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Content

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1. Introduction

Even though asset management and treatment of ageing effects have always been practiced at nuclear plants in order to optimize production and nuclear safety, equipment ageing management has become a core process in nuclear plant management in the world today. Ageing management that supports the full life cycle is fundamental to safely designing, constructing, operating, and maintaining a nuclear power generation facility, throughout its lifetime. The ageing management process deals with the integrated mechanisms and related processes used to manage ageing degradations of all safety related structures, systems, or components (SSCs) over time. These ageing degradations, if not properly managed, could lead to diminishing performance of the SSCs and may be detrimental to protection and nuclear safety of persons, property, and environment. These processes have therefore been included into the licensing basis.

As part of the management system of the utility, ageing management ensures that all equipment that is deemed important to nuclear safety and radiation mitigation is considered in a specific graded approach and all potential degradation, which could affect the function of the equipment, is treated or managed. Various overlapping processes support the management of ageing and provide reassurance of functional capability and defence in depth. The required processes and procedures to achieve good ageing management forms one of the cornerstones of asset management and is expected to be developed and implemented as part of the plant management functions.

Many international nuclear plant operators have decided to continue to operate beyond the original designed (and often licensed) period and have undertaken a specific review to justify this extended operating period. The International Atomic Energy Agency (IAEA) has responded to this trend and developed comprehensive guidance documents to allow utilities and regulators to manage this transition into long term operation (LTO). This LTO review, performed by industry expert peers, is expected to largely be based on the existing established processes related to ageing management of the plant.

Note: The asset management and treatment of non-safety related SSCs are often enveloped by the same management processes employed for safety related SSCs, but as the requirements for this equipment are not included in the licensing basis, their treatment is at the discretion of the utility. Eskom does subscribe to sound asset management practices for all production related equipment.

2. Supporting Clauses

2.1 Scope

This standard identifies all safety related SSCs and applies to all processes/procedures that combine to form the ageing management function of Koeberg Nuclear Power Station (KNPS). This requires addressing both the effects of physical ageing of SSCs, resulting in degradation of their performance characteristics, and the non-physical ageing (obsolescence) of SSCs. The following SSCs are included in the scope of licence basis ageing management:

a. SSCs important to nuclear safety that are necessary to fulfil the fundamental safety functions for Koeberg Nuclear Power Station.

b. Other SSCs whose failure may prevent SSCs important to nuclear safety from fulfilling their intended functions.

c. Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of events, including design base extension conditions and severe accident management.

2.1.1 Purpose

The purpose of this standard is to provide overall requirements for the ageing management of safety related equipment and to indicate the links to related physical and non-physical ageing management processes at Koeberg Nuclear Power Station, for the life of the plant, including LTO. It covers all stages of equipment life of the plant i.e., design, construction, manufacturing, commissioning, operating, LTO, suspended operation and decommissioning. The regulatory expectations and guidance contained in RG-0027, “Interim Regulatory Guide Ageing Management and Long-Term Operations of Nuclear Power Plants”, are used as guiding principles in this standard.

2.1.2 Applicability

This document shall apply throughout the Nuclear Operating Unit (NOU).

2.1.3 Effective date

This standard shall be effective within 6 months from the authorisation date and when published on Hyperwave.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 08016-S-LIC Rev1: Nuclear Licensing Strategy for Koeberg SALTO Assessment project

[2] 238-8: Nuclear Safety and Quality Manual

[3] 240-102714621: Terms of Reference for KPMC and MRC

[4] 240-125839632: Koeberg Safety Aspects of Long-Term Operation (SALTO) Scoping Methodology

[5] 240-139089079 Programme Oversight Committee

[6] 240-150384693: Ageing Management Programmes List

[7] 240-152428832 LTO Documentation List

[8] 240-89294359 [KSA-010]: Nuclear Safety, Seismic, Environmental, Quality and Importance Classification

[9] 331-102: Engineering Technical Management Meeting (Koeberg)

[10] 331-148: Programme Engineer’s Guide

[11] 36-197: Koeberg Licensing Basis Manual

[12] 331-275: Process for the development and control of ageing management programme at KOU

