PREEV PROJECT
“Regulatory Practices on Ageing and Life Extension”

TD2
GUIDE FOR ASSEMENT OF AGEING MANAGEMENT AND LONG TERM OPERATION OF NUCLEAR POWER PLANTS

First Edition
May 2011
GUIDE FOR ASSESSMENT OF AGEING MANAGEMENT 
AND LONG TERM OPERATION OF NUCLEAR POWER PLANTS

TABLE OF CONTENTS

1. INTRODUCTION .......................................................................................................... 1
2. DEFINITIONS AND ACRONYMS ............................................................................. 2
3. OBJECTIVES ................................................................................................................ 9
4. SCOPE OF THE GUIDE .............................................................................................. 9
5. ASSESSMENT OF AGEING MANAGEMENT ................................................... 10

5.1. Overview .............................................................................................................. 10
5.2. Basic Aspects of a Plant Life Management Plan (PLiM Plan) ................................ 11
5.2.1. Policy ................................................................................................................. 12
5.2.2. Plan ..................................................................................................................... 12
5.2.3. Procedures ........................................................................................................ 12
5.3. Aspects Subject to Assessment ........................................................................... 13
5.3.1. Organizational and Managing Aspects ............................................................... 13
5.3.2. Periodic Reports .................................................................................................. 15
5.3.3. Scope and screening of SSCs ............................................................................. 15
5.3.3.1. Assessment of Methodological Aspects for the Scope and Screening of SSCs Determination ................................................................. 17
5.3.3.1.1. Scope .............................................................................................................. 17
5.3.3.1.2. Screening ...................................................................................................... 21
5.3.3.2. Assessment of results related to the application of the Scope and Screening of SSCs methodology ................................................................. 24
5.3.4. Ageing Management Review ............................................................................. 28
5.3.4.1. Phases and contents of a PLiM Plan ................................................................. 28
5.3.4.1.1. PLiM Plan for CANDU Nuclear Power Plants ................................................. 28
5.3.4.1.2. PLiM Plan for PWR, BWR and PHWR with vessel ........................................... 33
5.3.4.1.3. Assessment of methodological aspects related to the Ageing Management Review .......................................................................... 34
5.3.4.2. Assessment of results related to the Ageing Management Review ................... 36
5.3.5. Results of the application of Ageing Management Programs (AMP) ................. 41
5.3.6. Monitoring of Improvement Proposals (IPs) ....................................................... 42
5.3.7. Monitoring of Design Modifications (DMs) and replacement of equipments related to Ageing Management ................................................................. 43
5.3.8. Monitoring of the Support Documents Reviews ................................................ 43
5.3.9. Assessment of the Process for the Identification and Resolution of Generic Safety Issues applicable to Nuclear Power Plants ............................................. 44
5.3.10 Obsolescence Management ............................................................................... 44

6. AGEING MANAGEMENT APPLICABLE TO THE LONG TERM 
OPERATION ..................................................................................................................... 45

6.1. Introduction .......................................................................................................... 45
6.2. Long Term Plant Life Management Plan (LT-PLiM Plan) .................................... 46
6.3. Integrated Plant Assessment (IPA) ........................................................................ 46
6.4. Aspects Subject to Assessment ............................................................................. 47
6.4.1. Review of the Time-Limited Ageing Analyses (TLAA) .................................................................47
6.4.1.1. Results of the identification process of TLAA ......................................................................48
6.4.1.2. TLAA Resolution Process ......................................................................................................48
6.4.1.3. Process for Identification and Resolution of Exemptions based on TLAA .........................49
6.4.1.4. References to TLAA in the Safety Analysis Report (SAR) ......................................................49
6.5. Specific Assessment Aspects related to the License Renewal Process ...........................................50
6.6. Assessment of Long Term Operation of CANDU Nuclear Power Plants ....................................50
6.6.1. Initiation of the Plant Life Extension (PLEX) Project ...............................................................50
6.6.2. Assessment of the Licensing Basis Document ...........................................................................51
6.6.3. Assessment of the Periodic Safety Review (PSR) ......................................................................51
6.6.4. Assessment of Ageing Studies ..................................................................................................51
6.6.5. Assessment of Safety Analyses ................................................................................................52
6.6.6. Assessment of the Safety Improvement Plan (SIP) ..................................................................52
6.6.7. Assessment of the Environmental Radiological Impact ............................................................53
6.6.8. Assessment of the works for the Implementation of Improvements on Systems, Equipments, and Components ........................................................................................................53
6.6.9. Assessment related to the License Renewal Process ..................................................................54
6.6.10. Milestones ..................................................................................................................................55
6.6.11. Checkpoints ...............................................................................................................................56
6.6.12. Return to Normal Operation ......................................................................................................56

LIST OF FIGURES

Figure 1. Scope and screening scheme of SSCs for the PLiM Plan of a PWR, BWR or PHWR Nuclear Power Plant with vessel ........................................................................................................22
Figure 2. Scope and screening scheme of SSCs of economic relevance or safety importance to be addressed in a CANDU Nuclear Power Plant’s PLiM Plan ........................................................................23
Figure 3. Phase 1 basic scheme of a CANDU-PLiM Plan ..................................................................30
Figure 4. Scheme of the integrated condition assessment report of a CANDU Nuclear Power Plant ..................................................................................................................................................32
Figure 5. Phases of the Life Management Process in a CANDU reactor ...........................................33

LIST OF TABLES

Table A. Summary of the PLiM Plan stages for a CANDU Nuclear Power Plant ...............................29
Table B. Aspects to consider in a condition assessment report of SSC ..................................................31
Table C. Aspects subject to assessment ................................................................................................47
GUIDE FOR ASSESSMENT OF AGEING MANAGEMENT AND LONG TERM OPERATION OF NUCLEAR POWER PLANTS

1. INTRODUCTION

In accordance with the mission of the Iberoamerican Forum of Radiological and Nuclear Regulatory Bodies (Foro Iberoamericano de Organismos Reguladores Radiológicos y Nucleares - FORO), the promotion of a high safety level in the practices that make use of radioactive and nuclear materials and the encouragement to exchange information and experience concerning nuclear safety and radiological protection are among the main objectives.

The development of technical projects through the constitution of working groups integrated by experts from member countries is one of the tools used by FORO for the fulfilment of these objectives.

In this context, the 2008 Plenary of FORO approved the beginning of the Prácticas Regulatorias en Envejecimiento y Extensión de Vida (PREEV) [Regulatory Practices on Ageing and Life Extension] Project, whose main objective is to improve regulatory action concerning life management programs and Long Term Operation of the Nuclear Power Plants in countries of the region.

The project was developed by a team integrated by experts from Argentina (ARN), Brazil (CNEN), Chile (CCHEN), Cuba (CNSN), Spain (CSN), and Mexico (CNSNS), assisted by an IAEA officer, who provided related information from such organization’s point of view. Likewise, the team was supported by other experts from those countries, who participated in certain activities of the project.

The tasks of the PREEV project were developed between 2009 and 2010, and were embodied in a documental set comprising four guides for regulators and a technical report of the project. Such guides were conceived to be used, in whole or in part, by each country of the region and, if applicable, to develop internal regulation and/or execute regulatory practices. In either case, due to their guidance nature, they are not intended to be binding documents. Despite the fact that these guides establish the essential regulatory bases regarding ageing management and Long Term Operation, it is considered that in order to establish a complete regulation on the matter, it is necessary to incorporate more detailed requirements, in accordance with the particular issues of each country.

Regarding the specific application field of the PREEV project, it is worth mentioning in the first place, that Regulatory Bodies (RB) from most FORO member countries had requested Nuclear Power Plant Licensees the implementation of an ageing management process, including the management in the case of life extension beyond the design life in documents concerning limits and terms of Operation Licenses.

In this context, the conception of the PREEV project responds to the convenience of establishing, in a general manner, the criteria to be applied by Regulatory Bodies to request the implementation of an ageing management system on Structures, Systems and Components (SSC), including the Long Term Operation (LTO), with features assuring that such system complies with the objectives expected from the safety point of view. It was also intended in this project, to establish general guidelines for the development and execution of regulatory practices associated to licensing, supervision, and control of related programs and activities.
The documents that result from the PREEV project are based on IAEA standards and regulations from the most advanced countries in nuclear technology. They are also in accordance with the reference levels established by the Western European Nuclear Regulators’ Association (WENRA) and are consistent with the regulatory framework of each member country represented in the project. On the other hand, they intend to reflect the experience gained from the regulatory practice in each member country of the project’s team.

In this context, the purpose of this Technical Document (“TD2”) is to provide regulators with a guide for the assessment of ageing management and Long Term Operation activities of Nuclear Power Plants.

The rest of the documents derived from the PREEV project are:

TD1: Guide for Regulatory Criteria on Ageing Management and Long Term Operation of Nuclear Power Plants


2. DEFINITIONS AND ACRONYMS

The following definitions are applicable for the purposes of this guide:

a) **Time Limited Ageing Analysis (TLAA):** Analyses and calculations carried out by the Nuclear Power Plant Licensee, which meet the following criteria:
   
i.) They are related to the SSCs considered within the ageing management scope.

   ii.) They take the effects of time and Long Term Operation into consideration.

   iii.) They maintain hypotheses of limited design life.

   iv.) They prove the existence or the lack of capability of SSCs to continue operating according to their specific functions after exceeding the hypotheses of limited design life.

   v.) The calculation or analysis was considered relevant in a safety assessment.

   vi.) The calculation or analysis is part of the current Licensing Terms of the plant.

b) **Active Component:** A component whose functioning depends on an external input such as actuaction, mechanical movement or supply of power, and which responds with relative movement of parts or with a configuration change.
c) **Long-Life Components**: Components and structures exempted from replacement based on a qualified life or a specified period of time.

d) **Passive Component**: A component whose functioning does not depend on an external input such as actuation, mechanical movement or supply of power, and lacks moving parts or parts subject to a configuration change.

e) **Licensing Terms**: Set of licensing requirements, and regulatory requirements and exemptions, derived from the regulations in force at the moment of the initial Operation License issuance as well as from regulations implemented thereinafter.

The Licensing Terms are included in the official documents of the Nuclear Power Plant’s operation, in the conditions associated with their approval and the Operation License, as well as in the commitments of the Licensee to assure the fulfilment of the safety systems design bases (including made modifications). These Licensing Terms must be updated every time modifications to their corresponding regulation framework are made.

f) **Ageing Degradation**: Process by which the physical characteristics of the SSCs of Nuclear Power Plants are modified, leading to a change in their behaviour due to phenomena such as radiation exposure, high temperature cyclic transients, pressure or corrosion attacks, among others. [IAEA definition: Ageing effects that could impair the ability of a Structure, System or Component to function within its acceptance criteria.]

g) **Ageing Effects**: Net changes in the characteristics of a SSC, over age or wear, due to ageing mechanisms.

h) **Ageing**: Set of processes (or mechanisms) by which SSCs characteristics progressively degrade over age or wear. It may appear either as **physical ageing** or as **obsolescence**.

i) **Physical Ageing**: Ageing caused by physical, chemical or biological processes (ageing mechanisms). Examples of ageing mechanisms include wear, thermal or radiation embrittlement, corrosion and microbiological fouling.

j) **Technical Specifications (TS)**: Mandatory document which comprehends the requirements under which the Nuclear Power Plant operation shall be carried out, and which establishes the limits, terms and monitoring for its safe operation.

k) **Structures Systems and Components (SSC)**: Generic term which comprises all the elements of a Nuclear Power Plant.

   i.) **Structures** are the passive elements that support or host other elements: buildings, civil works, shielding, etc.

   ii.) **A System** comprises several components or structures assembled in such a way as to perform a specific function.

   iii.) **A Component** is a combination of pieces and parts which comprises a simple and distinguishable functional unit that performs a specific task in a system. Examples of components are wires, transistors, integrated circuits, motors, relays, solenoids, pipes, pumps, vessels, heat exchangers, deposits and valves.

l) **Critical Structures, Systems and Components (CSSC)**: Structures, Systems and Components (which belong or not to safety systems), whose failure may affect the Nuclear Power Plant safety, and which are also determinant from the financial point of view.
m) **Ageing Management Analyses:** Analyses which demonstrate that time effects are properly considered for SSCs within the scope of ageing management, for them to maintain the functions defined in their licensing terms during their lifetime (or service life).

n) **Intended safety function:** Function which justifies that a SSC is included within the scope of the ageing management process.

The criteria that allow the identification of SSCs with intended safety function are:

i.) SSCs which must keep functioning during and after any design basis event that may arise, to guarantee the following functions:

1. Integrity of the reactor coolant system pressure boundary,
2. Capability to shutdown the reactor and maintain it in a safe shutdown condition; or
3. Capability to prevent or mitigate accident effects in order to maintain radiation exposure out of the site below the established limits.

ii.) SSCs whose failure could prevent the satisfactory fulfilment of any of the aforementioned functions.

iii.) SSCs included in the Nuclear Power Plant safety analysis and which are related to the requirements for fire safety, environmental qualification, pressurized thermal shock, anticipated transients without automatic reactor shutdown, and complete loss of electric power.

o) **Ageing Management:** Engineering, operations and maintenance actions to control within acceptable limits the ageing degradation of SSC.

