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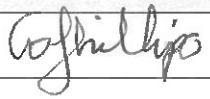
Safety Evaluation Report

Koeberg Long Term Operation

TR-NPP-24-001

Rev 1



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EXECUTIVE SUMMARY

Nuclear safety is defined in the Regulation on Safety Standards and Regulatory Practices (SSRP) as the achievement of safe operating conditions, prevention of nuclear accidents or mitigation of nuclear accident consequences, resulting in the protection of workers, the public and the environment against the potential harmful effects of ionizing radiation or radioactive material. Nuclear safety is essentially achieved through adhering to rigorous siting requirements considering external hazards, combined with a robust and safe design implementing nuclear safety principles of reliability of components and defence-in-depth and being operated in accordance with accepted operating practices and safety related programmes.

Operating the nuclear installation in accordance with the conditions of authorisation ensures the integrity of the licensing basis and therefore nuclear safety. KNPS has been operating safely for almost 40 years since initial commercial operation in July 1984. The KNPS design as well as the various safety related programmes have been modified or updated since its initial operation in line with the principle of continuous improvement, operating experience, and insights from periodic safety reviews.

The purpose of the LTO safety case is therefore in essence to identify the impact of extending the operating design life of the nuclear installation on the various design and safety analyses as well as to evaluate the adequacy of existing safety-related programmes for the period of extended operation as applied for. The safety case for LTO therefore, must demonstrate that the design and safety analyses as documented in the Safety Analysis Report (SAR) and operational practices as documented in various safety-related programmes are not negatively impacted by the extended period of operation.

The main technical concern related to extending the design life of a nuclear installation is the impact of ageing effects on the reliability of components and therefore potential safety functions and system performance. To this end, the SAR documents various design analyses assuming the limited operational design life of identified components. These have to be validated or re-analysed considering the period of LTO, the so-called time limited ageing analyses or TLAAs. A requirement of the ageing management process for nuclear power plants is that ageing management programmes should be developed, implemented, and maintained for all identified components subject to ageing to ensure that the safety function of the identified components is fulfilled over the entire operating life and for the proposed period of extended life of the nuclear power plant.

With the LTO safety case, Eskom therefore endeavoured to demonstrate that the design life of all identified components has been adequately revalidated and those identified components subjected to any ageing phenomena are covered by an ageing management programme and that the other safety-related programmes are adequate to ensure safe operation.

These requirements are captured in the NNR regulations on LTO (R266). The NNR assessment of the LTO safety case concluded that with respect to:

1) Submission of Safety case for LTO
2) Factors related to:
    a. Safety related programmes.
    b. Effectiveness of the ageing management programmes.
    c. Revalidation of time limited ageing analyses, except for the validation of; TLAA 301: Concrete Containment Tendon Pre-Stress that involves a time restriction of 8 years for Unit 2 of KNPS.
    d. Utilisation of the periodic safety review.
    e. Programme for LTO.

The Applicant has been informed of the regulatory concerns related to the validation of TLAA 301 on Unit 2. The resolution of the NNR concerns relating to Unit 2 of KNPS may require:

1) Conduct of additional tests to determine the material characteristics of the concrete (particularly in the dome area) to demonstrate the existence of adequate safety margin for the period of LTO.
2) Further analysis supported by results and calibration insights obtained from the cross-validation of the integrated leak rate tests (ILRTs) and the TLAA.
3) Additional containment monitoring instrumentation data to confirm respective safety and design margins.

The assessment also identified conditions that must be implemented during the period of LTO within specified timelines and that, if LTO is granted, will be subject to amongst other the following conditions during LTO:

1) Implement planned safety improvements PSR.
2) Implement post LTO commitments and activities.

1 INTRODUCTION

Koeberg Nuclear Power Station (KNPS) is situated on the Western Cape Coast approximately 30km north of Cape Town on Cape Farm No. 34, also known as Duynefontein. The Duynefontein Farm stretches 4.4km along the coast and 3.5km inland. The site is approximately 12km SSW of Atlantis and the nearest public residential area is the previous Eskom housing estate, now known as Duynefontein.

The KNPS is a twin-unit station, each unit contains a three-loop Pressurised Water Reactor (PWR) designed to produce 2785 MW (thermal) and a turbine generator with a net electrical output of 921.5 MW. The station was constructed between 1976 and 1985. The first unit was commissioned for commercial operation in 1984 (Unit 1) and the second unit in 1985 (Unit 2). The safety analysis for both units assumed a design life of 40 years.

Typically, the time when NPP operators start assessing their Long-Term Asset Management (LTAM) strategies and either decide to initiate the process for the approval and implementation of Plant Life Extension or prepare for decommissioning, is around the time when they reach 30 years of operation. Hence, Eskom approached the National Nuclear Regulator (NNR) in 2010 regarding its LTAM plans that included amongst others:

- A 60-year Plant Life Extension strategy;
- Steam Generator Replacement; and
- Thermal Power Uprate.

The potential thermal power uprates did not form part of either the SGR project or LTO applications and associated NNR reviews.

The challenges identified in the life extension strategy of KNPS included the review and extension of existing KNPS ageing management programmes together with establishing of the requirements for major equipment refurbishment and/or replacement. The LTAM plan included initially the Unit 2 reactor pressure vessel head replacement (Unit 1 reactor pressure vessel head was replaced prior to LTAM), refuelling water storage tank (PTR) replacements, and replacement of various cabling, switchboard, pump and feed-train components as well as considerations for additional spent fuel storage capacity.

In 2014 the IAEA commenced the process for Safety Aspects of Long-Term Operation (SALTO) peer review service for Koeberg in anticipation of and preparation for LTO. The peer

review work was conducted as a project, called the Koeberg SALTO Assessment Project, which followed the requirements of the IAEA SALTO process with the objective to provide KNPS with:

- an objective assessment of readiness for LTO; and
- recommendations and suggestions for improvement.

The precursor to the actual SALTO mission in 2022 was the Pre-SALTO missions that were concluded in 2015 and 2019. The NNR received the Pre-SALTO and SALTO mission reports and is monitoring the commitment of Eskom in implementing actions/safety improvements to resolve the recommendations and suggestions that were raised in the respective reports.

From the mission reports and in discussion with the IAEA during the Pre-SALTO missions it was evident that some of the Regulatory and Licensing Framework challenges were related to inadequate NNR standards for Ageing Management (AM), Periodic Safety Review (PSR) and Long-Term Operation (LTO), the periodicity and status of previous periodic safety reassessments and that there was no licensing period defined in the operating licence.

In line with good regulatory practices, it was important to establish a transparent regulatory framework for potential LTO of KNPS, which included the development of regulations and guidance documents. In most countries the option for LTO was not considered at the time of the original authorisation process of a nuclear power plant operation. Therefore, the applicability of the national regulatory framework for Long Term Operation had to be reviewed by regulatory bodies in general.

Similarly, the NNR initiated the process to review, revise and strengthen as necessary its regulatory framework for LTO with support from the IAEA through expert missions. The first expert mission took place in 2016 with the aim of reviewing the draft regulatory framework for LTO and Ageing Management. The support from the IAEA continued and assisted the NNR in the application of related international safety standards that informed the development of Regulations for LTO (R266) as well as NNR guidance documents (RG-0027 & RG-0028) on AM, PSR, and LTO which forms an integral part of the Regulatory Framework for LTO.

The Koeberg Nuclear Installation Licence, NIL-01, Variation 20, stipulates the conditions of operation for KNPS. The licence has a current operational design life of 40 years from date of start of commercial operation of Unit 1. The current operational phase is therefore justified until 21 July 2024, unless amended or varied for subsequent licensing stages, including LTO or varied, or suspended or revoked.

Eskom therefore had to apply for LTO of KNPS and must obtain approval and resultant amendment or variation of the licence for continued operations beyond the current operating design life.

Eskom formally applied to the NNR in January 2021 for LTO which included the aspect of separating the operating design life for Unit 1 and Unit 2. Subsequently, in November 2022, Eskom submitted a separate Licence Change Request to apply for the separation of the operating design life for Unit 1 and Unit 2 in the current licence.

The NNR granted approval for the separation of the end-of-life terms and issued Variation 20 of NIL-01 to reflect the individual operating design life of Unit 1 and Unit 2 of 21 July 2024 and 9 November 2025 respectively. The separation of the operating design life of the licence is aligned with the LTO application.

2 PURPOSE

The purpose of the SER is to:

1) Detail the outcome of the regulatory review and assessment of the Koeberg LTO application submitted by Eskom on 6 January 2021 in support of the LTO application, and subsequently revised on 10 May 2021 to align with the newly promulgated Regulations on LTO.
2) Detail the outcome of the public consultation process; and
3) State safety related findings on the LTO application.

3 SCOPE

Applicable to the process and review of the Eskom application to extend the operational design life of KNPS by another 20 years beyond the current licence term of 40 years.

