plants and the statement on an establishment of new term of operation of the power unit of the nuclear power plant, according to given in PSR to substantiations.

The current Ukrainian system of regulations, reviewed normative and technical documentation requirements correspond to the IAEA recommendations for LTO and AMP in operational NPPs [18.10-18.12].

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[18.6] PM-D.0.08.222-06 “Standard ageing management programme for NPP unit’s elements”, Kiev, (2006).

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19. UNITED STATES OF AMERICA

The Atomic Energy Act of 1954 (as amended) and U.S. Nuclear Regulatory Commission (NRC) regulations allow commercial power reactors to be licensed for an operating period of up to 40 years, with provisions that allow licenses to be renewed for additional operating periods of up to 20 years. This license renewal is in accordance with Part 54 of Title 10 of the Code of Federal Regulations, 'Requirements for Renewal of Operating Licenses for Nuclear Power Plants' (10 CFR Part 54) [19.1]. As of 2013, 73 out of over 100 reactor units have received renewed licenses, with applications for another 15 units under review.

19.1. NATIONAL REGULATORY REQUIREMENTS FOR AGEING MANAGEMENT AND LTO

From the beginning of plant operation, reactor licensees are required to conduct various activities that constitute AM, with new or enhanced activities developed as a consequence of operating experience or other bases to ensure that structures, systems, and components (SSCs) are capable of fulfilling their intended function (e.g., protection of fuel, core cooling, containment cooling, etc.). These licensee activities are mandated by regulation (such as Code and standards activities invoked by 10 CFR 50.55a, including the American Society of Mechanical Engineers Boiler and Pressure Vessel Code); are initiated in response to NRC generic communications (such as generic letters, bulletins, information notices, or regulatory issue summaries); are governed by industry programmes (such as the Boiling Water Reactor Vessel and Internals Programme and the Pressurized Water Reactor Materials Reliability Programme); or represent plant-specific activities. These licensee activities also include inspection programmes, operating experience programmes, maintenance programmes, quality assurance programmes, and corrective actions programmes. Taken together, these licensee activities that provide AM during the initial license term are called "existing programmes," and are an important aspect of AM used during the license renewal period of extended operation (PEO).

The NRC issued 10 CFR Part 54 in 1991 and amended the rule in 1995. The license renewal rule [19.1] requires AM of certain long-lived, passive SSCs, an evaluation of time limited ageing analyses (TLAAs), and consideration of environmental impacts in conformance with the National Environmental Policy Act (NEPA), as described in subpart A of 10 CFR Part 51 [19.2]. 10 CFR 54.29 specifies that a renewed license may be issued for up to 20 years of operation if (a) the NRC finds that the effects of ageing on the functionality of SSCs within the scope of review will be managed during the period of extended operation (PEO), and TLAAs have been evaluated, such that there is reasonable assurance that plant operation during the PEO will continue to be conducted in accordance with the plant's current licensing basis (CLB), and that any changes made to the plant's CLB are in accordance with the Act and NRC regulations; (b) any applicable requirements related to environmental impacts have been satisfied; and, (c) any matters raised in adjudicatory proceedings (hearings) have been addressed. Applicants may apply for a renewed license not more than 20 years before the expiration of the existing license; if the application is made at least 5 years before the expiration of the existing license, then the existing license will not be deemed to have expired until the NRC has made a final determination on the application (e.g., a plant that meets this requirement can continue to operate beyond its initial 40-year period if the NRC final determination on the license renewal applicant has been delayed for any reason).

The NRC has two safety principles that govern the review NRC performs for renewal of plant operating licenses. The first principle, as amended in 1995, states that, with the possible exception of the detrimental effects of ageing on the functionality of certain plant SSCs in the PEO and possibly a few other issues related to safety only during extended operation, the regulatory process is adequate to ensure that the licensing bases of all currently operating plants provides and maintains an acceptable level of safety so that operation will not be inimical to public health and safety or common defence and security. To support this principle, the NRC issued NUREG-1412 [19.3] as a supplement to the 1991 amendment of the rule. This report describes the regulatory processes that assure that plant-specific licensing bases will provide reasonable assurance that the operation of nuclear power plants will not be inimical to the public health and safety to the end of the PEO. The second principle of license renewal is that each plant's CLB must be maintained during the PEO, in part through age-degradation management of SSCs that are important for license renewal. Consistent with these two principles, the activities that were implemented and enhanced under the initial license to ensure the intended functions of SSCs (including those that manage the effects of ageing during the initial license period) are continued during the renewed license PEO.