[13] KAA-688: The Corrective Action Process

[14] KAA-826: Plant Health Committee Constitution

[15] KGU-011: Preparation of Life of Plant Plants

[16] KGU-023: Guide for Component Engineers

[17] KGU-031: System Health Reporting guide

[18] RG-0027: Interim Regulatory Guide Ageing Management and Long Term Operations of Nuclear Power Plants

[19] RG-0028: Interim Regulatory Guide Periodic Safety Review of Nuclear Power Plants

[20] NIL01 version 19 Nuclear Installation Licence

2.2.2 Informative

[21] 238-1: Integrated Management System Description

[22] 240-119744497: Control of the Safety Analysis Report

[23] 240-84975495: Terms of Reference of ECMC

[24] 36 -1143: Technical Planning Process Guideline

[25] ANSI N18.2: Nuclear Safety Criteria for the Design of Stationary Pressurised Water Reactor Plants

[26] SRS-82: IAEA Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learnt (IGALL)

[27] SSG-48: IAEA Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants

2.3 Definitions

2.3.1 Ageing Management Programme (AMP): A programme that manages the effects of ageing on SSCs so that the intended functions will be maintained in accordance with the design basis for the period of planned operation.

2.3.2 Commodity Group: Components or structures with similar functions and similar materials and are in a similar environment that can be treated together for ageing management.

2.3.3 Corrective Action Program: The process for identifying, reporting, investigating and trending occurrences, problems, events, conditions and near misses. The program also ensures that operating experience information is effectively identified, screened, classified, investigated, distributed, tracked to identify actions to improve nuclear safety, conventional safety, health, and environment, to prevent events from recurring and ensure continuous improvement, and to establish uniform practices for reporting, recording, classifying, investigating.

2.3.4 Plant Programme: A programme developed due to regulations, codes, operational experience, etc. (and not necessarily for ageing management). A plant programme may be credited for management of ageing where applicable.

2.3.5 Portfolio Investment Plan: The plan that captures projects that originate from either approved strategic and/or business requirements, including compliance with Eskom regulations (namely Generation, Transmission and Distribution / Customer Services). These projects are collated in development plans and appear as business prioritised projects. This plan consists of the aggregation of projects and programmes as indicated in a list of Operating Unit capital projects covering the 10 year Production Plan.

2.3.6 Process: A course of action or proceeding, especially a series of progressive stages in the manufacture of a product or some other operation.

2.3.7 Methods to manage ageing: There are many options that can be used to manage, mitigate, and control ageing and degradation effects. These include maintenance, inspections, tests, refurbishments, monitoring, justification, etc. These methods can be selected to be used either in isolation or in combination, in programmes or processes to achieve an acceptable situation in response to ageing effects.

2.4 Abbreviations

Abbreviation	Explanation
AMP	Ageing Management Programme
CAP	Corrective Action Programme
CSR	Critical Safety Related
DER	Design Extension Related
IAEA	International Atomic Energy Agency
IGALL	International Generic Ageing Lessons Learned
ISI	In-service Inspection
IST	In-service Testing
LOPP	Life of Plant Plan
LTO	Long Term Operation
NEPP	Nuclear Engineering Position Paper
NNR	National Nuclear Regulator
NOU	Nuclear Operating Unit
OEM	Original Equipment Manufacturer
PIP	Portfolio Investment Plan
TLAA	Time Limited Ageing Assessment
SALTO	Safety Assessment of Long Term Operation
SAR	Safety Analysis Report
SR	Safety Related
SRSM	Safety Related Surveillance Manual
SSC	Structure, System or Component

2.5 Roles and Responsibilities

Responsibilities, organizational structures, functions, interfaces, capabilities and competencies, resources, training, and strategies for delivery of the Koeberg ageing management aspects shall be defined and established as part of the Nuclear Operating Unit management system (and functional organisational structures, where applicable).