4 ABBREVIATIONS

AADQ	Annual Authorised Discharge Quantities
ALARA	As Low as Reasonably Achievable
AM	Ageing Management
AMP	Ageing Management Programme
ANS	American National Standard
ARE	Feedwater Flow Control

ASG	Auxiliary Feedwater System
ASME	American Standard Mechanical Engineers
CAMP	Cable Ageing Management Plan
CDF	Core Damage Frequency
CLB	Current Licensing Basis
CRE	Control Room Envelop
DiD	Defence in Depth
DOE	Department of Energy
DSA	Deterministic Safety Analysis
EAS	Containment Spray System
ESEP	Expedited Seismic Evaluation Process
ESL	Environmental Survey Laboratory
EDF	Électricité de France
EP	Emergency Planning
EQ	Equipment Qualification
FSF	Fundamental Safety Function
FSP	Fundamental Safety Principles
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronic Engineers
IEC	International Electrotechnical Commission
IIP	Integrated Implementation Plan
INPO	Institute of Nuclear Power Operations
IGALL	International Generic Ageing Lessons Learnt
KNEP	Koeberg Nuclear Emergency Plan
KNPS	Koeberg Nuclear Power Station
LCR	Licence Change Request
LLWB	Low Level Waste Building
LOPP	Life of Plant Plan
LTAM	Long Term Asset Management
LTO	Long Term Operation
LV	Low Voltage
MCCB	Moulded Case Circuit Breaker
MV	Medium Voltage
NIL	Nuclear Installation Licence
NNR	National Nuclear Regulator

OSGISF	Original Steam Generator Interim Storage Facility
PAIA	Promotion of Access to Information Act
PAJA	Promotion of Administrative Justice Act
PID	Public Information Document
PLEX	Plant Life Extension
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
PTR	Reactor and Spent Fuel Pool
PWR	Pressurised Water Reactor
PWSCC	Primary Water Stress Corrosion Cracking
RCV	Chemical and Volume Control System
RGL	Full Length Rod Control System
RLE	Review Level Earthquake
RPR	Reactor Protection System
RPVH	Reactor Pressure Vessel Head
RRA	Residual Heat Removal System
RRR	Radiological Release Response
SALTO	Safety Aspects of Long-Term Operation
SANS	South African National Standards
SAR	Safety Analysis Report
SGR	Steam Generator Replacement
SRA	Safety Re-assessment
SSC	System, Structures and Components
SSR	Site Safety Report
SSHAC	Senior Seismic Hazard Analysis Committee
SSRP	Regulations on Safety Standards and Regulatory Practices
TOP	Technological Obsolescence Programme
TLAA	Time-limited ageing analysis
USNRC	United States Nuclear Regulatory Commission
WANO	World Association of Nuclear Operators

5 REGULATORY FRAMEWORK

Information from international peers, bilateral cooperation with other Regulators and information shared via IAEA literature and IAEA expert missions highlighted that there are basically two international approaches to LTO. The approaches are different and are dependent on whether there is a licensing period in the regulatory framework. Both international approaches are dominated by the concept of a licensing period and involves the use of ten yearly Periodic Safety Reviews or Licence Renewals.

a) Periodic Safety Review

Periodic Safety Review (PSR) as a tool to justify continued operation is typically used in countries with unlimited or open-ended operating licenses, the operating licence remain valid as long as the respective safety requirements are met. The key features of this approach are:

- Long term operation is authorised based on periodic reviews of safety performed by the plant operator and the Regulatory Body.
- The licensing basis is reviewed during the PSR process and significant efforts are made to identify safety improvements.
- Based on the results submitted, the Regulatory Body may allow the continued operation for the next PSR cycle, which is typically 10 years.
- In the case of justifying LTO an extensive review of ageing management is conducted as part of the PSR.

b) Licence Renewal

Licence Renewals are typically used in countries where the operating design life is limited, i.e. normally 40 years, but in some countries, it could even be 10 years. The operating licence remains valid for the issued licence term and requires renewal for another period for the extended period of LTO.

The key features of this approach are:

- Countries following this approach have differences regarding the number of subsequent licence renewals and the duration of the extended licence.
- PSR may also be used as a tool for regularly reviewing the current licensing basis (CLB) and identifying safety improvements.
- A strong CLB approach is followed to review and ensure continuous compliance with

requirements with strict regulatory oversight of operation of the nuclear power plant.

- The scope and methods for safety demonstration are specifically outlined in the national regulations.
- The extended safety review to demonstrate that safety requirements will be met during the extended lifetime by adequate management of the effects of ageing.
- The Regulatory Body reviews the licence renewal application, conducts the appropriate inspections, and issues a decision at the end of the process.

From the two approaches, it is evident that in the case where there is no specific operating licence period (i.e. licence expiry date), the licensee is allowed to operate the plants in accordance with the licensing basis and the use of PSR to routinely assess the cumulative effects of power plant ageing and modifications. The PSR will provide recommendations on mainly some non-physical ageing (the process of their becoming out of date, i.e. obsolete, owing to the availability and evolution of knowledge and technology, and the associated changes in requirements, codes, and standards) of SSCs and identify and seek to implement safety improvements if the power plant is planned to be operated beyond its original design life. The conduct of the PSR is strictly controlled and enforced via an internationally accepted frequency of 10 years.

In the case where there is a specific licence period (operational licence expiry date), the licensee applies for a licence renewal OR use the last PSR combined with an LTO-specific safety review that focuses on ageing management and in-scope component life assessments as prerequisites to obtain an operating licence extension from the original design life.

Depending on the choice of LTO approach, there are different procedures for the justification of LTO and these are reliant on the regulatory framework of the specific country. If LTO is done based on the use of PSR, the authorisation is done under the framework of a current operating licence for the next PSR cycle. If the authorisation is a licence renewal, a new operating licence for a specified period is issued to cover the LTO period.

The regulatory framework for dealing with applications for authorisation of LTO should be defined and transparent, hence the country needs to develop and establish a clear and explicit set of requirements, criteria, and standards forming the basis for LTO authorisation. This should include requirements for the licensee to demonstrate that the effects of ageing have been and will be adequately managed, and Time Limited Ageing Analysis (TLAAs) have been appropriately dealt with. Internationally it is recognised that the authorisation process needs

to be transparent to the public, and authorisations need to be published or made available to the public.

The NNR strategy for ageing management and LTO was informed by the above international considerations, informed by the IAEA recognised SALTO methodology. The NNR's goal was to provide a regulatory framework considering national legislation such as the Promotion of Administrative Justice Act (PAJA), the Public Access to Information Act (PAIA) and international best practices and to be aligned with the IAEA standards.

Historically the approach employed for KNPS was the one applicable to an unlimited or continuing operating licence. All variations of NIL-01 up to Variation 18 had no operating design life specified and the operating licence was kept valid using the periodic performance of safety reviews. When Eskom informed the NNR of its intention of long-term operation at KNPS, the NNR undertook a review of its regulatory framework against current national legislation. It was determined that there was no administrative requirement that would prevent KNPS to proceed with LTO except the current 40-year design life of the Reactor Pressure Vessel (RPV) mentioned in the Safety Analysis Report (SAR) requiring the approval of SAR changes by the NNR. The NNR hence considered the following historical information to formulating the regulatory framework that has been adopted:

- The Koeberg licence at the time was open ended with no requirement for the successful completion of PSR. It was accepted that the performance of a PSR only informs the continuation of the licence.
- Koeberg at the time had only completed two safety re-assessments (SRA's) under the umbrella of periodic safety review. The first one in 1998 and the second one in 2011. These reports unfortunately did not contain a review of all the Safety Factors as required by international guidance in the IAEA Safety Guide SSG-25.
- Koeberg has performed an SRA following the Fukushima Daiichi accident with a scope limited to extreme external events.
- Plant Condition Management at KNPS that deals with the degradation or ageing of components have been aligned with and performed in accordance with the approach followed by EDF in France. It did not necessarily follow the systematic approach of the identification of SSCs affected by the internationally shared degradation/ageing mechanisms.
- The public awareness and expectation of KNPS reaching its end of operating design life and possible decommissioning due to the 40 years quoted in the SAR.

- The expansion of developments along the West Coast and the potential impact to the Emergency Planning arrangements for KNPS.
- History and absence of necessary legislation controlling developments within the emergency planning zone of KNPS.
- Koeberg's adoption of the IAEA-recognised SALTO process and methodology to prepare for LTO. This includes aligning its ageing management process with the internationally recognised International Generic Ageing Lessons Learnt (IGALL).

Further, extending the operational life of the KNPS for another 20 years involves a significant administrative action by the NNR that potentially impacts many stakeholders. The need for stakeholder consultation in line with the spirit of the NNR Act and the Promotion of Administrative Justice Act (PAJA) was a serious consideration.

The NNR subsequently developed, and the Minister promulgated the Regulations for LTO (R266). The Regulation complements the existing safety standards and is consistent with the guidance documents, RG-0027 (Ageing Management and Long-Term Operations of Nuclear Power Plants) and RG-0028 (Periodic Safety Review of Nuclear Power Plants) that were developed prior to the publication of the Regulations for LTO (R266). These documents, including the varying of NIL-01 to include the operating design life of KNPS in Variation 19, concluded the LTO regulatory framework, aligned with the IAEA standards and considers international best practices.

In the absence of the new regulations at the time of issuing Variation 19 of NIL-01, the implementation of the guidance documents was done through reference in the Koeberg licensing basis. This change was one of many in the update of the licence in preparation for LTO, which included:

- Incorporation of an operation design life in the licence (Operation design life limited to 40 years);
- Strengthening the licence condition related to PSR; and
- Strengthening the licence requirement related to Ageing Management.

With this implemented framework, licensees are required to apply for a variation of the licence. This application for a variation of the licence must be done in accordance with the current legislation and will require the submission of a safety case to support the application. The safety case must be informed by amongst others the outcomes of the SALTO Ageing

Management process and a comprehensive PSR, conducted in accordance with NNR guidance documents.

The approval process follows that of a new licence application and includes public consultation, the extend of the public consultation is determined by the Board in accordance with the provisions of the NNR Act. The NNR concluded that this approach and the changes introduced will provide for a transparent process, legally sound and in accordance with international standards and practices.