19.1.1. Current licensing basis and on-going regulatory process.

The CLB consists of a number of items: (1) the set of NRC requirements applicable to a specific plant; (2) a licensee's written commitments for ensuring compliance with and operation within the applicable NRC requirements and the plant-specific design basis; (3) orders; (4) license conditions; (5) exemptions; (6) technical specifications; (7) the plant-specific design-basis information documented in the most recent final safety analysis report (FSAR); and, (8) the licensee's commitments remaining in effect that were made in docketed licensing correspondence, such as responses to NRC bulletins, generic letters, and enforcement actions, as well as licensee commitments documented in NRC safety evaluations or licensee event reports.

The NRC's on-going regulatory process involves several oversight programmes that work together to ensure that the plant's CLB is modified as appropriate to reflect significant new information on technical topics, including the effects of age-related degradation affecting the design or operation of the licensed plant so that the CLB continues to provide an acceptable level of safety. Examples of the NRC regulatory programmes include operating events assessment and generic issues programmes, as well as the NRC's reactor inspection programme. These continuing NRC regulatory programmes in place for the initial license term continue to the end of the renewal period as well.

Reactor inspections are conducted primarily by resident (on-site) and region-based inspectors. Under a programme initiated in 1977, at least two resident inspectors are stationed at each nuclear power plant to provide first-hand, independent assessment of plant conditions and licensee performance. The resident inspectors are supplemented by engineers and specialists from a regional office and headquarters staff who perform inspections in a wide variety of engineering and scientific disciplines. The inspection specialists review plant security, emergency planning, radiation protection, environmental monitoring, periodic testing of plant equipment and systems, fire protection, construction activities, and other more specialized areas. During the course of a year, NRC regional inspection specialists may conduct 10 to 25 routine inspections at each nuclear power plant, depending on the activities at the plants and problems that may occur. The special team inspections may focus on a specific plant activity, like maintenance or security, or a team may be sent to the plant to look at a specific operating problem or accident. Because it would be impossible to review every aspect of licensee performance, the NRC systematically evaluates their adequacy through selective inspections. The inspection programme selects an appropriate inspection sample based on its potential risk, past operational experience, and regulatory requirements.

Based on these principles and the continued strength of the on-going regulatory process, the NRC's license renewal review focuses on AM of those SSCs that are within the scope of license renewal.

19.1.2. License renewal application.

The license renewal rule describes the contents of the license renewal application (LRA). The LRA provides: a) certain general information, b) an integrated plant assessment (IPA), c) an evaluation of TLAAs, d) a supplement to the FSAR, e) needed changes to the technical specifications to manage the effects of ageing, and f) a supplement to the environmental impact report described previously. In addition, license renewal applicants are required to periodically update their LRA to identify any CLB changes that affect the contents of the LRA. This report will discuss the IPA and evaluation of TLAAs in detail, since these topics relate directly to AM.

The purpose of the IPA is to demonstrate that the effects of ageing on SSCs within the scope of license renewal will be adequately managed during the PEO such that the intended functions of these SSCs will be maintained consistent with the CLB. This assessment is important in determining any new activities or changes to existing programmes that need to be established to manage the effects of ageing during the PEO. SSCs within the scope of license renewal are those that are a) safety related, b) non-safety related, whose failure could affect the ability of safety-related SSCs to perform their safety functions, and c) relied on in safety analyses to perform a function to show compliance with NRC regulations to address fire protection, environmental qualification, pressurized thermal shock, anticipated transients without scram, and station blackout. The structures and components within the scope of license renewal are screened in if they are "passive" and "long-lived" and therefore subject to an AMR.

For this purpose, 'passive' means that the structure or component performs an intended function without 'moving parts or change in configuration or properties'. Examples would be the reactor vessel, electrical cabling, and the containment, and also include pump casings and valve bodies (e.g., for the passive function of pressure retention) but not the internal moving parts. 'Active' components (such as motors, snubbers, relays, etc.), are not included within the scope of the license renewal review because activities associated with the NRC maintenance rule (10 CFR 50.65), Technical Specification surveillance activities, and in-service testing provide similar benefits for active components as the AM activities identified in license renewal for passive structures and components.