Examples of engineering actions include design, qualification and failure analysis. Examples of operations actions include surveillance, carrying out operating procedures and performing environmental measurements.

p) **Component Groups or “Commodities”:** They consist of groups of components or structures with similar characteristics that allow the performance of a unique ageing management analysis, valid for all of them.

The grouping criteria can be based on the existence of similar designs, materials in common, same kind of components, the application of similar ageing management practices, or the fact that they are subjected to a same internal or external environment.

q) **Safety Analysis Report (SAR):** Official document of the facility which comprises the necessary and sufficient information so that the Regulatory Body is able to perform an independent review of a Nuclear Power Plant on nuclear safety and radiological protection, as well as an analysis and assessment of the risks derived from the operation of the facility, both in normal and accident conditions.

This document also includes detailed descriptions of safety functions of all the safety systems and SSCs related to safety, of their design bases and functioning in all operational condition, including shutdown and accident conditions. It also identifies the regulations, codes and standards applicable to the Nuclear Power Plant. It is usually referred to as SAR or FSAR, (Final) Safety Analysis Report.
r) **Significant Ageing Mechanism:** Ageing mechanism whose potential development makes the requirement of a control or mitigation activity necessary, to guarantee the compliance with the functions assigned to the affected SSCs, during lifetime (or service life).

s) **Obsolescence:** The process of becoming out of date due to the evolution of knowledge, technology or associated changes in regulations or standards. Examples of obsolescence effects (or non-physical ageing) are: lack of effective safety elements or of safety design criteria (such as: diversity, separation or redundancy), the unavailability of spare parts, the incompatibility between new and old equipment or the existence of documentation that is old or does not meet regulations in force.

t) **Long Term Operation (LTO):** Continued operation of the Nuclear Power Plant maintaining an acceptable safety level, beyond its design life, after performing a safety assessment which assures that safety requirements applicable to its SSCs are met, by implementing the necessary improvements. It is also referred to as Life Extension.

The safety assessment supporting the Long Term Operation of the Nuclear Power Plant shall include, along with the ageing management review for the new period, the safety analysis review considering a lifetime longer than the design life of the Nuclear Power Plant. In such review, whether the conclusions of these analyses are valid taking into consideration the longer operation period shall be assessed.

u) **Plant Life Management (PLiM) Plan:** An action program whose aim is to achieve the original design life without safety deterioration and to keep the possibility of the Nuclear Power Plant License renewal open, for its Long Term Operation. In recent times, this concept applies to CANDU technology reactors; but in the past, it was referred to as Ageing Management Plan (AMP), with a similar methodology.

A Plant Life Management Plan must integrate and, if necessary, complement all the activities related to the assessment and control of the ageing mechanisms affecting passive and long term SSCs relevant to safety.

v) **Long Term Plant Life Management (LT-PLiM) Plan:** Set of Ageing Management Programs in force during Long Term Operation and oriented to the surveillance, control and mitigation of ageing and degradation mechanisms affecting the SSCs comprised within the scope of the ageing management process.

Ageing effects, degradation mechanisms, and related management programs within the scope of this Plan shall be those identified in the Integrated Plant Assessment (IPA) [Programa Integrado de Evaluación y Gestión de Envejecimiento (PIEGE), in Spanish], as well as any other which may arise as a consequence of internal or external operative experience, design modifications, research project results, etc., during the Long Term Operation period.

The LT-PLiM Plan must consider a formal procedure for identification and implementation of improvement proposals and design modification analyses.

w) **Integrated Plant Assessment (IPA)** [Programa Integrado de Evaluación y Gestión de Envejecimiento (PIEGE), in Spanish]: Set of ageing management analyses which comprise three classical stages: scoping and screening of SSCs, identification of ageing effects and degradation mechanisms, and definition of ageing management programs. It also includes the Time Limited Ageing Analyses (TLAA) which are necessary for the review of the analyses performed with a defined design life hypothesis.
x) **Ageing Management Programs (AMP):** Structured set of activities oriented to the surveillance, control and mitigation of ageing effects which affect the SSCs comprised in the ageing management process scope. Management programs are based on different predictive, preventive and corrective maintenance practices, environmental qualification programs, periodic testing and surveillance of Technical Specifications (TS), in service inspection programs, erosion-corrosion programs, etc., as well as any other specific activity which might be performed at the Nuclear Power Plant with the same purposes.

y) **Improvement Proposal (IP):** Specific improvement needs associated with a particular ageing management program, and which have become evident in the comparison of such program with a standard reference program (for instance, those from the NUREG-1801, GALL report of the USNRC), or in the assessment performed in a generic manner by means of the analysis of their attributes. Sometimes, improvements can be related only to the scope of the program (“scope improvements”), which usually arise when different ageing management studies are performed or when a particular ageing management program has to be applied to a new group of components or structures, implying the widening of its scope.

z) **Plant Life Extension (PLEX):** The extension of the safe operating life of a Nuclear Power Plant beyond its design life. This involves either the replacement or refurbishment of main components or substantial modifications, or both.

aa) **Periodic Safety Review (PSR):** Systematic safety reassessment of a Nuclear Power Plant performed at regular intervals (usually every 10 years), to determine the impact of the accumulative effects of ageing, modifications, operative experience, technical developments and site aspects on the facility, and whose aim is to guarantee a high safety level throughout the operating life of the facility.

bb) **Design life:** The period of time during which a Nuclear Power Plant or component is expected to behave according to the technical specifications to which it was built or manufactured.

In most western design Nuclear Power Plants, part of the studies which support the plant safety assessment have been performed with a 30 to 40 years design life hypothesis; for example, those components which cannot be replaced, such as the reactor vessel or the containment building, are the reason why a Nuclear Power Plant’s design life is usually considered to be of 30 to 40 years.

cc) **Lifetime:** Period of time from initial operation to final withdrawal from service of a Structure, System or Component. It may also be referred to as service life.

Lifetime may be longer than design life, provided that actual operating conditions have been less severe than the supposed design ones. The Remaining Life margin of a SSC can be determined by the comparison between the design conditions with the actual operating conditions.

The following acronyms are used in this guide:

a) AECL: Atomic Energy of Canada Limited

b) AMP: Ageing Management Program

c) AMR: Ageing Management Review

d) ARN: Autoridad Regulatoria Nuclear (Nuclear Regulatory Authority), from Argentina
e) BWR: Boiling Water Reactor
f) CANDU: Canadian Deuterium Uranium Reactor
g) CCHEN: Comisión Chilena de Energía Nuclear (Nuclear Energy Commission), from Chile
h) CFR: Code of Federal Regulations (US)
i) CNE: Embalse Nuclear Power Plant (Central Nuclear Embalse), from Argentina
j) CNEN: Comissão Nacional de Energia Nuclear (National Nuclear Energy Commission), from Brazil
k) CNSC: Canadian Nuclear Safety Commission (Canadian Regulatory Agency)
l) CNSN: Centro Nacional de Seguridad Nuclear (National Center on Nuclear Safety), from Cuba
m) CNSNS: Comisión Nacional de Seguridad Nuclear y Salvaguardias (National Commission on Nuclear Safety and Safeguards), from Mexico
n) CSN: Consejo de Seguridad Nuclear (Nuclear Safety Council), from Spain
o) CSNI: Committee on the Safety of Nuclear Installations (of the OECD/NEA)
p) CSSC: Critical SSCs
q) DM: Design Modification
r) EPRI: Electrical Power Research Institute, from US
s) FORO: Foro Iberoamericano de Organismos Reguladores, Radiológicos y Nucleares (Iberoamerican Forum of Radiological and Nuclear Regulatory Agencies)
t) GALL: Generic Ageing Lessons Learned, of the USNRC
u) GSI: Generic Safety Issue, of the USNRC
v) I&C: Instrumentation and control
w) IAEA: International Atomic Energy Agency
x) IP: Improvement Proposal
y) IPA: Integrated Plant Assessment [Programa Integrado de Evaluación y Gestión de Envejecimiento (PIEGE), in Spanish]
z) LRR: Licensing Renewal Rule, of the USNRC
aa) LT-PLiM Plan: Long Term Plant Life Management Plan
bb) MR: Maintenance Rule
cc) NEI: Nuclear Energy Institute, of the US
dd) NPP: Nuclear Power Plant
3. OBJECTIVES

The aim of this guide is to provide guidelines to assess the safety factors relative to the ageing management of Nuclear Power Plants, in order to assure they shall operate safely until the end of their lifetime.

This document deals, generically, with topics related to ageing management assessment, life extension projects and long term ageing management. Some singularities considered by the countries that participated in the development of this guide are mentioned.
Most differences when dealing with these topics are due to the technological differences and the different methodologies developed in the designing and manufacturing countries of the Nuclear Power Plants.

The assessments to be performed at the different phases of a Nuclear Power Plant’s lifetime, together with the regulatory inspections described in the TD3, shall aim to verify the following factors:

a) If the Nuclear Power Plant can reach the original design life, without safety deterioration, avoiding the unforeseen degradation of Structures, Systems and Components (SSCs) of the Nuclear Power Plant, framed within the scope of the hereinafter defined ageing management process.

b) If an ageing surveillance, control and mitigation program has been established during the original design life, which allows reaching the technical-economic life defined by the Licensee for the Nuclear Power Plant.

c) If the planning and systematization of the ageing management established for Long Term Operation (LTO) provides reasonable guarantee on the functionality of the SSCs framed within the scope of the ageing management process.

d) If during the Long Term Operation period (Life Extension), the necessary ageing management activities are performed so as to reasonably guarantee the surveillance, control and mitigation of ageing mechanisms of the SSCs framed within the scope of the ageing management process, avoiding their unforeseen degradation and therefore, a deterioration of safety.

Furthermore, this guide defines the assessments to be performed by the Regulatory Body (RB) to license the Long Term Operation of Nuclear Power Plants.

4. SCOPE OF THE GUIDE

This guide deals with:

a) The assessment of all the stages of the Plant Life Management (PLiM) Plan during the design life of the SSCs framed within the scope of the ageing management process.

b) The key elements to be considered and which shall be assessed when establishing the scope, planning and execution of a Plant Life Extension (PLEX) Project, (typical of CANDU Nuclear Power Plants) or during the Operation License renewal process if the Nuclear Power Plant’s design life is exceeded. This program is known as Integrated Plant Assessment (IPA) [Programa Integrado de Evaluación y Gestión de Envejecimiento (PIEGE), in Spanish], in the case of American design Nuclear Power Plants.

c) The assessment of Long Term Plant Life Management (LT-PLiM) Plans which include diverse Ageing Management Programs (AMPs) in force during the Long Term Operation period.

Such assessments comprise the following items:

a) The scope, requirements, methodologies and results of ageing assessments.
b) The acceptance of the refurbishment tasks and safety improvements’ scope proposed by the Licensee.

c) The verification of the appropriate planning for the tasks to be performed to implement improvements, taking aspects related to radiological and nuclear safety into consideration.

d) The verification of a proper execution of the improvement related works.

e) The verification of the mandatory documentation update, taking the extended operation period into consideration.

The guidelines regarding these items are also provided in the guide applicable to Periodic Safety Reviews, PSR (TD4).

If the Nuclear Power Plant design required an extended refurbishment shutdown, two fundamental factors related to the replacement of components affecting safety shall be considered due to their ageing. The first factor is related to SSCs that could be contaminated (fuel channels, feeders, steam generators, etc.) and the second one is related to the restart, especially if new components have been introduced in the reactor, which implies it shall be done with a fresh core. Therefore, the following items shall be added to the aforementioned ones:

a) Verification of an appropriate management of radioactive waste generated in the refurbishment tasks of the Nuclear Power Plant.

b) Verification of the application of an appropriate Radiological Protection system during the refurbishment shutdown.

c) Verification of the compliance with technical conditions to initiate the restart process of the Nuclear Power Plant.

d) Verification of the necessary conditions checking during the commissioning process for the safe restart of the Nuclear Power Plant.

This guide only deals with those factors related to nuclear and radiological safety. Even though the assessments related to physical safety and safeguards exceed the scope of this guide, these shall be established within the Long Term Operation Licensing framework. The same applies to assessments related to the Safety and Hygiene of the Nuclear Power Plants, for those countries in which the RB is responsible for the control of such factors.

5. ASSESSMENT OF AGEING MANAGEMENT

5.1. Overview

Nuclear Power Plants (NPPs), like other conventional facilities, are subject to ageing.

The aim of a NPP ageing management is to reach the design life guaranteeing the safe and economically feasible operation of the plant and to create the bases for a possible long term operation.

Ageing is manageable if:

a) Symptoms are recognizable.
b) The ageing mechanism is known and can be monitored.

c) Suitable and timely measures for its mitigation are taken.

The PLiM Plan allows a cost-benefit optimization for capital investment, replacement and modernization of equipments (obsolescence management), systems, and general operation and maintenance tasks. On the other hand, this plan provides evidence of:

a) Lifetime of the NPP SSCs.

b) Cost of their maintenance.

c) Cost of their replacement.

d) Change management.

A PLiM Plan provides a systematic analysis for early detection of the ageing effects of Critical SSCs (CSSC). The performed tasks are the precursor of refurbishment and modernization activities for a possible long term operation.

Furthermore, ageing management allows the control, improvement and update of the operation, maintenance (predictive, preventive and corrective), modification, chemistry monitoring and in-service inspection programs, among others, for them to be more effective.