In summary, the regulatory framework for reviewing the application for LTO comprises the NNR Act, the Regulation on Safety Standards and Regulatory Practices (SSRP), the Regulations on Long Term Operation for Nuclear Installations (R266), NIL-01 Variation 20 and regulatory guides RG-0027 and RG-0028. In addition, the current licensing basis is made up of all the applicable regulations, regulatory guidance documents, licensing directives and the licensing basis as defined in the Regulatory Guide on Safety Assessments of Nuclear Power Reactors, RG-0019.

6 SAFETY CASE

6.1 Introduction

The NNR has defined in the SSRP and supporting requirements documents fundamental safety criteria consisting of risk criteria and dose limits for the protection of workers and the public in all operating and accident conditions associated with nuclear installations.

The NNR's fundamental safety criteria and safety requirements are aligned with international best practices. The NNR requirements include deterministic and probabilistic risk assessments. The main objective of the fundamental safety criteria is to ensure that operations from nuclear installations do not cause undue nuclear safety risks and/or radiological safety risks to workers or the public as well as the environment.

In line with the principle that the holder/applicant has prime responsibility for safety, the applicant is required to present a safety case in support of the application. The LTO safety case aims to demonstrate at high-level, compliance with the LTO regulations which further includes:

- Demonstrating compliance with the relevant regulatory safety criteria and requirements.
- Results of safety analysis, with due consideration of the ageing of structures, systems, and components (SSCs).
- An overall assessment of the safety of the nuclear installation and justification for continued safe operation.
- Demonstration of the availability of adequate financial and human resources as well as knowledge management.
- Necessary safety improvements in the application, including refurbishment, provision of additional SSCs, safety analyses, and engineering justifications, to ensure that the licensing basis remains valid during the LTO period.

The key topics discussed in the safety case therefore include among others, adequacy of KNPS design, effectiveness of ageing management programmes as well as safety-related programmes.

The term safety case generally refers either to:

(1) the safety documentation, including the SAR, of the nuclear installation, which is part of the current licensing basis, or
(2) the safety submission to justify a modification or change to the current licensing basis.

In the case of an application for LTO, the safety case refers to the justification of a change (or variation) to the current licensing basis. The following subsections contextualises the use of the term safety case for the different applications.

6.1.1 Safety Case for initial application

Although the application for LTO is a "Safety Case for modification or change" as described below, some information pertaining to a safety case for initial application and subsequent authorisation stages is first provided below.

A safety case for a new installation must demonstrate compliance with the relevant nuclear and radiological safety criteria. The SSRP lays down "principal radiation and nuclear safety requirements" which include amongst others the following:

- Radiological dose and risk limits for the public and workers.
- Defence-in-depth
- ALARA
- Good engineering practice
- Safety Culture.

As the radiological dose and risk limits for the public and workers relate directly to the objectives of nuclear and radiation safety, they are considered fundamental yardsticks against which to assess the level of safety. These are complemented by requirements on defence-in-depth, ALARA and safety culture which must be respected.

The term safety case therefore refers to documentation relevant to the demonstration of compliance with the above-mentioned safety criteria, as applicable during the various authorisation stages and must include the relevant policies, industry standards, and procedures necessary to ensure the validity of the safety case on an ongoing basis.

The NNR reviews the safety case to verify that the action or nuclear installation meets the relevant requirements documented in the SSRP, NNR requirements and relevant IAEA Safety Standards.

6.1.2 Safety Case for modification or change

In the case of a safety case submitted to justify a modification or change, the NNR reviews the impact of the change submitted on the current licensing basis and the NNR safety requirements and criteria. Specifically, for LTO, the NNR reviews focussed on the impact of the change in the operational design life of the installation on the respective safety criteria, and on the current licensing basis that was previously updated, maintained, and systematically improved throughout the current operational licence term.

The LTO application process started with the notice from Eskom indicating their intention to pursue LTO at 48 months before LTO. This notification was received from Eskom in May 2020, in compliance with the process and timeline. The LTO application followed in January 2021 at 42 months before LTO. The application was received in compliance with the process and timeline as was specified. The application initiated the activities related to Eskom completing the Safety Case for submittal as well as completing the Public Information Document (PID) necessary for the start of the NNR public consultation process. The Safety Case was submitted by Eskom in July 2022, in compliance with the process and timeline. The final PIDs, translated in English, Afrikaans and isiXhosa, were received from Eskom in August 2022. The application, the PIDs and a redacted version of the safety case was published by the Applicant for notification and for public comment as was directed by the NNR in January 2023.

6.2 Summary of Application

The original Safety Case (Revision 1) was received in July 2022. Due to ongoing updates necessitated by the completion of safety case deliverables, requests for additional information by the NNR and requests for access to information from the public, there have been 3 revisions of the safety case released. The following explains the chronology and summary of extent of the updates to the safety case made to date:

1. Safety Case Revision 1

The first version of the Safety Case was submitted to the NNR in July 2022. The revision included various deliverables planned for submission to the NNR prior to LTO, including pre LTO and post LTO commitments.

2. Safety Case Revision 1a

An updated version of the Safety Case was submitted to the NNR in January 2023. The version included editorial updates following the NNR screening review of Revision 1. It was also the version that included the initial redactions following the NNR instruction to the applicant to redact and release the safety case for the purpose of providing the public access to information to make meaningful representation on health, safety and the environment related to the application.

3. Safety Case Revision 2

An updated version of the Safety Case was submitted to the NNR in February 2023. The version included updates based on the balance of NNR review comments following the review of Revision 1.

4. Safety Case Revision 2 (updated)

An updated version of the Safety Case was submitted to the NNR in September 2023 based on the Eskom review of the adequacy of redactions introduced in Revision 1a of the document. This was done following the PAIA request for an unredacted version.

5. Safety Case Revision 3

An updated version of the Safety Case was submitted to the NNR in October 2023 based on an up-to-date status of LTO activities completed, ongoing NNR review comments. Revision 3 also includes changes in technical positions and justifications related to the optimisation of the TLAA implementation strategy specifically with respect to some post-LTO (July 2024 and November 2025 respectively) commitments and modifications.

The above revisions and updates to the safety case provided an overall conclusion of the safety of Koeberg for the intended 20-year period of LTO. It discusses and evaluates the adequacy of KNPS design, the adequacy and effectiveness of safety-related programmes and organisational provisions, especially ageing management programmes. The main inputs to the safety case are the 3rd PSR and the SALTO project ageing management assessments and, where applicable, other relevant safety-related assessments to complement the case for continued safe operations.

6.3 Regulatory Basis

The basis for the content of the submitted Safety Case links directly to the framework described in the Regulations on the Long-Term Operation of Nuclear Installations (R266) and the Interim Guidance for the Long-Term Operation (RG-0027).

The first version of the document defining the structure and content of the safety case was drafted by Eskom in October 2020. The document content was informed by Eskom's understanding of the requirements in the LTO framework related to setting the boundaries of the information required to be provided to justify the change (Variation of the licence) applied for.

The NNR accepted the final structure of the safety case proposed by the applicant in March 2021.

6.4 Technical Assessments

The NNR completed the initial screening review of Revision 1 of the safety case in September 2022. The screening review was followed by the first round of detail review, which concluded in December 2022 with various requests for additional information from the applicant to resolve NNR comments. The NNR continued with a review of topical areas, safety case deliverables and responses to NNR review comments. Subsequently, the applicant updated the safety case to reflect the status and outcome of scheduled deliverables, changes in technical positions and justifications related to certain commitments as well as resolution of NNR review comments which ultimately led to the latest version, Revision 3 of the Safety Case.

The NNR assessment of the safety case is informed by reviews conducted across various technical areas and consolidated as follows considering the NNR regulatory requirements as detailed in the SSRP and LTO regulations.

6.4.1 Compliance with regulatory safety criteria

The existing safety case (SAR, SSR and probabilistic safety analyses (PSA)) aims to demonstrate compliance with the fundamental safety standards and other requirements which include:

1. The risk criteria addressing mortality risk to the public (present and future generations) and workforce.
2. The radiation dose limits to members of the public and workforce arising from normal operations.
3. The fundamental safety principles (including defence-in-depth and ALARA in accordance with the SSRP).
4. Requirements for emergency planning.
5. Management System requirements.
6. Compliance with international norms and standards.

Whilst complying with the above standards can be deemed to be acceptably safe, the levels of risk should be kept as far below the standards as reasonably achievable.

Eskom has confirmed in the 3rd PSR that there is no significant impact due to LTO on the fundamental safety criteria and safety requirements as defined in the SSRP. The evaluation and calculational models have been updated, verified, and validated as required and systematically improved as part of continuous improvement. Although the risk profile had shown a recent increase due to casking activities as part of the spent fuel management programme, the overall PSA results demonstrated that the risks associated with the operations of the nuclear installation are well within the respective risk limits notwithstanding various conservative input assumptions.

Oversight by the NNR, benchmarking and industry improvements in the PSA modelling as well as improved source term methodology implemented as part of the SGR project provides confidence in the deterministic and probabilistic safety analyses demonstrating compliance and improvement.

The 3rd PSR, submitted to the NNR in 2022, is one of the major inputs that informed the LTO safety case, ensures that a holistic overview of aspects related to defence in depth, ALARA, emergency planning and quality assurance are reviewed and any deviation from the latest local and international standards documented, and improvements implemented.