Even though the Chief Nuclear Officer is responsible for all ageing management related aspects in the NOU, the Nuclear Engineering Manager will assume overall responsibility for the development, implementation, and ongoing management of the ageing management aspects of the NOU. Delegated responsibilities of sub-processes of ageing management are in-line with formal delegated authorities.

Specifically, scoping, equipment design basis and TLAAs reside with the Manager, Design Engineering Department.

Ageing management and degradation evaluation and control of the ageing management matrix is with the Materials Reliability Group Manager, including the development and reporting of performance indicators. Review of yearly IGALL updates is the responsibility of the Materials Reliability Group.

The responsibility for the annual NNR ageing management report is with the Programmes Engineering Department Manager.

Ageing management aspects related to design basis documentation management and inputs to 36-197, “Koeberg Licensing Basis Manual”, is with the Koeberg Engineering Department Manager, including the tracking of LTO commitments.

Formal appointments are required to be implemented for specific ageing management responsibilities.

Scheduling, preparation and execution of monitoring, inspection, maintenance, calibration, and other tasks required by the ageing management programmes and management methods are performed by line groups, in-line with established responsibilities and documented functions.

2.6 Process for Monitoring

Refer to section 3.8 of this document.

2.7 Related/Supporting Documents

Not applicable.

3. Requirements

The requirements of ageing management are obtained from licensing regulation [20], [18] and [11] and international safety guidance [26]. The requirements cover all aspects that are needed to ensure that the effects of ageing will not prevent SSCs from accomplishing their required safety functions. The requirements are expanded on in sub-sections 3.1 to 3.8 below:

3.1 General Concept of Ageing Management

This section provides the basic concepts of ageing management, including their application to LTO.

a) The systematic approach to Ageing Management, shown in Figure 1, can be described along an adaptation of an iterative Deming four step cycle represented by “plan – do – check – act” framework. Figure 1 below was extracted from [27].
b) The fundamental concept is to understand ageing and using acquired plant knowledge to plan/prepare mitigation and/or monitoring activities, minimizing ageing by taking preventative actions, executing monitoring, and testing activities and concluding with corrective measures. Then, based on new understanding (that includes inputs from internal or external sources), repeat the cycle.
c) To apply the process, it is needed to identify the scope of equipment that must be included in the ageing management effort. To satisfy licensing requirements [18], all equipment related to nuclear safety must be included.
d) When the scope of safety equipment has been established, a comprehensive review is to be undertaken to identify all potential ageing and degradation that can be expected, termed Ageing Management Evaluation.
e) The identified ageing and degradation must be adequately managed, treated, prevented, maintained, or justified to reasonably ensure that the required functions of in-scope SSCs are fulfilled over the entire lifetime of the plant.
f) Design assumptions (including material condition) must remain valid throughout the lifetime of the plant.