For this purpose 'long-lived' means that the structure or components are not subject to replacement based on a qualified life or specified time period. Items that are replaced based on a qualified life or specified time period do not require AM to support continued operation because they are routinely replaced.

The IPA includes several essential elements:

- Identification of the specific components and structures that are subject to AMR:
  - The identification of the SSCs within the scope of license renewal is called 'scoping';
  - For those SSCs within the scope of license renewal, the identification of 'passive', 'long-lived' structures and components that are subject to an AMR is called 'screening';
- A description and justification of the methodology used for scoping and screening;
- A demonstration that the effects of ageing will be adequately managed so that the intended function(s) of each structure and component identified in Item a) will be maintained consistent with the CLB for the PEO:
  - This step involves identification of the ageing effects requiring management (AERM), and the mechanisms causing the ageing effects, based on the component/structure, material and environment;
  - The next step is the identification of the AMP that is credited for managing the ageing effects;
  - The final step is demonstrating that the ageing effect(s) will be adequately managed during the PEO.

Additional descriptions of AMR, AMPs, and TLAAs are provided below.

19.1.3. Guidance documents for license renewal.

The NRC has developed several documents to aid in effective and efficient evaluation of LRAs. The Standard Review Plan for License Renewal (SRP-LR), NUREG-1800 [19.4], was developed to assure quality and uniformity of NRC reviews and to present a well-defined technical basis from which to evaluate a licensee's application. Availability of the SRP-LR aids in the transparency of NRC reviews of LRAs such that applicants and the public can understand the types and detail of information needed by the staff in its reviews. The SRP incorporates by reference the Generic Aging Lessons Learned Report (GALL) report (NUREG-1801) [19.5], which provides generic evaluations of materials, environments, ageing effects and ageing mechanisms, along with acceptable AM approaches (e.g., AMPs). Use of the GALL Report by applicants facilitates NRC review of the LRA and provides for a stable review process, subject to emergent technical issues. Both the SRP-LR and the GALL Report were initially issued in 2001, with Revision 1 issued in 2005 and current Revision 2 issued in 2011.

The GALL Report provides a list of AMR items and AMPs to address them. Similar to the IAEA IGALL report, the AMR items provide, on a system and reactor type basis, a listing of structure/component, material, environment, ageing effect and mechanism, and AMP to manage the ageing effects. These items are based on the state of knowledge, based on prior versions of the GALL Report, license renewal applications, operating experience, and research. For cases where a material in a certain environment has no identified ageing effects requiring management, this combination is listed with a "None/None" entry for ageing effect/mechanism and AMP.

Referencing GALL in the application eliminates the need for NRC to perform a detailed review of proposed AMPs, provided that the specific conditions (i.e., structure/component, materials, ageing effects/ageing mechanisms, environments, and operating experience) delineated in the GALL Report are met. If an applicant references an AMP from the GALL Report, the NRC staff confirms that the proposed AMP is consistent with the recommended programme in the GALL Report for the structure or component under consideration, and no further staff-review of the programme is needed. This approach greatly streamlines the review required.

The GALL Report is not intended to be used as a scoping document and the structures and components contained in the GALL Report are neither all inclusive nor applicable to all plants.

19.1.4. Ageing management review.

LRAs provide detailed lists of AMR items that have been identified by the applicant for their specific plant. Items that match items from the GALL Report do not require additional review. Items that differ from those in the GALL Report require additional review to ensure that the applicant has identified all of the pertinent ageing effects/mechanisms and appropriate AMPs. Such items could be unique plant equipment, different materials, different ageing effects/mechanisms (based on plant-specific operating experience), or alternate AMPs. In these cases the NRC evaluates the applicant's information to ensure that the applicable ageing effects/mechanisms will be adequately managed by the identified AMP(s) during the PEO.

19.1.5. Review of ageing management programmes for LTO.

LRAs describe the AMPs that are proposed to manage the effects of ageing during the PEO. These AMPs may be existing programmes in current use at the plant (as described previously), or they may be new AMPs that will be established at the plant prior to entering the PEO. In addition, these AMPs may be consistent with the analogous AMP from the GALL Report, or these may be plant-specific AMPs. In general a large proportion of the AMPs proposed in the LRA for use during the PEO are existing programmes, many of which are consistent with the analogous AMP in the GALL Report, possibly after enhancement.