The 3rd PSR review of SF-5 revealed the extent to which the existing PSA study remains valid as a representative model of the KNPS and that the current KNPS design and operating features have been modelled to a sufficient level of detail to support the risk applications performed with it. It included whether the results of the PSA show that the risk is sufficiently low and well-balanced for all postulated initiating events and operating states. The review

confirmed that the overall PSA results demonstrate that the risks associated with the operation of KNPS are well within the Principal Safety Criteria (risk limits) specified in SSRP and therefore support safe continued operation.

6.4.2 Results of deterministic safety analyses

This includes the analyses to demonstrate compliance with nuclear safety criteria. Deterministic safety analysis shall be covering both normal operational and accident conditions. The objective of the deterministic safety analysis is to:

- Demonstrate compliance with safety requirements such as ensuring the integrity of barriers against the release of radioactive material and various other acceptance criteria.
- Determine whether there is adequate safety margin in the design and operation of a nuclear installation, or in the conduct of an activity.
- Derive or confirm operational limits and conditions that are consistent with the design and safety requirements for the facility.
- Assist in establishing and validating emergency operating procedures and accident management procedures and guidelines; and
- Confirm that modifications to the design or operation of the reactor facility have no significant adverse impact on safety.

The latest accident analyses, which have been performed as part of the SGR project have been updated using a new source term, reference core approach and a reversal to the original design operating temperature regime. The deterministic safety analyses were conducted to confirm the design basis for Structures Systems and Component's (SSCs) important to safety and to evaluate the plant behaviour for the postulated initiating events (PIEs).

The review of the deterministic safety analyses assessed the safety up to the end of LTO and therefore takes into consideration the replacement of the KNPS steam generators and other planned modifications.

The NNR accepted the presented results as part of the acceptance of the SGR safety case and subsequent reviews of all submitted analyses produced during the SGR project.

The conduct of the 3rd PSR and review of SF- 5 relied upon and reviewed the deterministic safety analysis process from the point of the current state of the deterministic safety analysis (original analysis and updated analysis), compliance to the latest standards and requirements

from the point of graded approach for PIEs, deterministic methods, and criteria, DSA quality, verification of DSA and adequacy of safety margins.

The crediting of the analyses performed during the SGR project and the results of the review from the 3rd PSR forms part of and informs the overall acceptance of and status of the deterministic safety analyses at KNPS by the NNR.

6.4.3 Overall assessment safety

Safety assessments of existing nuclear installations are a requirement for nuclear safety. In the case of KNPS, a safety assessment is expected to be performed every ten years. The safety assessments are performed to identify areas of weakness and areas where improvements can be made in view of technological advancements and operational experience. The assessments also account for KNPS modifications.

The NNR has provided guidelines for nuclear licence holders and nuclear licence applicants in the form of RG-0019 to facilitate the process of conducting safety assessments and, in the case of the Regulator, the safety assessment review. The holder of a nuclear installation licence is required to document and implement a methodology to maintain the validity of the safety assessment, including the PSA, on an ongoing basis, thereby addressing any issue giving rise to changes in safety, and must include the identification of those changes requiring submission of a safety case to the Regulator.

6.4.4 Safety improvements

One of the uses of the NNR-accepted PSA is to identify and prioritise modifications to KNPS and its procedures where the risk-benefit of these changes are within the scope of the current PSA models. The cumulative impact of these identified safety-related modifications and improvements during the KNPS operational life is reflected in the decrease in core damage frequency (CDF) indicator as shown and reported in the LTO safety case.

The KNPS modifications and improvements that have been implemented throughout the operational design life and that directly informed an improved baseline risk and licensing basis include:

- Containment sump blockage modification.
- Refuelling water tank level sensor flooding modification.
- Reactor coolant system over-pressure protection.

- Station blackout modification that included additional emergency diesel generators to supply backup to DC power and an additional reactor coolant pump emergency seal supply system.
- Installation of additional fire-doors and fire-curtains.
- Updating severe accident management guidelines relating to hydrogen-induced containment challenges.
- Containment passive autocatalytic recombiners installation.
- Water back-up from the fire protection system to the containment spray system.
- Modification to containment hatch bolts.
- Changes to the emergency operating procedures.
- Modifications to eliminate the risk to internal flooding of the component cooling pump rooms.

The NNR, through a condition of the licence, requires all KNPS modifications and safety improvements that could lead to a change to the design and licensing basis, whether negative or positive, to be submitted to the NNR for approval. The submittal must include an assessment of the impact of the change on the current licensing basis and PSA for KNPS.

6.4.5 Seismic Hazard Assessment

During the initial licensing of the KNPS, all hazards (external and internal) were analysed and assessed, and appropriate measures were implemented in the design and operating procedures to manage the impact of these hazards on the nuclear installation. For earthquake hazards, a seismic study was performed for the Duynefontein site to derive the seismic design basis for the initial licensing of KNPS. All subsequent seismic studies performed for the Duynefontein site show that earthquake hazards capable of exceeding design basis for the KNPS and their likelihood of occurrence are low. Similar to most nuclear installations around the world, the KNPS earthquake and tsunami hazard design basis has been established considering local conditions and historical event data.

KNPS is situated in a region that is insulated from severe external events. Nonetheless, KNPS has extensive protective features to prevent it from being impacted or affected by such eventualities. These protective features include, amongst others, the following:

1) The nuclear island is constructed on a seismic raft that provides the capability to withstand a design basis seismic event of up to 0.3g ground acceleration.
2) KNPS can withstand winds of up to 225 km/h; and

3) The terrace on which KNPS has been constructed protects it from tsunamis up to 8 m in height.

It should be noted that the design bases for nuclear installations are derived using conservative input assumptions in general. The Koeberg SSR contains information relating to the hazards applicable to the facility. The second safety reassessment of KNPS recommended that the Koeberg SSR be updated with the latest information relating to site-specific hazards. In accordance with the guidance in RG-0027, the justification for safe LTO, should include the description of any design basis reassessment. To determine any need for design basis reassessment, the studies relating to the update of the site characterisation had to be performed as part of the LTO assessments.

As part of the external events Safety Re-assessment (EE-SRA), informed by the Fukushima Daiichi disaster, a seismic evaluation (i.e. stress test) was performed in 2011 on the KNPS, for seismic events beyond the original seismic design basis of the KNPS, to identify potential seismic issues and potential cliff edge effects. The seismic stress test adopted a methodology based on a Seismic Margin Assessment (SMA) and reviewed critical safety systems for their seismic capability (robustness) against a review level earthquake (RLE) of 0.5g (compared to the Koeberg seismic design basis of 0.3g) obtained by using the expedited seismic evaluation process (ESEP) guidance to scale the above-mentioned original 0.3g value to 0.5g for the robustness verification. ESEP is an approach developed by EPRI which is accepted by the US-NRC and applied in the USA.

The NNR accepted Eskom's Interim Seismic Evaluation strategy to demonstrate that from a seismic hazard perspective the existing KNPS is safe, and that future enhancements are implemented appropriately by initially performing an interim review and justification in support of the LTO decision. The seismic design of the KNPS was demonstrated to be seismically robust against the assumed RLE.

The Interim Seismic Evaluation concluded that safe shutdown is possible after a RLE seismic event without posing significant risk to continued compliance with NNR risk limits in the LTO period. The future KNPS enhancements for Design Extension Conditions (DEC) recommended in the Interim Seismic Evaluation Report are included in the LTO Integrated Preparation Plan (IPP).

Subsequent to the Interim Seismic Evaluation, a Probabilistic Seismic Hazard Assessment (PSHA), was performed in accordance with the Senior Seismic Hazard Analysis Committee

(SSHAC) enhanced level 2 (SSHAC EL-2 PSHA). The SSHAC EL-2 PSHA for the Duynefontein site and the KNPS was conducted per the guidelines provided by USNRC in NUREG-2213. The SSHAC results show that the original design basis was overly conservative in the lower frequency ground motion ranges (the ranges with the most direct impact on structural design), and less conservative in the higher frequency ranges. The impact of the less conservative seismic hazard in the higher frequency ranges on the design has been assessed as part of Interim Seismic Evaluation Strategy which verified the robustness of the design for an RLE and concluded to not pose a threat.

Eskom incorporation of the results of the SSHAC EL-2 PSHA into the Koeberg design basis will form part of improvement actions emanating from the 3rd PSR.

6.5 Summary

The LTO safety case in its simplest form can be considered the integration of technical justifications that supported implementation of various modifications to or changes to the licensing basis of KNPS. The bulk of the technical justification, analyses, and reviews conducted within individual projects are credited in the LTO safety case. The various projects spanning over a timeframe from 2014 to 2024 include the Steam Generator project, 3rd PSR project, Safety Aspects of Long-Term Operation (SALTO) project and other individual improvement modifications. The NNR acceptance of the deliverables from these projects are credited in the NNR review of the arguments presented in the safety case where appropriate. The NNR review, compliance assurance activities and Bilateral engagements with other Regulators provided informed ongoing oversight over the technical aspects. Below in Figure 1 is an overview of the timeline reflective of the NNR review effort and involvement in the projects credited:

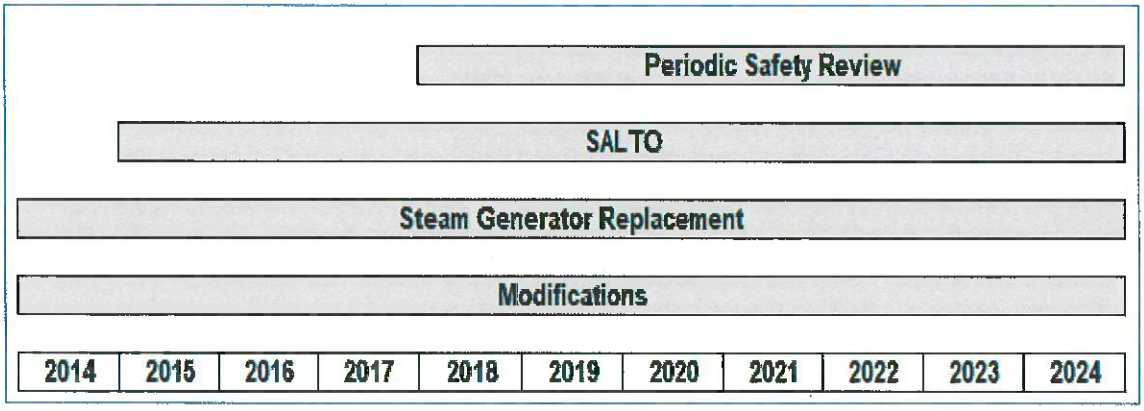


Figure 1: Projects

An important aspect introduced into the safety case was the concept of "commitments". These are actions not completed at the time of submittal of the safety case and committed to be completed at the time of the intended LTO. The NNR tracked the completion of the commitments and through the application of the graded approach verified the completion of selected commitments through compliance assurance activities.