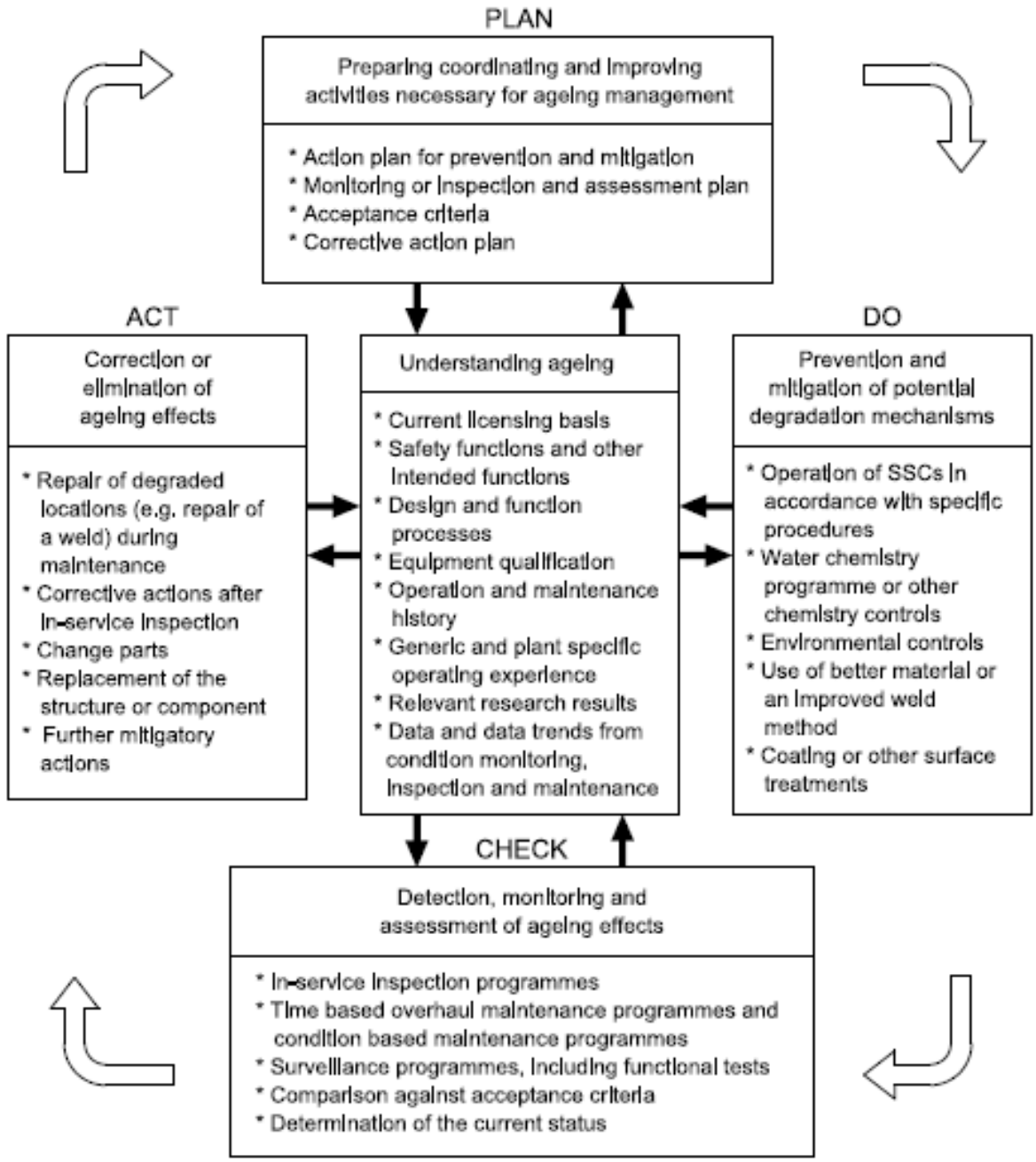

Figure 1: Deming four step cycle (Source [27])

3.2 Ageing Management Scope

The Koeberg equipment considered to be safety related as per [8], [18] and [4] were interpreted and defined in the following manner:

Requirement No. 1

> *1) SSCs important to safety that are necessary to fulfil the fundamental safety functions:*
>
> *a) Control of reactivity.*
>
> *b) Removal of heat from the reactor and from the used fuel storage facility; and*
>
> c) *Confinement of radioactive material, shielding against radiation, control of planned radioactive releases, and limitation of accidental radioactive releases.*

This requirement is interpreted as design basis equipment defined in accordance with the definitions of ANSI N18.2 and [8].

For Koeberg, SSCs required to fulfil the fundamental safety functions as described above, are design basis SSCs and are assigned design safety classes: 1, 2, 3, LS (for mechanical SSCs), and 1E (for electrical SSCs).

Requirement No. 2

> *2) Other SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions. Examples of such potential failures are:*
>
> *a) Missile impact from rotating machines.*
>
> *b) Failure of lifting equipment.*
>
> *c) Flooding.*
>
> *d) High-energy line break; and*
>
> e) *Leakage of liquids (e.g., from piping or other pressure boundary components).*

It is interpreted that this requirement is addressed by the identification of non-safety equipment that can affect the design safety function defined in Requirement No. 1.