There are several methodologies for the development of PLiM plans in the international practice. Some FORO member countries have accepted, among others, the analysis methodologies mainly developed by the American RB (USNRC) in the License Renewal Rule, 10CFR54 “Requirements for Renewal of Operating Licenses for NPP” [19], or the ones developed by the Canadian RB (CNSC) known as “Ageing and Ageing Management in CANDU Nuclear Power Plants” [17] or RD – 360 “Life Extension of NPP” [16].

In any case, and regardless of the adopted methodology, a set of basic documents subject to assessment by the RBs must exist, in which licensees will embody the objectives and basic principles of ageing management, as well as the methodology and results of the analyses performed in every stage of the process. These documents subject to assessment, shall be complemented by others which the licensee shall incorporate during the different inspections that the RB shall perform on ageing management during the different phases of the NPPs’ lifetime (in accordance with the TD3.).

5.2. Basic Aspects of a Plant Life Management (PLiM) plan

A PLiM plan shall include a basic ageing management strategy of the SSCs by the licensee during the NPP’s design life period, and shall at least allow the detection, measurement and control of natural ageing and obsolescence of SSCs, as well as the ageing caused by their operation under severe or adverse conditions.

It is important to observe that the number of stages or phases of a PLiM plan depends on the methodology used by the licensee’s organization. It is worth mentioning that in most IAEA member countries, a PLiM plan is considered a document of mandatory nature. In this case, the RB shall have to establish a definite period of time for the execution of the updates of such plan. These
periods normally vary from 1 to 5 years.

The PLiM plan shall be complemented by a periodic report in which the licensee shall include the main activities regarding ageing management performed during the previous period, following the criteria and methodology presented in the PLiM plan. The TD1 provides guidelines on these aspects.

The basic contents for the development of a PLiM plan are hereinafter dealt with.

The first step of a PLiM plan is to develop the policy, plans and procedures which shall outline the basic rules to perform its implementation at the NPP, for what it is necessary to have the following documents at disposal:

5.2.1. Policy

a) Defines the main elements of the plan.
b) Defines roles and responsibilities: it may include the specific personnel for the PLiM plan, as well as the structure for the necessary organization.

5.2.2. Plan

a) Details of the general plan and strategies: Specific goals and schedule.
b) Identification of necessary training, tools and sources of information.

5.2.3. Procedures

Procedures for the analysis of factors such as:

a) Plan implementation process.
b) SSC prioritization process.
c) Implementation procedure of ageing management and measurement of results.
d) SSC assessment methodologies (Condition Assessment, Life Assessment, maintenance systematic assessment, etc.)
e) Analyses monitoring process.
f) Quality Assurance.
g) Plan verification.
h) Improvement and feedback processes.

The development of this plan includes the analysis of CSSCs, through the implementation of assessment methodologies, as a basic task.

These tasks are supported by the plant programs in course and they require an analysis to guarantee that all ageing effects are considered.

Such analyses must be systematic, rigorous, and must adapt to the SSCs complexity.
The PLiM plans are supported by a series of more specific documents, which contain the details of
the analyses related to the different phases of ageing management. It is common that PLiM plans
refer to specific analyses regarding:

a) The scope and screening of components (mechanical and electrical components,
instrumentation and control, and structures),

b) Analyses of ageing phenomena and degradation mechanisms,

c) Specific Ageing Management Programs (AMP).

5.3. Aspects Subject to Assessment

A series of aspects regarding the PLiM plan shall have to be assessed depending on the phase in
which the NPP is in. In some cases, those aspects are coincident for the different phases, while
others are characteristic of a particular phase, as in the case of AMPs. Guidelines on the various
aspects to be assessed during the design life are hereinafter provided:

5.3.1. Organizational and Managing Aspects

Main aspects to assess:

a) Licensee’s organization related to ageing management

Regarding the organization, group or committee formed at the NPP for the management of
the aspects related to ageing management, the assessment shall have to include:

i.) Composition

The group or committee shall be integrated, preferably, by internal experts in
different disciplines or activities involved in the AMPs.

Some examples of the disciplines or activities which could be involved are
hereinafter listed:

(1) Maintenance (mechanical, electric, I&C, etc.).
(2) Maintenance Rule (MR).
(3) Design Modifications (DM).
(4) In-service Inspection Programs
(5) Environmental Qualification
(6) Periodic tests
(7) Operative Experience
(8) Research and Development
(9) Operation

ii.) Functions and activities to be developed by these groups

iii.) Hierarchical relationships

iv.) Frequency of meetings, topics dealt with, and made decisions.
v.) Ensure that in the organization there is a personnel responsible for the practical aspects in regard to the AMPs.

vi.) Assurance that the allocated resources are sufficient and adequate.

vii.) Assurance that responsibilities are clearly defined at all levels.

viii.) Assurance that the personnel involved in ageing management activities has the necessary knowledge in the specific aspects of this field.

Information about the previously mentioned aspects shall be incorporated in the PLiM plan, as well as in associated periodic reports. This information shall be complemented by the obtained from the inspections performed by the RB to the NPP, regarding ageing management.

b) Acquisition and registration of information regarding ageing management.

According to Safety Guide NS-G-2.10 of IAEA, section 4 [2] and the TD4, the licensee shall have to count on a systematic acquisition and registration system of data to support AMPs.

The evaluator shall perform verifications oriented to assess such system (data, analyses, etc.), by checking its main characteristics and effectiveness.

The establishment of this system at the beginning of the NPP’s design life is the most appropriate action to take in order to have a more complete data register. This information is essential to make decisions that prevent the loss of equipment functionality.

The data to be registered shall have to be related to the different phases of the management process. The data obtained as a consequence of tests, inspections and controls regarding the practical application of the AMPs are of special significance. This information shall allow the diagnosis of components and structures, as well as the consequent establishment of a management strategy to preserve their functionality.

Additionally, the documentary quality of methodological aspects and of the analyses results shall have to be assessed. These results must be properly documented and subject to the existing quality system controls at the NPP.

c) Monitoring of the commitments with the RB

The level of progress or the effective resolution of the commitments adopted by the licensee as a result of previous assessments or inspections shall be evaluated.

Apart from the information contained in the periodic reports, the information obtained during assessments and inspections shall be essential for the evaluation. This acquisition of information shall be included in the inspection schedule.

5.3.2. Periodic Reports

The aim of the periodic reports of the PLiM plan is to inform the RB about the main activities regarding ageing management performed by the licensee during the previous period. Such reports...
are basic documents which allow knowing the progress and evolution of the ageing management activities performed by the licensee. Furthermore, they allow knowing the current condition of components and systems, which shall enable the identification of degradation mechanisms related to ageing.

The TD1 provides general guidelines regarding these reports.

The basic points usually addressed in these reports in a general manner and whose proper development shall be subject to assessment are hereinafter listed:

a) Updates of organizational aspects.

b) Summary of meetings and performed activities within the specific existing management committee at the NPP for the development of activities and AMPs.

c) Basic ageing management activities performed by the licensee during the period (performance of new analyses, or review and update of existing ones), including an updated list of scheduled documents and analyses, with their reviews and conditions.

d) Monitoring of commitments with the RB, results of assessments and inspections performed on the ageing management.

e) Results related to the application of AMPs (performed activities, condition of components and structures, new Improvement Proposals, etc.).

f) Monitoring of Improvement Proposals (IP).

g) Results related to the participation of licensee’s representatives in research or work groups, related to the ageing management of SSCs.

5.3.3. Scope and screening of SSCs

A great percentage within the wide range of SSCs of a NPP can be replaced during routine operation, but there are other SSCs whose early replacement would involve either a high economic cost or a high dose cost for the personnel. This could question the feasibility of the NPP operation continuance.

In order to avoid these kind of situations, it is important that the licensee, prior to the development of a PLiM plan, performs a study for the identification and screening of CSSCs, by establishing a prioritization scheme to be dealt with by an analysis methodology during the development of the PLiM plan.

In international practices, different methodologies for the screening of SSCs are recognized.

The assessment is based on the fact that the licensee will screen the methodology deemed most appropriate to perform the analyses related to the scope and screening of SSCs and shall provide the RB with the basic principles of the screened methodology; the RB shall approve such methodology, applying modifications, limits or conditions to it, if necessary.

The TD1 provides guidelines to establish criteria regarding the SSCs scope in the PLiM plan, from a nuclear safety point of view.
and criteria of such methodology, with the final purpose of concretely define those SSCs within the scope.

The resulting information shall be organized by systems or type of components (“commodity” type groups). It is expected that each component or structure within the scope of the PLiM plan is identified with a specific name or code. This shall facilitate the review of present and absent elements on the final list.

The licensee shall send a list of the SSCs within the scope, with mandatory acceptance of the RB, before being included in the PLiM plan. The RB shall reserve the right to require or recommend the inclusion of other SSCs not previously considered by the licensee.

Based on the aforementioned information, the basic aspects to be assessed are:

a) The methodology defined by the licensee to determine the scope and screening of the SSCs which shall be subject to the ageing management process.

b) The result of the application of such methodology onto different SSCs of the NPP.

The assessment of these aspects shall require, on behalf of the evaluators, the usage of different kinds of technical documentation, especially of those documents related to the licensing terms of the NPP. Some of them are hereinafter mentioned:

a) Safety Analysis Report (SAR), project bases and technical specifications; normal, abnormal and emergency operating procedures, and guides or procedures for severe accident management;

b) Reports of equipments with seismic qualification;

c) Reports related to natural external events, such as floods, storms, hurricanes, tornadoes, earthquakes, tsunamis, etc., as well as internal events such as fire hazards, internal flood, etc.

d) Probabilistic Safety Analysis (PSA) to identify important SSCs from the hazard point of view;

e) Environmental Qualification analysis or study of electric and I&C equipments;

f) Technical reports, submitted to the RB, dealing with phenomena such as pressurized thermal shock transients, anticipated transients without automatic reactor shutdown, and complete loss of electric power;

g) Documentation associated with the enforcement of MRs on equipments, when applicable;

h) Plans and diagrams of the systems important to safety;

i) Analysis for the enforcement of new regulations.

5.3.3.1. Assessment of Methodological Aspects for the Scope and Screening of SSCs Determination.

5.3.3.1.1. Scope
The criteria used for the screening of SSCs are very similar among the methodologies used internationally. The applicable criteria shall be in accordance with the criteria in TD1:

a) Include those elements which must keep functioning during and after any design basis event that may arise, to guarantee the following functions:

i.) Integrity of the reactor coolant system pressure boundary,

ii.) Capability to shutdown the reactor and maintain it in a safe shutdown condition; or

iii.) Capability to prevent or mitigate accident effects in order to maintain radiation exposure out of the site below the established limits.

b) Include those elements whose failure could prevent the satisfactory fulfillment of any of the aforementioned functions.

c) Include those elements available in the NPP’s safety analysis, and that are related to the requirements for fire protection, environmental qualification, pressurized thermal shock, anticipated transient without automatic reactor shutdown, and total loss of electric power.

The main aspects to be assessed, according to the scope definition methodology, are:

a) General methodology used for the scope definition of mechanical and electrical components, I&C and structures.

It is the purpose of this item to assess the scope and screening general process, meaning, the different phases or stages followed by the licensee in the definition of the SSCs which shall be subject to the ageing management analysis process. Special attention shall be given to the sequential logic followed during the analysis; the documents developed in the process, used computer tools, etc.

It is worth emphasizing that the methodology, despite being common in general terms, could entail certain differences depending on whether it is about mechanical or electrical components, I&Cs or structures. These methodological differences shall be checked by the evaluator in order to verify their effectiveness within the scope definition.

The evaluator shall have to put special emphasis on the sources of information used by the licensee for the identification of structures and components of the plant, as well as of the intended safety functions performed by each one of them (databases, plans, manufacturer catalogues, licensing terms documents, etc.) This aspect shall illustrate the level of comprehensiveness applied in the process.

The component or structure grouping method chosen by the licensee to perform the ageing management analyses shall have to be verified. The aim of this verification is to reasonably ensure that there is no omission of SSCs.

In this context, there are two possibilities:

i.) “Commodity” grouping type, understood as the joint consideration of elements with
similar characteristics or properties that justify their consideration grouped in future ageing phenomena analyses.

ii.) System grouping, following the natural organization considered at the NPP.

b) Identification of intended safety functions at system and complex structure level.
The intended safety functions of a system or complex structure are those which justify their inclusion within the scope because of their compliance with one of the criteria established in the TD1. Therefore, the limits or “fractions” of the system or structure which complies with at least one of the criteria shall be defined.

Regarding the assessment, and at methodology level, the usage that the licensee has given to the concept of intended safety function within their scope analysis shall be verified.

c) Intended safety functions at component level.

The identification of intended safety functions at component level performed by the licensee shall be verified, understanding by them as those that contribute to the scope of the intended safety function of the system or structure they belong to.

The elements of the system or complex structure within the scope shall have to:

i.) be within the scope limits defined for the system or structure.

ii.) perform an intended safety function in an individual manner.

The assessment shall have to give special attention to those components or structures that could have several intended safety functions, such as heat exchangers or orifice plates, to ensure that no omission has been made, as the correct identification of intended safety functions shall condition the subsequent identification of degradation phenomena.

d) Verification of the identification of SSCs whose functions are Safety Related (SR), according to the criteria in 5.a or 5.c from the TD1.