The NNR's review outcome of the safety case is informed by the completion of all the activities tracked under the various projects credited in the safety case, completion of all commitments scheduled to be completed prior to LTO, resolution of all issues raised during the public consultation process related to health, safety and the environment and the impact of any outstanding technical review comment at the time of the decision.

7 SAFETY RELATED PROGRAMMES

7.1 Introduction

The NNR's approach to the regulation of nuclear safety and physical security takes into consideration operational safety-related programmes as well as their importance to safety. In accordance with the SSRP, the operational safety assessment must establish the basis for all the operational safety-related programmes. The NNR included into the framework for LTO, the requirement to assess other programmes that affect nuclear safety. The inclusion was based on the premise that not all safety-related programmes would be assessed for LTO if either the SALTO or 3rd PSR approach are utilised as justification. Both safety-related programmes linked to ageing management and programmes in place to ensure KNPS safety until the end of commercial operation must be adequate and effective.

Eskom defined in the document on content and structure of the safety case the safety-related programmes to be focused on and to be covered in the safety case. The determination was made based on the coverage of programmes as guided by RG-0027. Eskom excluded certain programmes from separate justification due to their inclusion in the 3rd PSR. These programmes are maintenance, equipment qualification, in-service inspection, and surveillance programmes that were assessed as part of the 3rd PSR and hence included into the safety case.

7.2 Regulatory Basis

The regulatory requirements against which the Safety Related Programmes were evaluated are:

a) Regulations in terms of section 36, read with section 47 of the NNR Act on the Long-Term Operation of Nuclear Installations, R266
b) Regulations in terms of section 36, of the National Nuclear Regulator Act, 1999 (Act no. 47 of 1999), on Safety Standards and Regulatory Practices (SSRP), GN R388.
c) NNR Interim Regulatory Guide RG-0027 Revision 0: Ageing Management and Long-Term Operations of Nuclear Power Plants.

7.3 Technical Assessment

7.3.1 Nuclear Security

The adequacy of the nuclear security arrangements for KNPS (reviewed by the NNR under a separate arrangement due to the sensitivity of the information) was done in accordance with the methodology and principles used to perform the 3rd PSR. The NNR verified that the security review was performed in accordance with the NNR agreed requirements and accepted review methodology. The review verified the Physical Security Systems and programmes for the period of LTO. Both physical as well as cyber security were assessed and verified that these can be maintained during the period of LTO. The NNR also verified that the results of the safety case and the separate Security review does not invalidate conclusions and/or statements between each other. Interaction between the two reports as appropriate has been considered.

Current procedures and processes adequately cover the provisions required for sabotage and unauthorised removal of nuclear or radioactive material, including radioactive sources. Over recent years great focus has been placed on the cyber security measures. Eskom developed and implemented a cybersecurity policy which is supported by the cybersecurity programme, with specific training courses to maintain a cybersecurity culture at KNPS.

The outcome of the LTO review indicated that adequate measures are in place to minimise the vulnerability and consequences of a breach at KNPS. Eskom KNPS has implemented a programme to improve the physical and cybersecurity measures which will be completed by means of modifications over the coming years. These modifications are planned to be in line with the changes required to meet the requirements of the updated National Design Basis Threat (DBT). As per current licensing requirements, any modification at KNPS is reviewed and approved by the NNR. The implementation of any changes as part of this improvement programme will be done in a controlled plan as approved by the NNR.

Together with the continued NNR oversight over the existing programme, it provides assurance regarding the adequacy of and integrity of the programme to support the nuclear security arrangements during the current as well as proposed LTO period.

7.3.2 Emergency Planning

Measures have been taken in siting, design and operations to ensure that accidents that may occur at Koeberg will not result in significant exposure to people both on and offsite.

The safety analyses have shown that the risk posed by KNPS is within acceptable limits. Nevertheless, because of the potential magnitude of accidents and the fact that such accidents

cannot be totally ruled out, Eskom have been obliged to set up an emergency response organisation with the objective of preventing short term severe health effects and minimising the number of latent health effects that may arise from large scale accidental release of radioactive material from KNPS.

- **Purpose of Emergency Plans**

The goal of emergency preparedness is to ensure that adequate capability is in place within the operating organisation and at local, regional and national levels and, where appropriate, at the international level, for an effective response in a nuclear or radiological emergency. To ensure adequate emergency planning and response (EPR) arrangements, an emergency plan is established to describe the objectives of the plan and it makes provision for an integrated set of infrastructural elements that include but are not limited to authority and responsibilities; organisation and staffing; coordination; tools, equipment and facilities; training, drills and exercises; and a management system for a systematic, coordinated and effective response.

The emergency plan serves as the basis for the development of other plans, procedures, and checklists. The emergency plan also takes into consideration hazard assessment which is an initial requirement to identify all potential hazards posed by the facility. For a facility like KNPS, the emergency plan is required to be coordinated with the local municipalities and all the other stakeholders inherently responsible for emergency response and must be submitted to the NNR for approval. The emergency plan for Koeberg is documented and is supported by a set of implementing procedures.

The 3rd PSR in SF-13 performed a review of emergency planning to determine whether the KNPS has adequate plans, staff, facilities, and equipment in place for dealing with emergencies; and whether arrangements for dealing with emergencies have been adequately coordinated with those of the local and national authorities and are regularly exercised.

- **Emergency Planning Technical Basis (EPTB)**

The NNR has consistently enforced emergency planning zones around KNPS, informed by risk analysis. The NNR has also consistently applied restrictions on developments in the formal emergency planning zones of KNPS, also informed by risk analysis, beyond present international requirements.
Since 2010 Eskom intended to pursue a re-assessment and change to the current Koeberg Emergency Planning Technical Basis (EPTB) and existing Emergency Planning (EP) zone

sizes and several compliance methodologies were investigated and documented. However, following the accident at the Fukushima Daiichi NPP in Japan in 2011 and the IAEA's indication that they will review the IAEA Safety Standards after their investigations and subsequent lessons learnt from the Fukushima accident, the NNR has put on hold Eskom's project to re-assess the Koeberg EPTB and EP zone sizes for the time-being.

The onset of the LTO project created the opportunity for Eskom to perform the re-assessment of the EPTB and existing EP zone sizes against the NNR EPTB requirements for existing nuclear installations. The aim was to re-affirm that the basis and zones remain adequate considering relevant operating experience and will provide sufficient protection to the public during a nuclear or radiological emergency. In order to provide such affirmation, Eskom submitted a "Re-assessment of Current Koeberg Emergency Planning Technical Basis (EPTB) for Long Term Operation", which documents the re-assessment of the Koeberg EPTB and EP zone sizes. The NNR accepted the re-assessment of the EPTB following review of the submission and resolution of comments and that Eskom must submit to the NNR the external events Level 2 PSA and the update of the EPTB with the results of the external events Level 2 PSA.

- **KNPS Emergency Plan Response Exercises**

The adequacy of emergency response arrangements is evaluated through the review of emergency plans, procedures and infrastructure that are established at the preparedness stage. The ability to carry out the required emergency actions during response phase is assessed through reviews of past performance, but it is most commonly evaluated through exercises. Emergency response exercises are a key component of a good emergency preparedness program. They provide a unique insight into the state of preparedness of emergency response organizations and are the basis for the identification of continued improvement of the overall emergency response infrastructure. For the exercises to be most useful, they need to be well organised, and professionally conducted and their evaluation must focus on constructive improvement potential.

Nuclear and radiological emergency response exercises are a powerful tool for verifying and improving the quality of emergency response arrangements. Each exercise represents a significant investment of effort, financial resources, and people. It is therefore important for each exercise to yield the maximum benefit.

The viability of the Koeberg Nuclear Emergency Plan (KNEP) and related programmes are periodically tested by the NNR. Although the recent exercise results showed some deficiencies in the management of the KNEP by the off-site functionaries, the viability of the plan was not in question. The response by the licensee adequately demonstrated that the on-site response is capable to deal with and timeously identify, declare and implement the first phases of an emergency response.

The identified off-site gaps are not considered symptomatic of an inadequate integrated nuclear emergency plan but rather the relaxation of compliance to existing programmes and requirements previously demonstrated to be met. This position is supported by the fact that the off-site functionaries demonstrated adequate response to deal with real disasters in the Western Cape and is considered as mitigation for the capabilities of the off-site organisations and their role in the integrated KNEP.