If a GALL Report AMP is selected to manage ageing, the applicant may take one or more 'exceptions' to specific GALL Report AMP programme elements. Exceptions are portions of the GALL Report AMP that the applicant does not intend to implement. Exceptions to the GALL Report AMP are described and justified in the LRA, and evaluated by the NRC.

In some cases, an applicant may choose an existing plant programme that does not currently meet all the programme elements defined in the GALL Report AMP. If the applicant chooses to make this existing programme consistent with the analogous AMP in the GALL Report, the applicant may make a commitment to augment the existing programme to satisfy the GALL Report AMP elements prior to the period of extended operation. This commitment is an AMP 'enhancement'. Enhancements are revisions or additions made to existing AMPs that the applicant commits to implement prior to the PEO. Enhancements include, but are not limited to, those activities needed to ensure consistency with the GALL Report recommendations. Enhancements may expand, but not reduce, the scope of an AMP.

An audit and review is conducted at the applicant's facility to evaluate AMPs that the applicant identifies to be consistent with the GALL Report. Reviews are performed to address those AMRs or AMPs that are related to emergent issues or stated to be not consistent with the GALL Report.

For AMPs identified in the LRA as consistent with the analogous AMP in the GALL Report and confirmed during the AMP audit as such, the AMP audit finding is sufficient for the NRC to conclude that the AMP will be effective to manage ageing during the PEO. For plant-specific AMPs and those AMPs that identify exceptions to the analogous AMP in the GALL Report, the applicant must demonstrate that the AMP will be effective to manage ageing during the PEO, subject to NRC review.

19.1.6. Revalidation of TLAAs for LTO.

The license renewal rule requires that applicants provide a list of TLAAs in their LRA and demonstrate that:

- The analyses remain valid for the period of extended operation;
- The analyses have been projected to the end of the period of extended operation;
- The effects of ageing on the intended function(s) will be adequately managed for the period of extended operation.

Guidance on TLAAs is provided in Section 4 of the SRP-LR [19.4]. This section of the SRP-LR provides guidance for certain generic TLAAs that apply to most applicants, such as neutron embrittlement, metal fatigue, and environmental qualification (EQ) of electrical equipment. This section also provides general guidance that can be applied to plant-specific TLAAs. Section 4 provides guidance on acceptance criteria and review procedures that are used by the NRC in the evaluation of TLAAs in the LRA. For the generic TLAAs, the acceptance criteria and review procedures are specific to the TLAA and the disposition of the TLAA, with separate guidance provided for (i), (ii), and (iii).

The disposition of a TLAA using (i) means that the original analysis remains valid for the PEO, such that, for example, the neutron fluence projected for the PEO is less than that assumed for the initial 40-year license period.

The disposition of a TLAA using (ii) means that the analysis has been projected to the end of the PEO, such as increasing the neutron fluence to cover the PEO, and the projected analysis still meets the acceptance criterion for the analysis. An example would be updating a fatigue cumulative usage factor (CUF) evaluation using number of cycles projected to the end of the PEO, and the resultant projected CUF continues to meet the acceptance criterion.

The disposition of a TLAA using (iii) means that the applicant will use an AMP to ensure that the TLAA remains valid during the PEO. For example, CUF TLAAs can be managed by the Fatigue Monitoring Programme, which counts transient cycles during the PEO, to ensure that the CUF evaluation continues to meet the acceptance criterion. If the AMP cannot demonstrate continued acceptability of the TLAA, then the licensee would implement corrective actions as applicable. For example, the component(s) could be repaired or replaced, or the CUF analyses could be refined to use more accurate and less conservative assumptions.

19.1.7. Management of obsolescence.

The NRC does not directly address management of obsolescence. Each plant must meet its CLB for the plant to continue to operate. Therefore to assure continued operability, plants may need to take pro-active measures to ensure that the potential consequences of obsolescence do not impede their ability to operate within their CLB.

19.1.8. License renewal inspections and audits.

The NRC performs various audits and inspections related to license renewal. The audits address the scoping and screening methodology performed by the applicant in developing the LRA, a site environmental audit, and an audit of AMPs that are consistent with the GALL Report. The findings from these audits are documented in audit reports.