The order followed for the identification of SR SSCs shall be specifically assessed. The SSCs with intended safety functions clearly defined in the documents of the NPP’s licensing terms shall be incorporated within the scope. They will typically be the nuclear class SSCs, with their support systems, as found in the SAR, design bases, etc.

The specific documentary sources considered by the licensee for this definition shall be assessed in order to determine whether they are sufficiently complete so as to reasonably assure the correct identification of the involved SSCs.

e) Verification of the identification of SSCs whose functions are Non Safety-Related (NSR), according to the criterion in 5.b from the TD1.

The process followed by the licensee for the identification of NSR SSCs whose failure could prevent the compliance with safety-related functions (according to the TD1), shall be assessed. The licensee shall have to bear in mind the intended safety function performed by each SSC and the set of existing physical and functional relationships among them.

The following aspects shall be taken into account in the assessment:

1) The magnitude of the analysis performed by the licensee shall mainly depend on the
used sources of information. Therefore, their extension and adaptation shall have to be verified.

ii.) It shall be ensured that the licensee considered in the analysis those structures or components identified as NSR in the design basis, but whose failure could make safety components fail. The intended safety function of these components is usually identified in this context as NSR.

The components identified as NSR in the License basis, but whose function is to protect SR structures and components in the case of failure or rupture of certain elements with which they have a spatial relationship, shall also be considered.

iii.) It shall be verified that the licensee had proceeded to the identification of NSR elements physically connected to SR components (typically, piping).

iv.) Finally, it shall be verified that the licensee has analysed the case of those NSR components which, without being physically connected to SR components, have a spatial proximity relationship with them in such a way that SR components’ failure could prevent their intended safety functions fulfilment. This is equally applied if there is a functional relationship between both types.

The components complying with the aforementioned requirements shall be incorporated within the scope for their NSR function. For the assessment of relationships (spatial and functional) among components, the following aspects shall be considered:

(1) If the safety element has a qualified design to fulfil its intended safety function, it is understood as prepared to resist the conditions caused by the failure of the NSR component. Therefore, its inclusion within the scope shall not be necessary. This shall be also applied if the safety element was designed following the “fail-safe” criterion.

(2) If the NSR component or structure contains air or gas inside, its rupture shall not be regarded as a threat.

(3) If the relationship between components is spatial, the licensee may include the existing protection elements with mitigation function within the scope, instead of the NSR elements with possibility of failure.

(4) The non inclusion within the scope of a NSR element with possibility to affect another SR one shall not be considered as acceptable, based on the fact that there are several redundancies of the SR one.

(5) NSR equipments improved by appropriate surveillance or monitoring programs which are used for the maintenance of the design analysis initial hypotheses, shall not be included within the scope. It is considered that the regulating programs, requirements and restrictions which already exist for them, assure their ageing control.

(6) The criterion which states that any malfunction of a NSR SSC involving the acting of a SR SSC does not justify its inclusion within the scope shall be applied, as this fact does not allow assuming the loss of intended safety.
function of the RS SSC.

(7) For those NSR SSCs which provide support for SSCs qualified as SR, the cascading effect shall be considered up to a relation level similar to the one established in the licensing terms.

That would be the case, for instance, of a coolant pump regarded as a safety component, whose sealing system is cooled by a non safety pump, which is in turn powered by a non safety electric system.

f) Identification of SSCs related to certain regulatory requirements.

The process followed by the licensee for the identification of SSC which comply with the criterion in 5.c from the TD1, related to requirements regarding fire safety, environmental qualification, pressurized thermal shock, anticipated transients without automatic reactor shutdown, and complete loss of electric power, shall be assessed.

For the assessment of this aspect, the specific documentary sources considered by the licensee for this definition shall be assessed in order to verify whether these used documentary sources are sufficiently complete so as to reasonably assure the correct identification of the SSCs involved.

g) Special associations of elements.

An assessment shall be performed on some particular associations made by the licensee of components or structures which are not a priori evident, as they belong to different types of elements. Piping supports or cable trays are examples of elements which could be included within the structure category and not in the mechanical or electrical component category, as it could be a priori expected.

h) Itemization of complex components in subcomponents.

Another aspect to be assessed is the development performed by the licensee of a systematic itemization of complex components in subcomponents with different materials and environments (for example in the case of a heat exchanger, its tubes, casing, bolts, nozzles, distribution plates, support plates, etc. should be distinguished, as the materials and environments shall be different in each case).

i) Components within the scope by exploitation criterion.

Those components and structures that the licensee decides to include within the scope for availability reasons, replacement costs, etc., shall be clearly distinguished from the ones complying with the safety scope criteria from the TD1. Therefore, it shall be verified that the information regarding these elements of interest by exploitation criterion is separately submitted.

5.3.3.1.2. Screening

Once the methodological aspects related to the scope definition process have been assessed, follows the assessment of the aspects related to the screening process of components and structures.
The screening process is performed on the basis of the components and structures obtained as a result of the scope process.

The SSC screening criteria are very similar among themselves at international level. The following are among them:

a) Passive components whose early replacement would involve either a high economic cost or a high dose cost for the personnel. This could question the feasibility of the NPP operation continuance. The active components shall have to be properly controlled by the application of preventive or corrective maintenance during a routine operation. These passive components and structures:

i.) include among others: the reactor vessel, the reactor coolant system pressure boundary, steam generators, the pressurizer, piping, pump casings, valve bodies, feeders, fuel channels, the calandria, the core barrel, component supports, pressure-retaining barriers, heat exchangers, fan casings, ventilation ducts, the containment, the containment cladding, electrical and mechanical penetrations, equipment airlocks, seismic Category 1 structures, wires and electrical connections, cable trays, and electrical cabinets.

ii.) exclude among others: pumps (except their casing), valves (except their body), motors, diesel generators, air compressors, snubbers, the control rods drive, ventilation gates, pressure transmitters, pressure and level indicators, switchgears, fans (except their casing), batteries, switches, relays, power inverters, circuit boards, battery chargers, and electrical power sources.

b) Components and structures which are not included in any replacement program based on the qualified life maintenance or any other replacement program.

Two examples of SSC scope and screening methodologies, synthesized in schemes, are shown in Figures 1 and 2. Prior to the development of the PLiM Plan or AMP, and according to the identification and screening criteria of SSC, a prioritization scheme of SSCs of economic relevance or importance to safety is established.

The analysis of the less important SSCs, which only suppose a residual risk, is omitted in Figure 2.

The RB shall approve such methodology, applying modifications, limits or conditions, if necessary. The licensee, by applying this methodology, shall prepare a list of the resulting SSCs, with mandatory acceptance of the RB, before being included in the PLiM plan. The RB shall reserve the right to require or recommend the inclusion of other SSCs not previously considered by the licensee.
Regarding the methodological approach adopted by the licensee, the practical experience shows that the aspects to be assessed related to the screening methodology are very similar, with some slight exceptions.

The main aspects to be assessed, in regard to the screening methodology, are hereinafter defined:

a) Passive components identification process.

It shall be verified that the licensee has followed an effective procedure for the identification of those components and structures which are passive within the scope.
The frequent manner to proceed consists in the performance of any kind of selective consulting of a database on components and structures of the NPP. In that case, the assessment shall focus on verifying the structure of the database, type of the performed consulting, its entire amount of contents, etc.

In those cases in which the aforementioned procedure is not the one followed or in which the licensee has made use of the database and the manual analysis of different documentation of the plant as a complementary method, the assessment shall check these sources and their adaptation for the purpose of the screening process. These verifications shall be mainly based on the information obtained from an inspection of the plant.

![Diagram](image)

Figure 2. Scope and Screening scheme of SSCs of economic relevance or importance to safety to be addressed in a CANDU nuclear power plant PLiM plan.

b) Identification of passive parts of active components.

It shall have to be verified that the methodology followed by the licensee, assures the inclusion of the passive parts of active components, such as pump casings, fans, valves, etc.

c) Components experiencing changes in their properties.

The assessment shall have to ensure that the employed methodology guarantees the non screening of those apparently passive components, but which experience a change in their properties, condition, etc., (typically, many instrumentation equipments).
d) Identification of long life components.

Finally, the process followed by the licensee for the identification of components which, besides being within the scope and being passive, are long life components, meaning that they are not subject to any kind of periodic replacement program during the NPP’s lifetime, shall be assessed. The sources of information used by the licensee, being typically maintenance procedures, work order records, catalogues and supplier recommendations, etc., shall be verified.

5.3.3.2. Assessment of results related to the application of the Scope and Screening Methodology.

The purpose of this section is to provide guidelines so that the evaluator verifies whether the scope and screening methodology has been properly applied and if the obtained results are satisfactory.

In this sense, except for particular justified cases, the sampling methodology shall be the one to be followed by the assessment; this means the screening of a finite set of SSCs onto which the assessment criteria shall be applied.

If the results of the initial sample assessment are not satisfactory, then the sample can be broadened. There shall be several criteria for the screening of the samples and they will be adapted to the element subject to assessment, as well as to the phase the NPP is at.

Some general criteria which can be applied for the definition of assessment samples are the ones based on the identification of:

a) SSCs especially important to safety.

b) SSCs with greater preponderance in the PSA assessments.

c) SSCs representative of different categories or types (reactor and internals, safeguards, auxiliary systems, electric systems and I&C, etc.).

d) SSCs recommended by internal or external operative experience.

e) SSCs with especially critical operating conditions, or especially vulnerable materials and environments.

f) SSCs with design attributes not fully demonstrated by testing.

g) SSCs with multiple functions in the MR, if applicable, or which support multiple systems.

h) SSCs not assessed in the past.

i) SSCs that have experienced changes due to design modifications, repairs, etc.

Taking the previous considerations as a base, the main aspects to be assessed are hereinafter defined.
a) General results at system and complex structure level.

i.) Final list of structures and complex systems contents.

It will be verified, from the final list of systems and complex structures resulting from the scope process, that other systems and structures clearly expected due to the intended safety functions they perform, are not absent.

As a complement of the previous assessment, a system or structure not included in the scope list shall be screened, with the purpose of verifying that indeed, it does not perform any intended safety function.

ii.) Definition process of the systems and structures within the scope.

In order to verify the correct implementation of the methodology, several systems and structures included in the final list shall be screened to check the correct identification of their intended safety functions and consequently, the system’s fractions within the scope.

b) General results at mechanical type component level.

Classically, these components shall belong to systems within one of the following categories:

i.) Reactor coolant systems (vessel and internals, pressure boundary, steam generators, etc.)

ii.) Technological safeguard systems (containment dousing system, containment insulation system, high pressure injection system, etc.).

iii.) Auxiliary systems (ventilation systems, cooling systems, etc.).

iv.) Power conversion and steam systems (turbine, main steam system, condensing system, etc.).

For mechanical type components, the assessment shall focus on the performance of the following verifications:

i.) Identification of mechanical components within the scope and screening.

The verification of the correct identification of individual components within the scope shall begin with the previously screened systems based on the intended safety function they perform.

Special attention shall be given to the boundary components among fractions within and out the scope, as well as to the components that the licensee concluded are not within the scope at component level, despite being within the system’s scope. In this case, the reasoning endorsing their exclusion shall be verified.

In the case of the components identified within the scope, it shall be verified that they are indeed passive and have a long life.
ii.) Particular case of “commodity” type groups.

In those cases in which the licensee has chosen to organize the components in “commodity” type groups, some of them shall be screened to verify that certain significant components of the plant are on the list associated with such group.

Some NSR components within the scope of the criteria in 5.b from the TD1 will be screened. It shall be verified, by means of the analysis performed by the licensee, that methodological aspects related to this criterion have been properly applied, obtaining satisfactory results.

In the case of the components identified within the scope, it shall be verified they are indeed passive and have a long life.

iii.) Specific verification of the screening criteria.

As a complement to previous verifications, several components within the scope (with a defined intended safety function) will be chosen, which have not been finally screened, so as to check that they do not comply with any of the screening criteria (passive and long life) and that their exclusion is well-grounded.

c) Results at structural component and structure level.

Typically, the structures and structural components resulting from the scope and screening process shall be included within one of the following categories:

i.) Structure of the primary containment.

ii.) Other main structures, such as the structure of the emergency diesel generators’ building, the auxiliary building, and the turbine building, etc.

iii.) Structural components such as: cable trays, piping supports, elastomers to mitigate vibration, equipment supports, ventilation ducts’ supports, etc. Non safety structures, but whose failure could prevent the performance of a component or safety structure’s safety function, for instance, seismic category II structures with respect to others of seismic category I.

For structures and components of structural type, the assessment shall focus on the performance of the following verifications:

(1) Identification of structures and structural components within the scope.

Several complex structures within the scope shall be screened (e.g. the containment building) to verify that the structures and structural components with intended safety function that belong to them have been properly identified (e.g. foundations, slabs, cable trays, piping supports and ventilation ducts’ supports, curbs, frames, bellows, containment walls, sheathings or liners, mechanical penetrations, sinks, etc.).

It shall be also verified that the intended safety function is clearly identified in all cases, and that based on that fact, the inclusion within the scope has been
justified.

(2) Particular case of “commodity” type groups

If the licensee has chosen to organize the analyses in “commodity” type groups, one of the groups related to complex structures shall be screened to verify that certain structural components, included in the group and which should be within the scope for the intended safety function they perform, are indeed on the list associated with the structural “commodity”.