- **Summary**

The NNR continued oversight, both on-site and off-site, ensures that compliance is established and the viability of the KNEP is assured.

The 3rd PSR in SF-13 assessed the adequacy of emergency planning processes and procedures. None of the deviations identified were of such a nature that they disposition the conclusions in the LTO safety case regarding the adequacy of the programme.

The NNR indicated during its review that the updated EPTB is a prerequisite for decision making on LTO and that the current EPTB study supports the DSSR. Following the NNR acceptance of the EPTB and the results from the 3rd PSR that did not identify any issues that will negatively impact the arguments presented in the safety case, it is concluded that the Integrated Koeberg Nuclear Emergency Plan is viable for the protection of persons and the environment during the period of LTO. Notwithstanding, specific areas for improvement have been identified from the PSR as well as NNR review.

7.3.3 Radioactive Waste Management

The NNR verified that the conclusions in the Safety Case related to radioactive waste management is in accordance with the content of the various input sources. The 3rd PSR in SF-8 performed a review of the adequacy of the radiation protection and radioactive waste programmes with the aim to assess the effectiveness of the Radioactive Waste Management Programme in ensuring that the generation of radioactive waste is minimised, the waste is

managed safely and is identified, quantified, characterised and classified. The NNR verified that adequate programmes to manage the generation of waste exists to facilitate continued operation for the period of LTO. None of the deviations identified in the PSR were of such a nature that they disposition the conclusions in the LTO safety case regarding the adequacy of the programme. The NNR review of the 3rd PSR results did not identify any other issues that will change these arguments presented in the safety case. The NNR verified that there will be adequate provisions to manage the disposal of low and intermediate waste for the period of LTO.

The LTO safety case identified that additional radioactive waste will be generated but the annual waste volume produced will not increase due to operating processes that remains unchanged. It is correctly identified that the cumulative volume of radioactive waste will increase due to LTO. It is concluded that although the LTO period will generate additional waste, that the waste will be managed in line with the existing radioactive waste management programmes which have been demonstrated to be adequate for the period of planned extended operation.

High level waste or used fuel is currently safely stored on the Koeberg site in both dry and wet storage. Regarding the expected increase in the volume of used fuel associated with LTO, it has been demonstrated that used fuel can be safely stored subject to authorisation of proposed storage facilities and will require successful licensing of the Transient Interim Storage Facility (TISF) on the Koeberg site. These are operational issues and not ageing-related which may curtail KNPS operations if these facilities are not authorised.

7.3.4 Environmental protection

The 3rd PSR evaluated whether occupational and public exposures to radiation are always kept as low as reasonably achievable (ALARA) and below regulatory limits through the application of effective radiation protection principles and processes. The 3rd PSR also evaluated the impact on the environment due to current KNPS operations. The liquid and gaseous effluent discharged during normal operation are released under controlled conditions and are required to conform to the Annual Allowable Discharge Quantities (AADQ), which complies with the maximum annual effective dose limit as set by legislation.

There are individual safety factor areas in the 3rd PSR that directly deal with the aspects of radiological impact on the environment and the public dose.

The NNR verified that the conclusions in the Safety Case related to environmental protection aspects are in accordance with the content of the various input sources. SF-14 of the 3rd PSR reviewed the radiological impact on the environment to establish whether the KNPS has an adequate and effective programme for monitoring the radiological impact of KNPS on the environment, which ensures that emissions are properly controlled in accordance with the ALARA concept.

The NNR verified that adequate programmes exist to monitor the impact of radiological effluents to the environment. The Eskom environmental monitoring and surveillance programme ensure that the storage, disposal, or effluent discharge of radioactive waste, does not result in unacceptable contamination of the environment. Eskom shall report promptly to the NNR any significant increase in environmental radiation fields or contamination that could be attributed to the radiation or radioactive discharges emitted by sources under Eskom control.

In addition, the NNR independent environmental monitoring programme provides assurance that the integrity of the environmental surveillance programme of Eskom is maintained and that there is indeed no significant build up or increase of environmental radiation or contamination due to periodic discharges of effluents.

The NNR confirmed that these discharge limits and conditions, design, and actual condition of relevant KNPS systems are effective in limiting and optimising radioactive discharges. Monitoring programs are in place and deemed effective, to adequately monitor radioactive releases to the environment, and to confirm that the impact on the environment is within expectations.

There are adequate controls and procedures in place to ensure that the permitted release limits are not exceeded. The instrumentation in place to respond to unplanned releases is suitably designed and available and regularly tested.

The NNR verified that the dose assessment on non-human biota has been conducted in line with international guidelines and the environmental and effluent monitoring programmes are sufficiently comprehensive and appropriate to confirm that discharges are optimised, and no new dose pathways need to be considered.

The NNR review concludes that the environmental impact of the KNPS is not significant and that the measures in place to control effluent discharges and monitor effluent and the

environmental impacts are appropriate and meet expectations. None of the deviations identified in the 3rd PSR were of such a nature that they disposition the conclusions in the LTO safety case regarding the adequacy of the programme. The NNR review of the 3rd PSR results did not identify any other issues that will change these arguments presented in the safety case.

7.3.5 Organisational Provisions

The intention of the LTO safety case is to demonstrate that organisational provisions are adequate to support the extended period of LTO. These include aspects of policies, human resources, competency management, knowledge management and financial resources.

Policies were drafted for the period of LTO that ensure the correct placement and alignment of the organisation to support the management of ageing. It also lays the groundwork for the establishment of the resource needs for the period of LTO.

Maintaining competency in the workforce for the period of LTO is considered part of the existing KNPS Systematic Approach to Training philosophy, adopted by all departments to manage the training and competency needs.

In the area of knowledge management, identified as a weakness during the SALTO review, there have been various initiatives implemented to ensure the integrity of identifying, capturing, evaluating, retrieving, and sharing relevant KNPS information assets (such as databases, documents, policies, procedures, and previously uncaptured expertise and experiences from individual workers). The NNR verified the actions to close the open actions and considers the implementation of knowledge management activities adequate for the purpose of meeting the objectives for the period of LTO.

The SALTO process and peer review service conducted by the IAEA are focussed on the aspect of the availability of human resources, external technical support and knowledge management for the period of LTO. They specifically dealt with evaluating the adequacy of and competence of the staff responsible for safety-related activities linked to LTO. The 3rd PSR in addition added to the evaluation aspects of human resources in and across the individual safety factor reviews. Under the 3rd PSR, the review of resources is not isolated to a specific safety factor and is integrated throughout the 3rd PSR safety factor reviews. The NNR requires that changes in the licensee organisation, including structure, staffing levels and resources, be evaluated to ensure that they will not adversely impact safety. Any changes that

may impact nuclear safety must be submitted to the NNR for acceptance prior to implementation. Personnel at KNPS who undertake safety-related work are required to have a minimum level of qualification and experience. The minimum number of personnel per position is also determined. This includes personnel required for severe accident management. The sufficiency of staff numbers is measured and monitored through an Authorisation Indicator, which provides an indication of actual numbers against minimum staffing levels.
The NNR requires Koeberg to conduct an annual assessment of its staffing and competency levels and to report to the NNR accordingly. This process is further covered by the NNR's compliance assurance programme.

It is a requirement of the nuclear installation licence that the efficacy of training programmes be audited on a regular basis.

The NNR is satisfied that all safety-related work is performed by competent individuals, and although human resources are considered adequate, the NNR continues to monitor staffing and competency levels at KNPS.

The 3rd PSR under SF-10 performed a review to evaluate whether existing policies and business objectives are adequate and are implemented in a safe and effective manner. It was further evaluated whether the existing organisation, management system, and safety culture meet current requirements, and that they are adequate and effective for ensuring the safe operation of the KNPS.

None of the deviations identified were of such a nature that they disposition the conclusions in the LTO safety case regarding the adequacy of the programme. The NNR review of the 3rd PSR results did not identify any other issues that will change these arguments presented in the safety case.

The NNR consider the current organisational provisions adequate to support the period of planned extended operation. Improvements of provisions for funding for decommissioning is currently under review. Eskom has established interim measures to ringfence the funds that have been put in place, including additional transactional controls to ringfence investments. The process has commenced, including engagement with the banking institution for the creation of this new bank account. Routine feedback is provided on the status of implementing agreed measures on safeguarding of the ringfenced funds, beyond the above initial arrangements.

7.3.6 Operating Experience

The use of operating experience as an integral part of the integrated management system is to continuously learn and improve on KNPS safety and processes.
The established KNPS programme and established links to international sources of experience has been demonstrated to be effective on acquiring and sharing of information. The continued NNR oversight activities, the demonstrated use of experience from international counterparts and the timeous manner in which certain experience is captured and incorporated, i.e. sump blockage issues, Fukushima, Control Rod Drive Mechanism (CRDM) wear, etc. have provided assurance of the efficiency of the programme.

Not all shared OE are applicable to the KNPS design, but all received are evaluated for applicability and acted upon in accordance with its safety significance. Latest international OE relating to the cracks identified in some of the reactors in France was a topic of discussion between the NNR and the French regulator in 2022. At the time the issue was ringfenced to be unique to the 4 loop designs and at the time eliminated to be a phenomenon present on the KNPS 3 loop design due to design and piping layout differences.

Although it was initially concluded that the cracks found were linked to thermal fatigue, it was later confirmed to be intergranular stress corrosion cracking, a complex phenomenon that is currently subject to further investigation and research to ensure future detection capabilities, clear identification of where it may be present as it is a phenomenon predominantly occurring because of mechanical stresses (manufacturing or in-service), material susceptibility (steel hardness) and influence of environmental conditions (thermally activated) that differs between power plant designs.