For Koeberg, part of this equipment is classified for seismic impact as seismic class 1A, 1P, and ND [8]. Additionally, the Koeberg importance classification process considers potential failure impact during the assignment of this category (SR, CSR) [8]. Finally, non-safety class items of equipment that meet this requirement are identified in specific commissioned studies such as the fire, flooding, explosion, and seismic studies. Confirmation of this scope is to be obtained by plant walkdowns.

Requirement No. 3

> *3) Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of events consistent with national regulatory requirements, such as:*

a) SSCs needed to cope with internal events (e.g., internal fire and internal flooding).

b) SSCs needed to cope with external hazards (e.g., extreme weather conditions, earthquakes, tsunamis, external flooding, tornados, and external fire).

c) SSCs needed to cope with specific regulated events (e.g., pressurised thermal shock, anticipated transient without scram and station black-out).

d) SSCs needed to cope with design extension conditions or to mitigate the consequences of severe accidents.

This requirement is interpreted as the equipment needed to address risk-significant plant impacts, complimentary accidents, beyond-design-basis accidents, and other probabilistic risks.

For Koeberg, this equipment is identified by [8]:

- Importance categories SR and CSR based on deterministic considerations.
- Importance category SR based on probabilistic considerations.
- Importance category DER.

The establishment and control of the in-scope SSC list is the responsibility of Design Engineering. Formal processes are required to manage the list, in-line with acceptable configuration control requirements of the NOU. The expectation is that the list remains current and any changes to the list, inclusive of material, exposed environment, classification, and specification must be considered for ageing and potential degradation implications (refer to 3.3).

3.3 Ageing Management Evaluation

In addition to what was practiced in the past (responding to internal and external OE, implementing regulatory monitoring and generic preventative activities), a comprehensive review of all the ageing management programmes is required.

To perform ageing management evaluation of all SSCs identified under the scope of 3.2, a formal process shall be followed that comprises of commodity grouping, degradation identification, identification of management method/s and review of time limited assumptions [18].

Commodity grouping:

A group of structures or components with characteristics such as similar design, similar materials of construction, similar ageing management practices and similar environments can be grouped (called commodity groups) and evaluated together. In-scope SSCs that cannot be grouped into commodity groups shall be evaluated as stand-alone structures and components.

Degradation identification:

Evaluation of commodity groups and stand-alone SSCs shall be systematically performed. All potential ageing and degradation of all functional parts of the commodity group or SCs must be considered [4]. Where there are applicable degradation and ageing effects identified, these must be documented and linked to the commodity group and/or SSC.

Identification of management methods:

Ageing management evaluation shall be documented, and one or more management methods determined.

The management method could be diverse, inclusive of preventative maintenance tasks, justifications (inclusive of acceptance of risk of failure), mitigation, monitoring, surveillances, or any other acceptable method. Acceptable methods can be a combination of actions and based on a graded approach taking into account realisation of ageing effects on the SSC.

The Ageing Matrix (as reflected in the Ageing Management Database, COMSY) shall be kept current with changes to equipment, plant knowledge and operating experiences should be updated at least on an annual basis. International experience shall be included into the Ageing Matrix as this is confirmed and becomes available, however a detailed comparison with IAEA SRS 082 IGALL [26] shall be undertaken as part of the 10 yearly Periodic Safety Review [19].

All ageing evaluations that result in inclusion, alteration, or exclusion of items in the Ageing Matrix must be treated formally and technically controlled. These must be retrievable and auditable.

3.4 Ageing Management Programmes

Methods for managing ageing are often captured in plant programmes that envelope actions for several SSCs. The objectives of these programmes are wide ranging, but even if the intent of the programme is not specifically equipment ageing management, they can be used for ageing management. Many plant programmes were engineered to support plant reliability, due to regulations or out of need (often based on experience feedback) and can be used to manage ageing and degradation.

Where existing plant programmes or methods are used to manage ageing degradation and ageing effects in the Ageing Matrix, they shall comply with the attributes required for ageing management [18]. This is to ensure that the plant programme identified is an acceptable method for ageing management.