(3) Verification of the screening criteria

Most structures and structural components within the scope shall comply with the screening criteria, as they are passive and have a long life. The verification shall focus on the justification provided by the licensee in those cases excluded from the final list due to screening reasons.

d) Results at electrical type components and I&C level.

The typical components in this area will be the wires, phase bars, high-voltage conductors, electrical penetrations, connectors to ground, connectors, insulators, etc.

The assessment shall focus on the following verifications:

i.) Identification of electrical type components and I&C within the scope and screening.

Several electric systems and I&C within the scope shall be screened to verify that individual components have been correctly identified, taking the intended safety function performed by each one of them as a base. Additionally, it shall be verified that such components are passive and have a long life.

ii.) Particular case of “commodity” type groups

In the cases in which the licensee has chosen to organize the components in “commodity” type groups, some of these groups will be screened to verify that certain significant components, clearly within the scope due to the intended safety function they perform, are in the list of components of such group and that they are passive and long life components.

In NSR components that due to their characteristic intended safety function should be included within the scope of the criteria in 5.b from the TD1, it shall be verified by means of the analysis related to them whether the methodological aspects related to this criterion have been properly applied by the licensee, obtaining satisfactory results.

iii.) Verifications related to the “analysis by areas”

The “analysis by areas” consists in the analysis of a set of components which belong to different electric and I&C systems within the scope, all of them with an intended safety function, located in the same site or area, and which comply with the limit environmental conditions characteristics of such site or area.

In those cases in which the licensee has used the “analysis by areas” methodology for the definition of the scope, one or some areas within the scope shall be screened to
verify that those individual components comprising it have been considered. Additionally, one or several areas that have not been included within the scope shall be screened so as to verify that there are no components with intended safety functions complying with the inclusion criteria.

iv.) Specific verification of the screening criteria

As a complement to previous verifications, several elements within the scope, but which in the end did not comply with the screening criteria, shall be screened. It shall be verified whether their exclusion is properly justified.

v.) Environmental qualification

It shall be verified that all electrical and I&C components which are not only passive and have a long life, but are also subject to environmental qualification, have been properly identified. These components shall be analysed in the corresponding Time-Limited Ageing Analysis (TLAA).

5.3.4. Ageing Management Review

In this section, the main purpose of the assessment shall be to ensure that the ageing effects in SSCs are properly managed, in such a way that the corresponding intended safety functions are maintained throughout the NPP lifetime.

Prior to dealing with the aspects to be assessed related to this point, it is considered appropriate to develop a synthesis of how is ageing managed according to different approaches. This shall help to understand which aspects are dealt with by the methodology and what elements need to be assessed.

It is important to mention that despite the fact that the methodologies are different, they all tend to properly assure the ageing management of NPPs’ SSCs.

In those NPPs that have not used the American ageing management methodology as a basic reference, as in CANDU type NPPs, the implementation of the ageing management is performed throughout a unique life management process which is developed in 3 phases (see Figure 5)

A synthesis about the application of a PLiM plan and about the aspects it deals with, based on the CANDU methodology and in comparison with the American methodology is hereinafter exhibited. Along with the description of the process, some guidelines for the RB’s evaluation are presented. Afterwards, general guidelines are provided for the assessment of different aspects associated with the ageing management review.

5.3.4.1. Phases and Contents of a PLiM Plan

5.3.4.1.1. PLiM Plan for CANDU Nuclear Power Plants

Phase I
Table A shows the steps contained in Phase I of a PLiM Plan for NPPs with CANDU reactors, in accordance with the methodology developed by AECL known as “Plant Life Management for CANDU Reactors” [18]. The first step of such phase is to develop the policy, plans and procedures which shall outline the basic rules to carry out its implementation at the NPP. It is important to mention that this step is similar to the American ageing management
methodology.

The development of this phase consists in the analysis of CSSCs, through the implementation of assessment methodologies. Condition Assessments, Life Assessments, and the systematic maintenance assessment are among them. Such methodologies are applicable to CANDU NPPs, and are not considered in the American methodology.

These assessments are supported by the plant programs in course, and require an analysis to ensure that all the ageing effects are considered. Such analyses are systematic, rigorous, and can be adapted to the complexity of SSCs.

Table A. Summary of the PLiM Plan phases for a CANDU Nuclear Power Plant.

<table>
<thead>
<tr>
<th>PLiM Plan Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Defines the main elements of the program</td>
</tr>
<tr>
<td>• Defines the roles and responsibilities: it may include the specific personnel for the PLiM Plan as well as the necessary structure of organization.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Details of the program in general and strategies: specific goals and schedule.</td>
</tr>
<tr>
<td>• Identification of training, tools, and necessary sources of information.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedures for Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Implementation process.</td>
</tr>
<tr>
<td>• Prioritization process.</td>
</tr>
<tr>
<td>• Implementation procedure for life management and effectiveness measurement (performance).</td>
</tr>
<tr>
<td>• Condition Assessment.</td>
</tr>
<tr>
<td>• Life Assessment.</td>
</tr>
<tr>
<td>• Systematic maintenance assessment.</td>
</tr>
<tr>
<td>• Process for the monitoring of analyses.</td>
</tr>
<tr>
<td>• Quality Assurance.</td>
</tr>
<tr>
<td>• Plan Verification.</td>
</tr>
<tr>
<td>• Feedback and improvement process.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment methodologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Condition Assessment.</td>
</tr>
<tr>
<td>• Life Assessment.</td>
</tr>
<tr>
<td>• Systematic assessment of maintenance.</td>
</tr>
</tbody>
</table>

**Condition Assessment Report**

The purpose of a condition assessment report is to establish the current condition of SSCs and to provide a life prognosis for them, both to reach their design life, and their possible Life Extension (long term operation). This is based on a detailed study on degradation mechanisms and the development of models which allow foretelling their behaviour (See Figure 3 for Phase I).

The results of this stage or Phase I shall be registered in a condition assessment report, which will provide a preliminary assessment on ageing degradation of the screened SSCs (Phase II).

In addition, this condition assessment report shall establish the research and development works to be performed in the next phase (Phase III), for a better understanding of ageing mechanisms, their monitoring, and the necessary mitigation actions.
The condition assessment report, included in the PLiM Plan methodology of CANDU reactors, shall have to be permanently updated. These updates shall have to be performed after the scheduled reviews, as they provide important information on the SSCs, or when other events or relevant changes suggest it. After the issuance of the initial condition assessment report or of one of its updates, it shall have to be assessed especially considering the ageing management proposals.

These proposals may include changes in the chemistry in the systems, modification in the operation processes, new monitoring methods, more detailed studies of the degradation mechanisms, SSCs’ modification, repair or replacement, etc.

![Diagram of Phase I basic scheme of the CANDU-PLiM Plan.](image)

Figure 3. Phase I basic scheme of the CANDU-PLiM Plan.

The typical contents of a condition assessment report can be observed in Table B.

The analysis of possible options to solve the set out problems shall be performed by taking into consideration the acceptability of the solutions proposed by the RB, who shall also:

a) Review the condition assessment reports of SR SSCs, by verifying that the assessment methodology is appropriate.

b) Ensure that the report is complete and that it reflects the plant’s real situation.

c) Assess whether the inspection or data gathering techniques are appropriate and if the personnel performing these tasks is qualified and trained as demanded.
d) Assess whether the recommendations are sufficient or adequate, and shall identify deviations.

e) Determine recommendations critical to safety.

f) Control the implementation of recommendations or modifications.

g) Be able to require an increase in the frequency and a broadened scope of the inspection to a particular SSC.

Table B. Aspects to consider in the condition assessment report of a SSC.

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>MINIMUM CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION AND OBJECTIVES</td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Functions</td>
</tr>
<tr>
<td></td>
<td>• Scope and outlines</td>
</tr>
<tr>
<td></td>
<td>• Design specifications and codes</td>
</tr>
<tr>
<td></td>
<td>• Design changes</td>
</tr>
<tr>
<td></td>
<td>• Environmental qualification</td>
</tr>
<tr>
<td></td>
<td>• Subcomponent prioritization</td>
</tr>
<tr>
<td></td>
<td>• Construction / Manufacture, assembly and materials</td>
</tr>
<tr>
<td></td>
<td>• References</td>
</tr>
<tr>
<td></td>
<td>• Annexes</td>
</tr>
<tr>
<td>DESCRIPTION AND FUNCTIONS</td>
<td>• Chronological record of events</td>
</tr>
<tr>
<td></td>
<td>• Chemistry controls</td>
</tr>
<tr>
<td></td>
<td>• References</td>
</tr>
<tr>
<td></td>
<td>• Annexes</td>
</tr>
<tr>
<td>OPERATION RECORD</td>
<td>• Corrective maintenance</td>
</tr>
<tr>
<td></td>
<td>• Preventive maintenance and inspections</td>
</tr>
<tr>
<td></td>
<td>• Predictive maintenance</td>
</tr>
<tr>
<td></td>
<td>• Obsolescence / Manufacturer information</td>
</tr>
<tr>
<td></td>
<td>• References</td>
</tr>
<tr>
<td></td>
<td>• Annexes</td>
</tr>
<tr>
<td>MAINTENANCE AND INSPECTIONS</td>
<td>• Possible degradation mechanisms</td>
</tr>
<tr>
<td></td>
<td>• Assessment of existing degradation mechanisms at the NPP</td>
</tr>
<tr>
<td></td>
<td>• Degradation mechanisms matrix</td>
</tr>
<tr>
<td></td>
<td>• References</td>
</tr>
<tr>
<td></td>
<td>• Annexes</td>
</tr>
<tr>
<td>ASSESSMENT OF DEGRADATION MECHANISMS</td>
<td>• Conclusions</td>
</tr>
<tr>
<td></td>
<td>• Life prognosis</td>
</tr>
<tr>
<td></td>
<td>• Recommendations</td>
</tr>
</tbody>
</table>

Permanent monitoring is applied on each SSC, out of the data gathered from the operation, maintenance, the in-service inspection program, surveillance programs, operative experience, etc.
From the particular analysis of each condition assessment report, a general assessment of the set of condition assessment reports and the technical-economic assessment reports is performed. The result is registered in an integrated condition assessment report on the NPP’s lifetime management, as illustrated in Figure 4.

![Figure 4. Scheme of the integrated condition assessment report of a CANDU Nuclear Power Plant Phase II](image)

This stage consists of a detailed study on ageing knowledge, in order to deepen the conclusions obtained at the preliminary studies stage, particularly those weak points related both to technology and to the safety functioning of the SSC during its lifetime.

Main scheduled tasks:

a) Research and development studies to improve the current knowledge on significant ageing mechanisms and determine the root causes of the SSCs’ ageing degradation.

b) Studies on the monitoring of ageing with the purpose of verifying the existing diagnosis and the existing data assessment techniques or developing new ones, capable of detecting the SSC’s ageing degradation in a timely manner.

c) Studies on ageing mitigation to improve the existing methods or to develop new ones, operation and maintenance practices or new designs, necessary to control the ageing degradation of an SSC.
d) Preparation of the report on this stage detailing the conclusions obtained in the previous items.

Phase III

This phase considers the Plant Life Extension (PLEX) Project of a CANDU NPP and includes modernization, refurbishment, and long term operation tasks.

If the assessments performed on the SSCs in the previous phases showed that the design life is achieved in good conditions, this would allow the licensee to propose the possibility of facing a PLEX Project with view to the long term operation (LTO).

At Phase III, the technical and economic studies supporting such decision are performed, as well as the engineering of the PLEX and the implementation of modernization and refurbishment changes which shall guarantee the LTO of the plant in safe and economic conditions. (See Figure 5)

![Figure 5. Phases of the Life management process in a CANDU reactor](image_url)

5.3.4.1.2. PLiM plan for PWR, BWR and PHWR with vessel

In order to make reference to a PLiM plan, the American methodology employs the terminology of the Ageing Management Programs (AMPs), which are usually several at a NPP.

The AMPs are a structured set of activities oriented to the surveillance, control and mitigation of ageing effects affecting the SSCs important to safety. The AMPs are based on different practices of predictive, preventive and corrective maintenance, environmental qualification programs, periodic tests and surveillances of the technical specifications, in-service inspection programs, erosion-corrosion programs, etc., as well as any other specific activity that could be performed at the NPP with the same purpose.
It is important to highlight that, by following the American methodology, certain systems or sets of “commodity” type groups are gathered in specific AMPs which have a similar set of maintenance, inspection and control activities.

For the assessment, the starting point is the final list of mechanical, electrical and I&C systems and components, as well as of structures (including structural components) which have complied with the scope and screening phase.

The logical sequence to develop the ageing management analysis supposes, firstly, to determine the materials and environments which correspond to the different elements within the scope and screening. Secondly, and based on these two fundamental parameters, the ageing mechanisms and associated effects are identified. Finally, the appropriate AMPs for the control of the ageing mechanisms and effects previously mentioned are defined.

As well as in the scope and screening phase, the licensee shall have defined a general methodology to perform the associated analyses. As a result of the guidelines application and criteria of such methodology, the licensee shall perform the specific analyses for the identification of ageing mechanisms and phenomena, and shall undertake the definition of the necessary AMPs.