The predominant cause of the in-service stresses is considered to be originating from thermal stratification, further investigations are ongoing to improve the understanding. It was also concluded early on that the phenomena are not age related as the older designs seems less affected based on the initial expanded inspection results from the 3 loop designs.

KNPS on receipt of the operating experience (OE) directly from their French counterparts in 2022, as per KNPS licensing basis process, graded the OE and initiated the process of investigation into whether the specific KNPS piping may be affected by the phenomenon. An engineering evaluation of the impact of this OE on KNPS and identification of the scope and

timing of any supplementary inspections that may need to be carried out was done with input from the French.

The evaluation concluded that there was no immediate concern for this degradation issue occurring at KNPS and that further information would be evaluated as it becomes available.

NNR consider the current OE provisions adequate to support the period of planned extended operation. Topical OE issues are acted upon timeously based on its importance to safety and, examples include historical containment sump blockage issues, Control Rod Drive Mechanism (CRDM) wear, and the latest cracks identified in NPP's in France.

7.3.7 Safety Culture

From the periodic three yearly safety culture surveys and the integrated review from the 3rd PSR it was established in the LTO safety case that there is currently a healthy safety culture. Although there are identified gaps, the integrated assessment did not identify issues that warrant a high grading.

The 3rd PSR under SF-10 assessed the adequacy of the organisation, management system and safety culture processes and procedures. None of the deviations identified were of such a nature that they disposition the conclusions in the LTO safety case regarding the adequacy of the programme. The NNR review of the 3rd PSR results did not identify any other issues that will change these arguments presented in the safety case.

The NNR periodic review of safety culture reports and review of the 3rd PSR results did not identify any issues related to safety culture that disposition these conclusions.

7.4 Conclusion on Safety Related Programmes

Based on the above statements regarding the adequacy of safety related programmes and others, the NNR concludes that for the planned period of operation there is minimal to no impact on safety-related programmes due to LTO as determined from:

- Current NNR oversight activities (Compliance assurance and review activities).
- Information and status of PSR results and impact from grading of applicable deviations.
- Post SGR design initiatives and improvements implemented (Control Room Envelope improvements, programmatic updates, revised KNPS analyses).

- Continued updating and improvement initiatives implemented through application of OE and 3rd PSR information.

8 SAFETY ASPECTS OF LONG-TERM OPERATION

8.1 Introduction

Eskom initiated the start of the SALTO process in early 2014 and the subsequent NNR interaction with the IAEA started in 2015. Eskom preparation activities were originally aligned to IAEA SSG 48 and involved early self-assessments. It was subsequently adjusted to align to the guidance in RG-0027.

The licensing strategy together with the Project Management plan, associated Risk management plans and LTO Framework were submitted to the NNR in 2016 for acceptance. The NNR acceptance allowed Eskom to proceed with the identified SALTO phases of assessment that ensure for the period of intended LTO that all aspects of the overarching established ageing management programme are in place, and it can be demonstrated that the previous programmes were effective in managing ageing throughout the original KNPS operational life.

The SALTO project implemented by Eskom consisted of two essential phases, the first called the definition phase involved the:

- Establishment of the required information, configuration, and quality control systems for the project.
- Scoping to identify the scope of KNPS SSCs subject to SALTO evaluation.
- Screening and Ageing Management Reviews, identify improvement of existing Programmes, new Programmes, required once-off inspections and other related requirements.
- Identify existing TLAAs, design basis documentation, TLAA studies to be revalidated.
- Close organisational or process gaps from Self-Assessments.

Eskom enlisted the support of an external organisation with local, OEM and international experts to perform the technical activities.

The second phase called the execution phase involved:

- Updating of and the establishment of new Ageing Management Programmes (AMPs).
- Revalidation of identified TLAAs.
- Execute defined items to close organisational and process gaps.
- Preparing the documentation in relation to SALTO.

- SALTO mission with IAEA.

Eskom predominantly utilised inhouse expertise for the performance of the technical activities related to phase 2.

Through Eskom adoption of the processes, methodologies and lessons learned from the IAEA recognised Safe Long-Term Operation of Nuclear Power Plants it allowed for the utilisation of the IAEA peer review service to obtain support in application of the related safety standards. This enabled Eskom to receive and exchange information regarding the application of SALTO and information from the IGALL programmes.

The IAEA SALTO peer review service assisted Eskom with an independent comprehensive operational safety review service, addressing strategy and key elements for safe LTO, the results of these IAEA missions did not directly influence or inform the NNR decision making process but was used as supplementary information to either support or substantiate a regulatory position that was formulated through separate technical evaluation. The schedule of IAEA missions that were completed are:

- 1st Pre-Salto Mission completed in 2015
- 2nd Pre-Salto Mission completed in 2019
- Full Salto Mission completed in 2022

There is a follow up mission scheduled towards the end of 2024 which is standard practice by the IAEA. The purpose of the follow up mission is to verify the progress in implementing improvement actions to address the recommendations and suggestions. It is normally scheduled to take place 18 – 24 months after the Full SALTO Mission.

The process allowed for the independent review of the Eskom developed and implemented SALTO processes by specialists from the international industry. All the IAEA selected specialists used during the peer reviews were experts in their individual fields and were identified to perform an overall integrated view on Eskom's readiness to proceed with LTO. By the time a full SALTO Mission is completed it is industry norm that ideally all activities related to SALTO would be implemented in accordance with the minimum requirements in the IAEA standards applicable to LTO. Ideally all gaps or improvements identified during the Pre-SALTO missions are resolved. The results from the full mission conducted at Eskom revealed that not all activities were completed, and gaps identified as important to the justification for LTO were listed as commitments in the safety case to track to completion prior to LTO.

8.2 Application of SALTO process

The NNR responded to various interactions with Eskom, prior to the start of the SALTO process. These interactions were done in accordance with Licence conditions, and the establishment of a licencing framework for the project. This includes the acceptance of the Eskom documented processes and evaluation strategies to perform an objective and comprehensive ageing management review. It was submitted to the NNR in accordance with Condition 16 of NIL-01 related to Ageing Management and LTO, guidance provided in RG-0027 and in alignment with the IAEA safety standards for SALTO.

The technical aspect of safe long-term operation is primarily informed by the results obtained from the integrated ageing management assessment. The performance thereof was initiated by Eskom in accordance with and in alignment with the regulatory guidance in RG-0027. The overarching IAEA SALTO process was used as a vehicle by Eskom to ensure the systematic implementation thereof and to ensure application is in alignment with international practices and experiences. The results of the assessment were submitted as part of the SALTO project and used as input to the safety case and 3rd PSR. The various building blocks of the process were submitted to and accepted by the NNR, in a separate process from the IAEA SALTO peer review service. These included the following as specified in the accepted Licensing strategy:

- Koeberg SALTO Licensing Strategy, the strategy was submitted to and accepted by the NNR (2019).
- Koeberg SALTO Scoping Methodology, the scoping methodology was submitted to and accepted by the NNR (2019).
- Koeberg SALTO Ageing Management Evaluation (AME) Process, the AME evaluation was submitted to and accepted by the NNR (2019).
- SAR and related licence basis changes identified through SALTO, submitted to the NNR over a timeframe from 2023 to 2024.
- Koeberg SALTO Assessment Final Report – The report was accepted as an integral part of the review of the LTO Safety Case approval (2024).

After completion of the first phase of the SALTO project, Eskom opted to compile and submit for information an interim AM assessment report to the NNR. The NNR reviewed and accepted the information as interim while the final report was scheduled for completion in 2024. Eskom,

on compiling of the safety case and in the absence of the final report, credited the information contained in the interim report in the safety case. Any outstanding SALTO actions were documented as commitments contained in the safety case.

Commitments in the safety case related to the SALTO process and required to be completed prior to LTO included actions related to:

- Organisation and Management (Knowledge management).
- Mechanical, Civil and Electrical TLAAs (New or required re-analyses)
- Mechanical, Civil and Electrical Ageing Management Programmes (New or required programme updates).
- Mechanical, Civil and Electrical One-Time inspections.
- Mechanical modifications.

The above SALTO related commitments have all been subjected to a NNR oversight process to verify completion. This could be either through compliance assurance activities or assessments as part of the licensing basis submittal process or as identified for submittal to NNR in the accepted licensing strategy.

8.3 Regulatory Basis

The regulatory requirements against which the individual activities conducted under the SALTO project were evaluated are:

a) Regulations in terms of section 36, read with section 47 of the NNR Act on the Long-Term Operation of Nuclear Installations (R266).
b) Regulations in terms of section 36, of the National Nuclear Regulator Act, 1999 (Act no. 47 of 1999), on Safety Standards and Regulatory Practices, R388 (SSRP).
c) NNR Interim Regulatory Guide RG-0027 Revision 0: Ageing Management and Long-Term Operations of Nuclear Power Plants.

8.4 Technical Assessment

Adopting the implementation of the SALTO processes aims to entrench the complete concept of the management of ageing. It spans across organisational structures, resources, information management, and the core technical aspect of the LTO technical assessment. The processes supporting the core technical aspects may be summarised as shown in Figure

2 below and highlight the major building blocks or steps that inform or provide the LTO deliverables for NNR review and acceptance.

The major steps indicated are standard activities required by the SALTO process and are core to the process of alignment with IAEA standards, allow peer review and technical support when requested or required. The major steps below are reliant on some pre-assessment activities that include feasibility studies, identifying Regulatory requirements and performance of self-assessments to identify gaps or deviations from the newly adopted SALTO processes.