Existing programmes and methods that are credited for ageing management should be consistent with the nine attributes of an effective ageing management programme [18]. It is required to perform a documented evaluation of the nine attributes against the plant programme. All shortcomings are required to be addressed or justified. If a programme is of such a nature that it cannot meet all the attributes, its use for ageing management should be documented and justified.

New plant programmes used for ageing management are required to be developed in line with the nine attributes of an effective ageing management programme [18].

The list of plant programmes that is identified for use in ageing management is documented in 240-150483693, “Ageing Management Programmes List” [6].

Nuclear Engineering Position Papers (NEPP) and Life of Plant Plans (LOPP) [14] can be utilized to manage equipment ageing, although not considered plant programmes. Based on this use, it is required to communicate proposed changes to NEPP and/or LOPP to the Ageing Management Programme Engineer. It is also important to ensure all actions identified in these documents are captured in DevonWay (or other formal tracking mechanism) as a manner of tracking the intended action.

3.5 Management of Technological Obsolescence

Technological obsolescence of the SSCs within the scope of ageing management shall be managed through a dedicated programme with foresight and anticipation and should be resolved before any associated decrease in reliability and availability occur [18].

3.6 Time Limited Ageing Analyses

During the design of the plant, the architect or OEM made several assumptions and based the design, calculations, material selection, operating and maintenance instructions on these assumptions. These assumptions are sometimes clearly documented and sometimes not apparent. The most significant to these is the intended operational life of the units of 40 years. This assumption led to many secondary limitations, e.g., the anticipated radiation fluence to be expected for the reactor vessel in the worst area. As radiation fluence leads to material embrittlement, specific limitations are derived. When operating the plant within the initial anticipated operating life, management of life limiting assumptions are relatively easy as the limitations are assumed to be enveloped. When the original plant life is to be exceeded, all limiting assumptions must be reviewed and revalidated for the intended plant life.

To achieve an extended plant life or LTO, a list of applicable Time Limited Ageing Analyses (TLAAs) must be established, revalidated, and controlled. This list of TLAAs is to be established and based on the six criteria as per RG-0027: Interim Regulatory Guide Ageing Management and Long Term Operations of Nuclear Power Plants par. 6.9 [18]. Revalidation of TLAAs shall be in accordance with RG-0027 [18]. The TLAAs can be considered design basis documentation and the TLAA list must be included in the SAR [23].

3.7 Implementation

Implementation of a comprehensive ageing management process depends on existing procedures and processes (or creates new) to provide controls of activities to achieve the objective of ensuring that all equipment that is deemed important to nuclear safety and radiation mitigation are considered in a specific approach and all identified, potential degradation treated or managed. In particular, the following must be established:

- Sufficient, designated personnel responsible for ageing management must possess the necessary competence, skills, and experience to manage all aspects stipulated in this standard.
- Note that human skills and knowledge management is excluded from this standard. The required strategy and process controls for the human aspects of ageing management is to be developed separately.
- All equipment changes processes (design changes, modifications, equivalencies, temporary design changes) shall formally consider the impact of proposed or considered changes on ageing and degradation of in-scope equipment. Eroding of ageing margins must be considered for the entire life of the plant and justified.
- All physical equipment changes (including classification changes) shall be considered for implications on the Ageing Matrix.
- All changes to the in-scope list (3.2) shall be formally communicated to the Ageing Management Programme Engineer.
- Changes to operating procedures and maintenance strategies must consider potential implications of ageing and degradation of SSCs. Where impacts are identified, the implications shall be justified and incorporated in the Ageing Matrix.
- All changes considered for the plant programmes (3.4) shall be reviewed for impact on the Ageing Matrix.