Consequently, an assessment strategy similar to the one in the scope and screening phase is suggested, consistent in the review of the methodological general aspects, which is afterwards applied to verify the results obtained from the application of the suggested methodology.

5.3.4.1.3. Assessment of methodological aspects related to the Ageing Management Review.

The assessment of methodological aspects shall focus on the following aspects:

a) General criteria followed by the licensee for the definition of materials and environments.

It shall be verified if the criteria and methodology defined by the licensee allow the acquisition of a set of materials and environments (internal and external), representative of the existing casuistry in the different operative condition to be considered in the analysis. The support documentation, the support computing tools (databases), etc. used by the licensee, and in general, the analysis order for the identification of materials and environments shall be reviewed.

Furthermore, it shall be verified that the licensee has generated a definition of materials and environments (internal and external) detailed enough to be used in the analyses.

b) Operative condition considered in the analyses.

It shall be verified if the licensee has considered the different operative conditions with relevance in the ageing management analysis, as they condition the ageing phenomena and environments which affect the SSCs (normal operation, periodic functional tests, refuelling periods, etc.).

c) Consideration of the operative experience.

The usage of a systematic methodology by the licensee for the consideration of internal and external (national and international) operative experience in the identification of degradation mechanisms and ageing effects, as well as in the definition of the AMPs, shall be verified.
d) Documentary references and other sources of information.

The specific sources of information used by the licensee for the identification of the degradation mechanisms and phenomena, and for the definition of the AMPs, shall be verified.

Additionally, it shall be verified that the licensee considers the information from research programs, *Generic Safety Issues* (GSI), new measurement and trial procedures, etc. in the analyses and programs.

e) Process for the definition of degradation mechanisms and phenomena.

The specific procedure followed by the licensee for the assignment of degradation mechanisms and phenomena shall be verified.

It is customary to define characteristic “material-environment” groups (“Ageing Management Review (AMR) groups”), described in section 5.3.4.2 of this guide, as these two aspects condition the acting degradation mechanisms. Each AMR group shall be associated with a group of potentially occurring degradation mechanisms and phenomena. The grouping of elements within the scope in accordance with these two variables is concurrently carried out, for then to proceed to the assignment of mechanisms through the matching of the groups of elements with the corresponding AMR groups.

The aforementioned is usually supported by computer tools that facilitate the mentioned grouping and matching processes.

It shall be verified that the licensee considers the detection of certain elements that constitute particular cases derived from specific circumstances in which the SSCs are defined (flow stagnation areas, flow acceleration areas, especially aggressive environments, etc.). In this way, these components may not comply with what was established for their group, or may be subject to additional mechanisms that the licensee shall be able to identify.

It shall be verified that the methodology considers the definition of degradation mechanisms and ageing effects regarding the intended safety function that the component or structure performs in the system. Special attention shall be given to those components or structures with several intended safety functions. In these cases, the specific degradation mechanisms and effects linked to each one of them shall be defined.

For those elements that belong to an AMR group, but that the licensee defines as unaffected by its characteristic ageing effects, it shall be verified that a reasonable explanation supporting the result is provided.

f) Definition of Ageing Management Programs (AMPs)

The methodology followed by the licensee for the definition of AMPs oriented to control the previously identified degradation phenomena shall be reviewed. Such definition shall be materialized in a supporting document with essential information about each program.

In this context, it shall be verified that the methodology considers the adoption of standard programs with direct application to the NPP, as well as the definition of specific programs.
when required.

It shall be verified that each AMP is subjected to the technical assessment of its characteristic attributes, and if the scheme of AMPs contains, at least:

i.) A section in which the SSCs within the scope are comprehensively mentioned, indicating the materials, environments, and degradation mechanisms they are associated with.

ii.) A descriptive section of the specific inspection and control programs on which the AMP is based.

iii.) List of IPs awaiting resolution.

g) Identification of Improvement Programs (IPs)

It shall be verified that the licensee considers the systematic identification of the IPs associated with AMPs, and that these are properly defined and registered.

IPs may arise during the conciliation process of the plant AMPs with some standard programs taken as a reference in the industry.

The ageing management review process itself shall also generate what is known as “scope improvement proposals”, as new components or structures that require the application of a particular AMP, whose scope shall have to be broadened, arise.

5.3.4.2. Assessment of results related to the Ageing Management Review.

Once the methodological general aspects have been assessed, the results obtained by the licensee from the application of such methodology shall be assessed.

In general, and regarding the screening of the assessment sample, the systems or “commodity” type groups already used at the scope and screening phase shall follow. For the verification of certain particular aspects, other SSCs, more appropriate for the pursued objective, may be screened.

The main points to be assessed are:

a) Verifications related to the definition of materials.

In order to ensure that the set of materials considered in the analyses are in accordance with the actual existing ones at the NPP, several components or structures shall be screened to verify that the identification of materials has been correctly performed, at subcomponent level (this means, with the appropriate dismantlement level).

The basic information needed to perform this verification, shall be normally included in the documentation provided by the manufacturer (catalogues), or in the databases of the components, available at the plant. Therefore, this aspect is capable of becoming part of an inspection schedule on ageing management.

b) Verifications related to the definition of environments.
In order to equally ensure that the set of internal and external environments considered in the analyses are representative of the actual existing ones, several components or structures in which more than one operative condition has been identified as significant for the analysis shall be screened, verifying that in each case, both the internal and external environments are correct, and that no omissions are shown.

c) Assignment of ageing effects and degradation mechanisms.

It is the verification, in practice, of the proper assignment of ageing effects and degradation mechanisms to the components and structures within the scope. For such purpose, the assessment shall focus on the following aspects:

i.) If the licensee had defined generic “material-environment” groups [Ageing Management Review (AMR) groups], some of them, applicable to the system or “commodity” subject to assessment, shall be screened to verify the correction and entirety of the ageing effects and degradation mechanisms assigned to the AMR group.

As a complement, a combination of “material-environment” which was not considered and not a priori disposable for being typical of similar facilities shall be screened. It shall be verified that indeed there is no component or structure responding to it.

ii.) Several components and structures of the system or “commodity” subject to assessment shall be screened in order to verify, individually, that the degradation phenomena and ageing mechanisms identified as applicable are appropriate, and that no omissions are shown.

If the degradation mechanisms had been identified by matching the elements with an AMR group, it shall be verified that indeed, the components or structures subject to assessment belong to such group. If this methodology had not been followed, the phenomena and mechanisms identified by the licensee shall be assessed by using reliable and recognized references.

It shall be equally important to verify, through the screening of a component adapted to that end, that the licensee has detected the particular ageing mechanisms affecting it, besides the general ones that affect the AMR group it belongs to (for instance, the case of a pipe section to which the erosion-corrosion applies because of the particular conditions of its tracing, and which has been shown as a consequence of the internal operative experience).

Special attention shall be given to ensuring that the applicable degradation mechanisms and ageing effects have been defined taking into account the intended safety functions of the component or structure.

Likewise, it shall be ensured that the licensee provides a technical justification for all those ageing phenomena which have not been finally qualified as significant among the list of the a priori applicable ones because of the AMR group they belong to.

d) Ageing Management Programs (AMP)
This point establishes the verifications which shall be performed in order to ensure that the finally defined set of maintenance practices and activities, are sufficient and appropriate for the effective control of the degradation mechanisms they are associated with.

As mentioned in previous sections, the set of maintenance, inspection and control activities shall be grouped into specific programs named AMP. This name shall appear in those cases in which the licensee has developed a methodology based on the regulations by the USNRC.

For these aspects’ assessment, the systems or “commodity” type groups screened in earlier stages shall be taken as a reference. Again, for certain concrete matters, a system or “commodity” type group different from the ones already used could be employed.

In accordance with the aforementioned, several AMPs applicable to particular combinations defined by type of component, material, environment, or degradation mechanism shall be chosen from the screened systems or “commodity” type groups. The following aspects and considerations shall be considered during the assessment:

i.) The report NUREG-1801, Rev. 1 Generic Ageing Lessons Learned (GALL) [21] from the USNRC shall be used as a basic verification tool. This report provides, by systems, a proposal of AMPs valid for concrete combinations (type of component/ material/ environment/ degradation mechanism).

ii.) By using this reference, it shall be verified that the AMPs proposed by the licensee for the screened combinations are consistent with the ones proposed by the GALL report.

The AMPs from GALL to be used for comparison, can be easily defined by means of the identification of the GALL line applicable to the concrete combination (type of component/material/environment/degradation mechanism), of the element subject to verification.

Once the contrast AMP has been identified, each characteristic attribute of the licensee’s program shall be afterwards compared to the equivalent attributes of the standard program. In this way, the coincidence level between both programs shall be verified.

iii.) Special attention shall be given to those cases in which the GALL report establishes that the applicable standard AMP must be broadened as an essential requirement to assure its validity. Thus, it shall have to be verified that the AMP defined by the licensee has been effectively improved with respect to the standard program from GALL (For this purpose, the GALL report itself provides instructions on how to improve programs).

iv.) In those cases where the licensee has categorized one of their AMPs as consistent with GALL, but with exceptions, it shall be verified that:

(1) The exceptions are properly grounded.

(2) The alternative proposed by the licensee to those points from GALL that they don’t conciliate with, complies (where applicable) with the criteria mentioned in the following point for the assessment of the NPP specific AMPs.

v.) In those cases where the GALL report does not include information regarding the
particular combination to be assessed (type of component/material/environment/degradation mechanism), or in those cases where the GALL report itself indicates that the licensee needs to develop a specific AMP for the NPP, the methodology proposed in the Branch Technical Position RLSB-1, included in Appendix A from the NUREG-1800, Rev. 1 (SRP) [20] report by the USNRC, shall be used as an assessment guide.

This reference sets out the assessment of 10 attributes for the validation of any AMP. These attributes are generic, and according to the type of AMP (preventive, mitigation, condition monitoring, or operation monitoring), one of them could be left without content.

For the licensee’s assessment of attributes, and in the absence of the support provided by the GALL report, the verification of the NPP’s own experience shall be mainly resorted to. This experience shall justify the adaptation and effectiveness of the content of such AMP.

The experience of other NPP with similar technology and with AMPs already assessed by the corresponding RBs could be used as a reference.

As from the recommendations on references [20] and [22] of the USNRC and of the Nuclear Energy Institute (NEI), the 10 attributes that allow the characterization of any AMP to be used as bases for assessment are hereinafter described.

(1) Scope of the program.

The AMP shall consider, within its scope, the general definition of the type of components, materials, environments, and degradation phenomena it applies to. This information shall be coherent with the result of the ageing management analysis.

Furthermore, the AMP shall include a list with the concrete reference of components and structures within its scope.

(2) Preventive actions.

In those cases in which the AMP bases all its strategy, or part of it, on the implementation of preventive measures (for example, a program of protecting paints), it shall describe the foreseen actions to avoid or minimize the occurrence of the degradation mechanisms it manages. These actions could consist of maintenance activities, inspections, operation optimization, and even Design Modifications (DMs) to control the degradation of the component or structure.

(3) Monitored or inspected parameters.

The AMP shall have to describe the parameters to monitor, along with the testing and inspection activities suitable to monitor and control the degradation phenomena.
(4) Detection of ageing effects.

The AMP shall have to consider the necessary methods and techniques to detect ageing phenomena before the component or structure is incapable of performing its intended safety function. To that end, the type and/or methods for testing, inspection, trial, etc., the frequency, the sample size, measurement points and instruments, etc., shall have to be adapted to the previous purpose.

In those cases in which the control strategy is based on sampling, it shall have to be verified that the established criteria in this regard are reasonable to assure the representativeness of the total population.

(5) Trend monitoring and analysis.

The AMP shall consider the performance of monitoring activities and trend analysis which allow knowing the ageing phenomena progress rate, and therefore, enable the adoption of additional controlling, corrective, or mitigation measures.

In this sense, the AMP shall have to include a description of the monitoring parameters or indicators, the future projection methodology, and the acceptance criteria applicable for decision making.

(6) Acceptance Criteria.

The AMP shall have to describe, for each control, the applicable acceptance criteria, under which the need to undertake corrective actions shall be defined.

These criteria shall be sufficiently conservative so as to assure that the component or structure shall not be incapable of performing its intended safety function during the foreseen operation period.

Additionally, the AMP shall have to describe the analysis methodology to determine whether the acceptance criteria are complied with or not.

(7) Corrective actions.

In those cases where the acceptance criteria are not complied with, the AMP shall have to describe the corrective actions to be performed (operative changes, repairs, replacements, etc.).

Where required, the need to perform a root cause analysis for the non-compliance analysis shall be specified.

It shall have to be specified, for each defined corrective action, the organizational units and personnel responsible for its implementation, along with the period established in that regard.

(8) Confirmation process.
The AMP shall have to include a description of those actions that allow verifying the complete execution and effectiveness of the corrective, preventive, or mitigation actions to be performed.

(9) **Administrative controls.**

The AMP shall have to be within the scope of the existing quality control system at the NPP.

(10) **Operative experience.**

The effectiveness of the AMP shall be justified with base on the accumulated internal and external operative experience, and this aspect shall be properly and periodically reviewed to incorporate new experiences and lessons learned. In this same context, the licensee shall consider the information derived from research projects that could be applicable to the AMP.

5.3.5. **Results of the application of Ageing Management Programs (AMP)**

This section deals with the verification that the AMPs defined by the licensee are actually applied at the NPP, and that these are effective for the control of the degradation mechanisms they refer to.