NRC inspections related to license renewal are described in NRC Inspection Manual Chapter 2516. The objectives of these inspections are (1) to provide a basis for recommending issuance or denial of a renewed license, (2) to identify weaknesses within an applicant's overall license renewal programme or an individual AMP that fail to provide reasonable assurance that the applicable ageing effects will be adequately managed during the period of extended operation, and (3) to determine the status of compliance with 10 CFR Part 54 and other areas relating to maintaining and operating the plant such that the continued operation beyond the current licensing term will not be inimical to the public health and safety.

These inspections are implemented in accordance with Inspection Procedure (IP) 71002 (License renewal inspection) and IP71003 (Post-Approval Site Inspection for License Renewal). The IP 71002 inspection is composed of a Scoping and Screening Inspection and an AMP Inspection, and is performed contemporaneous with the review of the LRA.

To accommodate the licensee's implementation schedule, the IP 71003 inspection can be implemented in a three phase approach, with a majority of the IP 71003 inspection conducted before the licensee enters the PEO. The inspections are scheduled to support completion of the review in sufficient time for licensees to make any necessary corrections to their AMPs before entering the PEO. The IP 71003 inspection verifies that the license conditions added as part of the renewed operating license, regulatory commitments, selected AMPs, and TLAAs are implemented and/or completed in accordance with the license renewal rule. In addition this inspection verifies the licensee appropriately implemented any changes to regulatory commitments from the SER for license renewal, changes to AMPs, TLAAs and other license renewal activities incorporated as part of the updated FSAR supplement, and changes to license conditions that were added as part of the renewed operating license.

The results from these inspections are documented in inspection reports.

REFERENCES TO SECTION 19

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20. ABBREVIATIONS

AAS	ageing analysis sheets
ADU	agreed design upgrade
AM	ageing management
AMPs	ageing management programmes
AMR	ageing management review
AMTE	ageing management technical evaluation
ARN	Nuclear Regulatory Authority
ATWS	anticipated transients without scram
BC	building class
CFE	Comision Federal de Electricidad
CG	clearing group
CLB	current licensing basis
CNEA	National Technical Support Organization
CNEN	Comissão Nacional de Energia Nuclear
CNSC	Canadian Nuclear Safety Commission
CNSNS	Comision Nacional de Seguridad Nuclear y Salvaguardas
CSA	Canadian Standards Association
CSAMPs	component specific ageing management programmes
DAAR	detailed ageing analysis reports
DACAAM	Data Acquisition and Analysis System for Ageing Management
DTAMPs	degradation type ageing management programmes
EBP	extrabudgetary programme
EQ	environmental qualification
FAC	flow-accelerated corrosion
FANC	Belgian Federal Agency for Nuclear Control
FSAR	final safety analysis report
GALL	generic ageing lessons learned
GE	General Electric
IGALL	international generic ageing lessons learned
IIP	integrated implementation plan
IP	Inspection Procedure
IPA	integrated plant assessment
IRRS	Integrated Regulatory Review Service
ISIs	in-service inspection programmes
ISR	integrated safety review
JNES	Japan Nuclear Energy Safety Organization
LR	licensing renewal
LRA	license renewal application
LTMP	long term maintenance programme
LTO	long term operation
MEM	maintenance effectiveness monitoring
MIC	microbiologically influenced corrosion
NA-SA	Nucleoeléctrica Argentina SA
NEPA	National Environmental Policy Act
NPP	nuclear power plant
NRA	Nuclear Regulation Authority
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OE	operating experience

PEO	period of extended operation
PLIM	plant life management
PSR	periodic safety review
PTS	pressurized thermal shock
RCM	reliability centred maintenance
RTN	Rostechnadzor
SC	safety class
SCs	structures and components
SG	steering group
SKI	Swedish Nuclear Power Inspectorate
SONS	State Office for Nuclear Safety
SRP-LR	Standard Review Plan for License Renewal
SSCs	systems, structures and components
SSM	Swedish Radiation Safety Authority
STO	Standards of the operational organization
TLAAs	typical time limited ageing analyses
UAAR	unit ageing analysis report
UT	ultrasonic test
VT	visual test
WG	working groups

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