- The Corrective Action Program (CAP) shall identify all SSC ageing related, un-anticipated component or equipment failures. The evaluation of these instances must include a review of the Ageing Matrix with the objective to identify new ageing degradation/ageing effects and/or consideration of ineffective methods for ageing management. This effort will be done to satisfy the ongoing review of internal operational experiences (at least on an annual basis as per 3.3).
- Potential external operating experience as identified by the CAP, for ageing management implications shall be considered by formal evaluation. This effort will be done to satisfy the ongoing review of international operational experiences, as and when these are identified.
- Consideration should be given for the arranging of peer reviews of ageing management programmes, to obtain independent views and benchmarks and allow for programme improvements.
- The IAEA IGALL work groups continually collect and evaluate new materials knowledge, insights, ageing and degradation effects and mitigation and management methods. Changes and updates to IGALL (list of TLAAs, list of plant programmes and degradation tables) are made every year as agreed by the member states. These updates represent the broadest international operating experience related to ageing management. The IGALL changes and updates shall be reviewed and evaluated within one year of issue for impact and implication on the Koeberg ageing management programme. Gaps and improvements shall be actioned as appropriate.
- When identified, technical aspects of significant design basis and licensing issues are considered and overseen by the Engineering Technical Management Meeting. Often these issues involve integrity aspects of the equipment and could be related to ageing and degradation. Should the issue be linked to ageing and degradation of SSCs, the management position shall be communicated to the Ageing Management Programme Engineer and included in the Ageing Matrix as appropriate.
- In some cases, the management of equipment ageing is selected to be by replacement. At times, this replacement can't (or is chosen to not) be done with identical equipment and leads to design changes. Design changes that involve hardware are linked to the modification process and controlled/managed via the PIP [3]. The Ageing Matrix (and referenced management methods e.g., LOPP/NEPP) must be aligned to the PIP. There shall be a review of notifications of all changes to the PIP by the Materials Reliability group.

  Note: Minor modifications that are not controlled by the PIP must also be linked to the Ageing Matrix. Solution changes and implementation scheduled changes in minor modifications must also be reviewed by the Ageing Management Programme Engineer.
- Documentation identified and required for LTO [7] shall be confirmed available and managed under the NOU document processes.
- As required by RG-0027, "Interim Regulatory Guide Ageing Management and Long Term Operations of Nuclear Power Plants", par 6.8.3 [18], an annual report shall be compiled and submitted to the NNR. Reporting criteria shall be agreed with the NNR.

3.8 Oversight

Oversight of the ageing management process shall be achieved by a layered approach. This approach is made up of development and review of performance indicators, presenting of health reports at management level and tracking of commitments.

Performance indicators for ageing management must be developed, accepted, and annually reported via the appropriate management committee/s. The status report shall conclude on the effectiveness of ageing management at Koeberg Nuclear Power station and include items (as a minimum):

- All new ageing degradation/ageing identified and included in the Ageing Matrix.
- All plant failures and ageing related items identified for inclusion into the Ageing Matrix (but not completed).
- All implemented and required changes to ageing related programmes.
- Any new applicable industry ageing trends identified.
- Equipment reliability analysis and history for the plant (for the past year).
- Any changes to TLAAs.
- Formal appointment status as required by section 2.5.

Programme Health, System Health and Component Health Reports are required as a measurement of the effectiveness of site programmes and processes to maintain and improve plant safety, integrity, material condition and equipment reliability. These reports are to provide objective evidence of the status of plant programmes and equipment condition. If the plant programmes are not sufficiently effective, the programmes shall be improved, and all shortcomings addressed. Oversight of these reports shall be at management level, in line with governing procedures and terms of reference [5] and [16].

In support of the LTO safety case, it is anticipated that Eskom will have to commit to implement several ageing management related tasks. These could include one-time inspections, plant programme updates, new monitoring programme development and implementation, correction of identified configuration anomalies, documentation/procedure updates, etc. These commitments must be formally tracked and reported to the appropriate management forum and the NNR.

4. Acceptance

This document has been seen and accepted by:

Name	Designation
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5. Revisions

Date	Rev.	Compiler	Remarks
March 2022	2	K Moroka	Updated with comments from NNR letter k27142N - Koeberg Nuclear Power Station: Provision of the Koeberg Ageing Management Standard (dated 13 May 2021).
June 2020	1	A Kotze	Initial issue.

6. Development Team

The following people were involved in the development of this document:

- Anton Kotze

7. Acknowledgements

Not applicable.