Due to the eminently practical nature of the documentation to be managed, these verifications shall be mainly supported by the information gathered from the inspections performed at the NPP.

For the assessment, several AMPs shall be screened to verify the results obtained during the period deemed convenient, in regard to one or more SSCs within the scope.

Special attention shall be given to those specific plant AMPs, or which present exceptions to GALL, or those newly implemented at the NPP, in order to verify their adaptation and effectiveness for the control of the degradation mechanisms they are aimed at.

Likewise, and due to their specificity, those AMPs defined as a result of a TLAA or of a *Generic Safety Issue* (GSI) resolution shall be considered for assessment.

In accordance to the aforementioned, and for the screened AMPs, the following aspects shall be verified:

a) It shall be verified that the monitored parameters and variables are coherent with the ones specified in the AMP. Likewise, the inspections, trials, tests, etc., executed shall have been performed by following the techniques, frequency criteria, sampling techniques, etc. specified in the AMP, and always in accordance with the procedure guidelines.

It shall be also ensured that the personnel responsible for the performance of tests, inspections and controls, has the necessary experience and training.

b) It shall be verified that the corresponding trend analyses have been performed in those cases required by the AMP.

c) It shall be verified that all the analyses of results derived from the application of AMPs are clearly defined in the acceptance criteria, and that the obtained results have been compared.
to the applicable criteria.

d) In those cases where the acceptance criteria have not been complied with, it shall be verified:

i) That the broadening of a sample has been performed, if required by the AMP.

ii) That the necessary subsequent analyses have been performed (root cause analyses, loss of functionality forecast, etc.).

iii) That when needed, the necessary corrective measures, replacements or DMs, as well as their implementation strategy have been defined.

e) Likewise, it shall be verified that the different AMP activities have been performed following the quality assurance requirements established in it.

f) It shall have to be verified that the licensee, when required and as a consequence of the experience acquired from the AMPs practical application, has defined the IPs necessary to increase the adaptation and effectiveness. In this context, the definition of the effectiveness indicators related to the results obtained from the application of each AMP shall be of great help.

5.3.6. Monitoring of Improvement Proposals (IPs)

The IPs shall arise as a consequence of the following activities:

a) Initial AMP definition process, when evaluating the 10 characteristic attributes.

b) Ageing management analysis (initial or reviews to the initial ones), when the broadening of the AMP’s scope to include new SSCs is required.

c) As a result of the experience acquired from the practical application of AMPs.

d) As a consequence of the external operative experience analysis, of research programs, technical advances, etc. which could be specifically applied to the NPP.

The assessment shall try to verify that the licensee has defined a clear monitoring order of the IPs, and that the results obtained from its application are satisfactory. For that purpose, the following items shall be taken as a base:

a) The results obtained from inspections performed on ageing management aspects, in which the performance of verifications related to IP management has been taken as a point of inspection.

b) The information provided in the periodic reports submitted by the NPP to the RB.

The gathered information shall serve as reference to assess the general effectiveness of the IP resolution process, by verifying, among other aspects, the number of IPs resolved in the period, expected resolution time against the required real time, definition of effectiveness indicators, indicators’ results, etc.

5.3.7. Monitoring of Design Modifications (DMs) and replacement of equipments related to
Ageing Management.

As part of the assessment, it is necessary to verify that the licensee deals with the DMs and equipment replacements performed at the NPP appropriately.

In the particular case of power increase projects, the following shall be applied, as they may involve DMs, changes in the operational conditions, equipment replacements, etc. that could affect ageing management. Likewise, any modification in the operation procedures performed at the NPP shall be analysed to determine its consequences in the existing ageing management analyses.

For this purpose, a DM or equipment replacement project shall be screened, verifying:

a) That the licensee has explicitly considered the aspects related to ageing management in the general design criteria in the case of DMs, or in the specification of new equipments in the case of replacements. This shall have implications in the screening of materials, protection systems, design margins, sampling systems, monitoring, inspection, testing, etc. to mention some examples.

b) That the licensee has analysed the effect that the DM or replacement may indirectly cause in the operative conditions of already existing components or structures at the NPP, as its variation could entail changes in the environments and possible applicable ageing mechanisms.

c) That the new components or structures incorporated into the NPP have been analysed following the general methodology of the ageing management analyses. The results of these analyses shall be assessed according to the previously established criteria. The licensee shall propose a strategy for modifications and replacements based on the accumulated experience, the SSCs condition, as well as on their obsolescence conditions. This plan shall have to be specifically assessed, by analysing the reasons that justify it, along with the proposed measurements adaptation.

5.3.8. Monitoring of Support Documents Reviews

These verifications are oriented to the monitoring of the analysis developed at previous stages, and which shall be updated over time for several reasons: incorporation of results obtained from the operative experience analyses, research programs, new GSI, etc.

Firstly, it shall be verified whether the licensee has a systematic review procedure of the several sources of information that could be of interest for the improvement and update of analyses and programs (operative experience, research programs results, etc.).

Taking the updated list of support documentation developed through different stages of the process as a base (scope and screening, identification of ageing mechanisms, degradation mechanisms, AMP definition, etc.), one of the reviewed documents shall be screened in order to verify:

a) the causes that led to its review.

b) the adaptation and consistency of the incorporated modifications, according to the objective of the support documentation.

Likewise, when applicable, the modified aspects shall be assessed in accordance with the previously described methodology, considering the criteria for scope, screening, ageing
Finally, in those cases in which the evaluator has information about operative experience (internal or external), or about results of research programs that could be reasonably applied to the NPP, it shall be verified if the licensee has assessed the impact, and if so, whether this has generated a new review of the involved analyses. This matter could be addressed with the licensee as an item of an inspection agenda.

5.3.9. Assessment of the Process for the Identification and Resolution of Generic Safety Issues (GSI) applicable to Nuclear Power Plants.

This point refers to the verification of the licensee’s periodical proceeding for the identification of those GSI related to ageing phenomena that apply to SSCs within the scope.

For assessment purposes, the following aspects shall be verified:

a) If the licensee has defined a systematic manner to identify GSI with implications in ageing management.

b) Based on the list of the GSI identified, one or several GSI not included in the list and which could be included according to the licensee’s point of view, will be screened. It shall be verified if the licensee has a reasonable justification regarding their exclusion.

c) It shall be also verified, in view of a License renewal process, that the licensee has proceeded to the GSI previously identified reassessment, and has detected those that due to their time dependence, constitute a TLAA; the latter shall be addressed as described in section 6.4.1 of this guide.

d) Likewise, it shall be verified that the licensee has the AMPs for the control of the degradation mechanisms related to those GSI with implications in this area.

5.3.10. Obsolescence management

The obsolescence of SSCs important to safety shall be proactively managed, with foresight and anticipation, throughout the NPP lifetime.

The licensee shall have to establish an obsolescence management program. This includes the disposition of the strategy, objective and organizational agreements, the allocation of suitable resources (human and financial), and the monitoring of the program to assure the compliance with its objectives [1].

In this context, two different kinds of obsolescence can be distinguished:

a) Regulatory: characterized by components that do not comply with the regulations, criteria, etc. valid at the current moment (for instance, equipment qualification criteria, separation, diversity, functioning under severe accident conditions, etc.). In the case of control components, this may affect both the software and the hardware.

b) Technological: characterized by the difficulty to find spare components or specialized technical support.
If obsolescence is not properly managed, it could entail the loss of functionality of components important to safety. Therefore, the licensee shall have to incorporate a management plan based on anticipation throughout the NPP lifetime.

The obsolescence management program shall have to be more focused on the technological obsolescence management. Furthermore, the program shall have to provide a guide for obsolescence management of the standards and regulations by means of a PSR [2] and the TD4.

The licensee’s obsolescence management activities shall have to be supervised by the RB throughout the plant lifetime.

Based on the aforementioned, and for assessment purposes, it shall be verified:

a) That the licensee has defined and put into practice an obsolescence management program that clearly establishes the scope, objectives, responsibilities, deadlines, actions, resources, as well as the monitoring to measure its effectiveness.

b) That the obsolescence management programs include:
   i) A systematic and periodic obsolescence assessment.
   ii) The strategy to be followed once the obsolescence issue has been detected for a type component.

c) That the programs are effective as they enable the definition of necessary actions and resources, to assure the functionality of components throughout the NPP lifetime (spares purchase, replacements, specialized technical staff availability, etc.).

6. AGEING MANAGEMENT APPLICABLE TO THE LONG TERM OPERATION

6.1. Introduction

In this chapter the aspects of interest for the assessment are described, both in regard to the long term operation (LTO) itself, and to the licensing process for the long term operation (or License renewal process for the LTO).

At first and to that end, a brief introduction to the two licensing documents basic in these processes (IPA and LT-PLiM Plan) is shown. Afterwards, guidelines applicable to the assessment of different important aspects in these processes are provided. Finally, the same is described in section 6.6, but in the context of CANDU NPPs; the specificity of the licensing process applied to these NPPs requires a specific section.

Despite the aforementioned, it is understood that the guidelines and criteria directly applicable to the assessment, both in the context of NPPs using methodologies based on the American methodology (sections 6.4 and 6.5) and of plants based on CANDU methodologies (section 6.6), could be of general application as they can act as guidance for regulators in their licensing projects and LTO programs assessment tasks. For instance, the guidelines provided in section 6.6 on refurbishment shutdowns and subsequent restart, are in general applicable to any kind of plant.

Finally, it is important to mention that the majority of guidelines provided in Chapter 4, applicable to ageing management during the design life, are also applicable to long term operation.

6.2. Long Term Plant Life Management Plan (LT – PLiM Plan)
This document shall include the basic ageing management strategy of the licensee, during the long term operation period of a NPP. It shall be also variable if it is perdurable, depending on the life extension length, which shall be defined by the licensee, but with some permanence tendency.

As in the PLiM plan, the LT-PLiM plan is complemented by a periodic report in which the licensee states the main activities regarding ageing management, performed during the previous period and following the criteria and methodology proposed in the LT-PLiM plan.

Among the basic points addressed by this document are:

a) Organizational and management aspects related to the PLiM plan implemented at the NPP.

b) General aspects related to the implementation of the AMPs (SSC monitoring activities, IP management, etc.).

c) Aspects related to the review of different ageing management analyses derived from DM undertaken at the NPP, implementation of IPs, results from the internal and external operative experience, research programs, etc.

d) Progress in the activities to be developed by the licensee, in accordance with the contents of the operation license granted for the long term operation period.

The LT-PLiM Plan shall be mainly supported by the hereinafter mentioned IPA as well as by the specific documents of analyses developed during the License renewal process. These analyses shall primarily deal with the already mentioned topics, in regard to the PLiM plan.

6.3. Integrated Plant Assessment (IPA)

By definition, the IPA is the set of ageing management analyses which comprise three classical stages: scope and screening of SSCs, identification of ageing effects and degradation mechanisms, and definition of ageing management programs. It also includes the Time Limited Ageing Analyses (TLAA) which are necessary for the review of the analyses performed with a defined design life hypothesis.

This Plan may make reference to the American regulation contained in the rule 10CFR54 “Requirements for operation license renewal” [19] and the documents of the USNRC or the nuclear industry from which it is developed by.

The IPA constitutes the basic document for the SSCs ageing assessment submitted by the licensee when interested in obtaining a new operation license, beyond the design life of the NPP.

6.4. Aspects subject to Assessment

Table C shows the aspects subject to assessment during the design life, the License renewal process, and the long term operation period. Many of these aspects shall have been applied during the design life, and have already been mentioned and discussed in detail in Chapter 4.

For that reason, this table shows the stages at which it is necessary to consider each aspect.

6.4.1. Review of the Time-Limited Ageing Analyses (TLAA)
The main objective when this aspect assessed, is the effective verification that the licensee:

a) Has followed a methodology that reasonably assures the identification of all TLAAs, in accordance with the License Terms in force.

b) Has proceeded to the analysis, review and resolution of the identified TLAAs, by following the criteria established by the TD1.

Table C. Aspects subject to Assessment.

<table>
<thead>
<tr>
<th>Aspects subject to Assessment</th>
<th>Design life</th>
<th>License renewal</th>
<th>Long Term Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational and management aspects.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>SSC Scope and screening.</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ageing management review analysis.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Results of the application of Ageing Management Programs (AMPs)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring of Improvement Proposals (IPs).</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring of Design Modifications (DMs) and equipment replacements related to ageing management.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring of supporting document reviews.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Process for identification and resolution of Generic Safety Issue (GSI) applicable to the NPP.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Obsolescence management</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Review of Time-limited Ageing Analyses (TLAA).</td>
<td>(*)</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ = applicable topic    (*) only definition

6.4.1.1. Results of the identification process of TLAA

The TLAA are, by definition, totally dependent on the hypotheses and analysis methodology employed in the documents which constitute the licensing terms in force.

For the performance of the assessment, one or more analyses not identified by the licensee as TLAA, and which could potentially be one from the evaluator’s point of view, shall also be screened.

In the screening process of potential TLAA, the following documentary references may be used:

a) Documents integrating the licensing terms or mandatory documentation:

i) SAR.

ii) OL and its complementary instructions.

iii) License related correspondence between the licensee and the RB.
iv) Design basis documents.

v) Technical specifications.

vi) Others mentioned in the licensing terms such as the fire risk analysis, environmental qualification studies, etc.

b) Generic TLAA included in the Standard Review Plan (SRP) (Chapter 4 [20]), in the GALL report (Chapter X [21]), and in the NEI 95-10 guide (Chapter 5 [22]).

c) Requests of License renewal and assessments by the USNRC or other RBs taken as reference, corresponding to plants of similar technology.

For the analyses not identified as TLAA, it shall be verified if the licensee has a reasonable justification for their exclusion within the list of TLAAs of the NPP.

6.4.1.2. TLAA Resolution process

There are three valid methods for the assessment and resolution of TLAAs. Each method is hereinafter mentioned:

a) The licensee may justify, by means of the corresponding analysis, that the TLAA remains valid for the long term operation period.

b) Extending the TLAA until the end of the LTO period (considering the additional period starting from the initial analysis)

c) Resolving the TLAA through the ageing effects management during all the LTO period (definition of an applicable AMP, or corrective or compensatory actions).

For assessment purposes, and taking the final list of identified TLAAs as a base, some of them shall be screened, giving special attention to the plant specific ones, meaning those non generically identified in the GALL report, SRP, etc.

It shall be verified in each case that they have been resolved by following one of the valid methods, and that the followed procedure, the employed calculation programs, and obtained conclusions are correct and appropriate to the applicable regulation.

Special emphasis shall be placed on the licensee’s consideration of the actual operative conditions to which the TLAA object components have been subjected, which condition the ageing level they have suffered.

If there is any TLAA resolved by means of the “ageing effect management” option, it shall be verified in these cases that there is an AMP associated whose scope and contents are coherent with the criteria established in the corresponding TLAA (affected structures and components, management strategy, etc.).

If the licensee has opted for the corrective or compensatory actions option, it shall be verified that an implementation program exists, and that the deadlines associated to it are acceptable. If such deadline implies an implementation before the start of the LTO period, this aspect shall be specifically verified in one of the scheduled inspections.
Finally, it shall be verified if the application of a particular TLAA to the corresponding structures and components is properly reflected in the ageing management analyses. The same verification shall be performed if the TLAA has been resolved through the application of an AMP.

6.4.1.3. Process for Identification and Resolution of Exemptions based on TLAA

This section refers to certain exemptions to the Licensing requirements obtained by the licensee, which due to their dependence on the “time” variable, may constitute a TLAA.

These exemptions must comply with the hereinafter mentioned requirements:

a) The exemption shall be still applied during the LTO period.

b) The exemption affects the SSCs included within the scope of the ageing management review.

c) The exemption is based on a TLAA.

For the assessment, and based on a list with the valid exemptions, one or several exemptions shall be screened from those which could constitute a TLAA from the evaluator’s point of view, but which have not been identified as such by the licensee. In these cases, it shall be verified that the analysis has a justification in that regard.

One of the exemptions which actually constitutes a TLAA shall be screened, in order to verify that the licensee has properly resolved it for the long term operation period.

6.4.1.4. Reference to the TLAA in the Safety Analysis Report (SAR)

It shall be verified that the SAR makes reference to the different TLAA defined during the License renewal process, properly collected in the IPA. The licensee shall include such information into the SAR, where a summary of the analyses corresponding to each identified TLAA shall be stated.

6.5. Specific Assessment Aspects related to the License Renewal Process

In the License renewal process, it shall be verified if the licensee has performed the following actions before the end of the validity of the current OL:

a) Satisfactory resolution of all the IPs associated with the AMPs defined for the LTO period.

b) Effective implementation of all the AMPs defined for the LTO period, as from the new OL enforcement.

c) Performance of all the single inspections defined in the ageing management analysis. Single inspections shall have the corresponding analysis of results and redefinition, if required, of the AMPs applicable to the involved components or structures.

d) Verification that the SAR makes reference to the different AMPs defined during the OL renewal process (properly collected in the IPA). To that end, the licensee shall include such information into the SAR, where a summary of the contents corresponding to each of them shall be stated.

These verifications shall be mainly based on the information gathered from a specific inspection to
be performed at the NPP.

6.6. **Assessment of the Long Term Operation at CANDU Nuclear Power Plants**

6.6.1. **Initiation of the Plant Life Extension (PLEX) Project**

To start a PLEX Project, the licensee shall have to formally notify such intention to the RB, and submit a description of the long term operation project (Life Extension) along with this notification; which shall consider, at least, the following aspects:

a) Definition of the project’s objective and scope.

b) Current design and operation condition of the plant.

c) Components and structures (temporary and permanent structures, infrastructure, construction equipment, etc.).

d) Scheduled activities of the project (operational phases, timing and schedule of each phase, etc.).

e) Site information (location, environmental characteristics, and land usage).

f) Waste management.

g) Foreseen milestones.

The RB shall have to assess the preliminary project description submitted by the licensee, whose purpose is to determine if there are observations on such project that should be taken into account by the licensee.

6.6.2. **Assessment of the Licensing Basis Document**

The RB must assess and approve a Licensing Basis Document which defines the guidelines to be followed for the different Licensing topics. A standard content could be:

a) Introduction/ Scope / Objective.

b) Project management / Quality assurance.

c) Environmental radiological impact.

d) Periodic Safety Review (RPS).

e) Compliance with standards and regulatory documents.

f) Plant Condition Assessment.

g) Design improvements.

h) Safety Analysis Report (SAR).

i) Deterministic, probabilistic, and risk analysis.

j) Waste management.

k) Activities during the refurbishment shutdown.
6.6.3. Assessment of the Periodic Safety Review (PSR)

The PSR of a NPP in operation allows having an overview of the NPP safety level and consequently, to determine whether it is necessary to perform practical and reasonable modifications to achieve and maintain a high safety level, closest to that of the most modern plants.

When it is intended to extend the life of a NPP, an integrated safety review is usually performed, with requirements and philosophy similar to the PSR, but focused on the NPP safety diagnosis in view of long term operation.

The assessments related to ageing management within the PSR are described in the TD4.

6.6.4. Assessment of Ageing Studies

The evaluations related to the SSCs condition assessment for the long term operation are hereinafter briefly described.

a) The work procedures shall be reviewed in order to verify that the assessment methodologies are the ones recommended by international practices.

b) Safety systems or SR systems reports shall be reviewed, verifying that the assessment methodology is properly applied.

c) The condition assessment report shall be verified to check if it reflects the actual situation of SSCs of regulatory interest, and if it is complete.

d) The conclusions and recommendations derived from the ageing assessments of SSCs of regulatory interest shall be assessed. Critical safety recommendations shall be determined and deviations shall be identified.

e) The control over the implementation of recommendations or modifications derived from the ageing assessments of SSCs of regulatory interest (prioritization, disposition and implementation) shall be performed.

6.6.5. Assessment of Safety Analyses

The safety analyses that must be performed within an NPP long term operation framework are included within the PSR, and the assessments related to them are described in the TD4.

To summarize, it is necessary to assess the scope, requirements, methodologies, and results of:

a) Probabilistic and deterministic analyses.

b) Risk analysis.

c) Design Review according to standards, codes and modern practices.

d) Severe Accident Management program within “PSA” safety factor.
e) Review of the Design Improvements incorporated in NPPs of similar design.

6.6.6. Assessment of the Safety Improvement Plan (SIP)

The results of the safety and ageing assessments and the PSR must be employed to develop a SIP which shall be submitted to and approved by the RB before its implementation.

The assessments related to a SIP are:

a) Assessment of the sufficiency of corrective actions, plant modifications, safety improvements, compensatory measures, and improvements of the operation and management programs derived from the identified weaknesses.

To determine the sufficiency of such measures it shall be necessary to assess the justification developed by the licensee for those weaknesses that will not be solved. Such justifications may be based on the cost-benefit analysis, reliability analysis, experts’ judgements, etc.

b) Assessment of the improvement implementation schedule.

As improvements may refer to DM, changes in the plant practices or programs, changes in the maintenance or inspection policies, etc., the licensee shall have to define an implementation schedule, which shall be approved by the RB.

The assessment of such schedule shall respond to an assignment of improvement priorities according to their impact on safety.

c) Improvement assessment.

Depending on the regulations of each country, a category of modifications to the NPP exists, which shall have to be approved by the RB.

In the case of changes in the operation, testing, or maintenance procedures this assessment typically includes:

i) Assessment of the safety analysis of such change.

ii) Assessment of procedures, instructions, or plans.

iii) Assessment of personnel training plans.

In the case of DM in equipments and components, the assessment usually includes aspects such as:

i.) Assessment of the safety analysis.

ii.) Assessment of the design concept.

iii.) Assessment of supplier qualification.
Regarding major changes in the programs and policies of the NPP, the assessments may involve areas such as personnel licensing, operation organizational Table, related mandatory documentation, etc.

In all cases, the assessment of the consideration of human factors in the changes, and the update of the corresponding documentation shall be necessary.

6.6.7. Assessment of the Environmental Radiological Impact

The licensee shall have to assess the radiological impact that the LTO shall have on the environment. The RB shall assess a report developed by the licensee containing the result of such assessment. Although it is included it the PSR, the performed assessments may be typically summarized in:

a) Limitation of radioactive effluents.
b) Changes in land usage.
c) Precautions for the radioactive waste management originated in the plant refurbishment and the long term operation.
d) Review of the radiological environmental monitoring system.


In case extended refurbishment shutdowns are required for the replacement of critical components, the following assessments shall have to be performed:

a) Assessment of work procedures and plans.
b) Assessment of the radiological protection program.
c) Assessment of personnel qualification and training plans.
d) Assessment of plans for the SSCs commissioning.
e) Assessment of emergency plans for special configurations.
f) Assessment of policies, plans and transient operation procedures for shutdown.
g) Assessment of plans for heavy water management during shutdown.
h) Assessment of facilities licensing for management of radioactive waste generated during shutdown.
i) Assessments related to personnel licensing.
j) Assessments related to the operation of large components movement.

When required by the improvements incorporated in the NPP, assessments related to major changes
in the mandatory documentation, operation limits, and OL requirements may be necessary.

6.6.9. Assessments related to the License Renewal Process

The grant of OL for the extended period involves the following assessments:

a) Assessment of the SIP implementation report.

b) Assessment of mandatory documentation that has been updated or modified.

In case of an extended refurbishment shutdown, a series of assessments related to the restart are needed.

The restart involves returning the reactor and the nuclear and non-nuclear systems, back to commercial operation. It also implies the demonstration by the licensee that all relevant Licensing conditions have been fulfilled and that the associated work has been performed to the satisfaction of the RB.

The assessments related to the restart are:

A) Assessment of the commissioning plan, which includes:
   i) The description and schedule of activities, including the organization and assignment of responsibilities.
   ii) The acceptance criteria for each commissioning phase.
   iii) Definition of the shortcomings by the RA and reports presented by the licensee in each case.

B) Assessment of the results of commissioning phases.
   i) Phase A (Preliminary tests):
      In this phase the correct state of new or modified equipments is confirmed, and the service capability of new or existing SSCs at the plant is confirmed, through a testing program of individual components and integrated systems. This phase must be successfully completed prior to the fuel loading in the reactor.
   
   ii) Phase B (Fuel loading):
      In this phase it must be ensured that the fuel is safely loaded into the reactor, and confirmed that the reactor is in suitable conditions to be started and that all the requirements to allow the reactor to go critical have been met. This phase must be successfully completed prior to removal of the guaranteed shutdown state.
   
   iii) Phase C (Criticality):
      This phase confirms reactor behaviour at the initial criticality stage and subsequent low power tests, and includes activities that cannot be performed during the guaranteed shutdown state.
   
   iv) Phase D (Power operation):
In this phase, the reactor and systems behaviour at high power levels, including activities that cannot be performed at low power levels, is demonstrated.

6.6.10. Milestones

The restart is achieved by means of the accomplishment of numerous milestones. Milestones that might be reflected in the restart stage of a PLEX Project include:

a) Fuel Loading.
b) Removal of the guaranteed shutdown state.
c) Heat transport system operation.
d) Turbine operation.
e) Synchronization of the turbine to the grid.
f) Reactor at full power.
g) Specific commissioning tests.

6.6.11. Hold points

The process of restart includes the progress to regulatory hold points. These are typically aligned with commissioning phases, and may include the aforementioned milestones. License Terms are established for the administration of the hold points, which are then incorporated by the licensee in the Restart Plan.

The RB approves the removal of a given hold points depending on the licensee’s submission of a Completion Assurance Document. This document presents evidence that all project commitments scheduled for completion prior to removal of the respective hold points have been met. The Completion Assurance Document must be accepted by the RB before authorization to remove the hold point is issued.

6.6.12. Return to Normal Operation

Once all RB approvals have been granted and hold points have been removed, the licensee shall proceed to normal operation.
REFERENCES


LIST OF AUTHORS AND REVIEWERS

Conrado Alfonso Pallarés, CNSN (Cuba)
Diego Encinas Cerezo, CSN (Spain)
José María Figueras Clavijo, CSN (Spain)
Alexandre Gromann Araujo de Góes, CNEN (Brazil)
Ricardo Pérez Pérez, CNSNS (Mexico)
Jaime Riesle Wetherby, CCHEN (Chile)
Reinaldo Valle Cepero, ARN (Argentina)