The component of technical justification however is the result of the outputs consolidated from the major activity steps shown below:

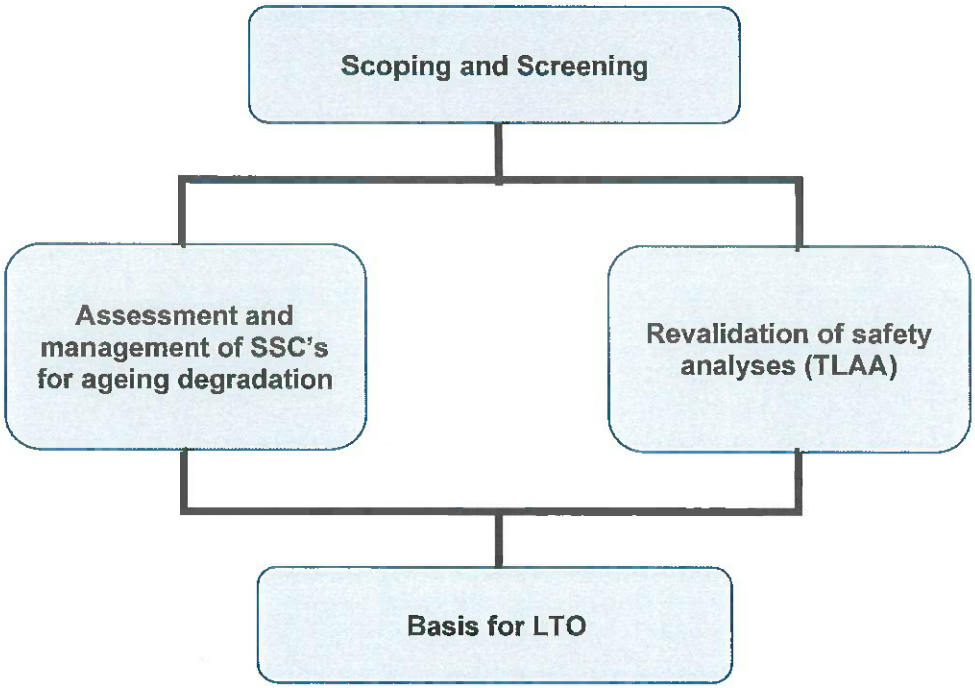


Figure 2: Major steps

The NNR involvement in and verification activities related to the activities above are further articulated below.

8.4.1 Scope setting

Eskom developed the systematic scope setting process to identify structures, systems and components (SSCs) that should be subject to an ageing management assessment. The existing Koeberg classification system formed the basis for the scoping process. The process

defined that the following type of SSCs should be included in the scope of ageing management:

- SSCs important to nuclear safety that are necessary to fulfil the fundamental safety functions.
- Other SSCs whose failure may prevent SSCs important to nuclear safety from fulfilling their intended functions.
- 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 basis extension conditions and severe accident management.

The scope setting process was designed in accordance with regulatory requirements and complies with the minimum requirements as prescribed by the IAEA and in alignment with guidance in RG-0027. Both the in-scope and out of scope SSCs were verified on a sample basis for adequacy and compliance with the agreed scoping methodology by the NNR.

All SSCs (In-scope) that have been determined to be subject to ageing management through this process were subjected to an ageing management evaluation.

To note, the scope setting process was also utilised by Eskom to ensure that all digital sources of data that contained classification information are integrated, validated by cross referencing to other design basis information and consolidated to allow extraction of the final in-scope (+/- 87 000) SSCs.

Consistent with guidance in RG-0027, the licensee submitted the scoping methodology to the NNR for acceptance in 2017, the NNR finally accepted the latest revision in 2020.

8.4.2 Assessment and management of SSCs for ageing degradation

The integrated review process for performing an ageing management assessment of the identified in-scope SSCs obtained from the scoping process includes aspects of commodity grouping, ageing management programme review and the performance of the equipment ageing management review. In alignment with guidance in RG-0027, the licensee submitted the Ageing Management Evaluation Process for NNR acceptance in December 2020. The NNR finally accepted the licensee Ageing Management Evaluation Process in March 2021.

The commodity grouping activity entails the grouping of structures and components to be assessed into logical groupings that would have similar ageing effects and degradation

mechanisms and treatment plans. The grouping of structures or components are based on characteristics such as similar functions, materials and environment. In-scope SSCs that could not be grouped into commodity groups have to be evaluated as stand-alone structures and components. The process is a unique SALTO activity and an accepted international approach to optimise the review process. The use of commercially available software to manage the information as well as the concept of commodity grouping were accepted by the NNR as part of the AME process.

The Ageing Management Programme Review activity aims to verify that the existing KNPS programmes fulfil the requirements of the IGALL. Where there were no KNPS ageing management programmes to deal with ageing or degradation, new KNPS programmes were identified to be developed, tracked through either commitments or completed prior to the safety case submittal. The programmes are required to be reviewed against the nine attributes as required by IGALL and in accordance with RG-0027. Where existing KNPS programmes were found to be not consistent with the nine attributes, these existing programmes were actioned to be updated accordingly, any outstanding updates at time of drafting the safety case were captured as commitments in the safety case. The review was performed for mechanical, electrical, and civil ageing management programmes. The NNR accepted the AMP review process through acceptance of the AME process.

The Ageing Management Review (AMR) process for the in-scope SSCs (commodity groups and stand-alone SSC's) were performed to demonstrate that actual management of ageing is comprehensive and that ageing concerns will be effectively managed so that the intended function(s) of the SSCs are maintained for the period of extended operation. The SSCs were evaluated for ageing effects based on their materials of construction, operating environments, and operating experience. The ageing management review systematically assessed the ageing effects and related degradation mechanisms that are experienced or are anticipated for specific commodity groups and SSCs. It was conducted to provide the assurance of the ability of the SSCs to perform their intended function(s) throughout the extended KNPS life. This review included an assessment of the actual condition of the in-scope SSCs. The NNR accepted the AMR process through acceptance of the AME process.

A regulatory review process was undertaken to ensure that, at a minimum, the guidance outlined in RG-0027 were considered. The Regulator's considerations included, but were not limited to, the following aspects, related to ageing management programmes, to determine whether the ageing management regime at KNPS is adequate to justify a variation of the licence to extend operation for another 20 years.

The results from the AMR process review and the NNR position in regards are summarised for the various disciplines below:

8.4.2.1 Mechanical SSC's

1) Health of Major SSCs

A feasibility study was conducted to identify any KNPS life limiting SSCs that would require replacement to support the application for LTO. The results of the study, which are discussed in the safety case, indicated that the following in-scope mechanical SSCs required replacement:

- **Steam Generators (SGs)**

The 6 SGs at KNPS were earmarked for replacement to mitigate ageing effects including primary water stress corrosion cracking (PWSCC). The 3 SGs on Unit 1 were replaced during outage 126 in 2023 and the replacement of the 3 SGs on Unit 2 will be completed during outage 226 in 2024.

- **Reactor Pressure Vessel Head (RPVH)**

RPVH for both Units 1 and 2 were replaced in 2008 and 2022 respectively. This was done, similar to the SGs, to mitigate the risks of RPVH failure due to ageing effects, including the PWSCC degradation phenomenon, which mainly affected the penetrations on the RPVH.

- **Refuelling Water Storage tanks (PTR)**

The PTR tanks for both units were identified for replacement in order to address the degradation caused by both the external atmospheric environment and the internal borated water environment. The Unit 2 tank was installed first in 2018 and the Unit 1 tank was installed in 2019.

Not all major components were identified to require replacement. In those instances, where time limited ageing analysis for SSCs could not be validated for the envisaged period of LTO, AMPs were developed for said SSCs.

The following are two important to safety of mechanical SSCs that fall into this category:

- **Pressurizer**

The pressurizer is a major mechanical SSC that was not identified, through the feasibility study, as requiring replacement. As such, following the performance of an ageing management review on the pressurizer and its components, several ageing management programmes (including AMP 102 In-service inspections, which is discussed in more detail in the RPV summary) have been identified to ensure that the degradation mechanisms that affect the pressurizer can be managed such that the pressurizer maintains its safety function though-out the proposed life extension period.

It was, however, determined that the pressurizer heaters require replacement, which is planned for outages 127 and 227 for Units 1 and 2, respectively. In the case of Unit 1, the replacement falls beyond the period specified in the current licence. Eskom has thus opted to demonstrate that the pressurizer heaters can maintain their safety function, through a TLAA revalidation, until the replacement.

- **Reactor Pressure Vessel (RPV)**

The RPV is one of the major mechanical SSCs that cannot typically be replaced during the lifetime of a nuclear power plant, therefore there is a need for the development and implementation of suitable AMPs through the life of a nuclear power plant to manage the ageing phenomena that affect the RPV. A summary of the ageing management considerations for the RPV is discussed under 'Relevant AMPs'.

2) Analyses of AMPs

Section 6 of RG-0027 states that AMPs should be developed, implemented and maintained for all in-scope SSCs that could not be validated for the proposed life of the nuclear power plant. Eskom demonstrated their effort to comply with the requirements on AMPs related to mechanical SSCs through the relevant submissions listed in the Safety Case, including those described below:

- The document L1124-GN-RPT-030, titled "*Comparison report existing KNPS plant programmes with IGALL AMP requirements*" is a report that demonstrates the analysis of AMPs already existing at KNPS against the 9 attributes of effective AMPs to confirm the effectiveness of the AMPs and identify any gaps where new AMPs would be required, and

existing AMPs would require improvement. This process is in alignment with the guidance outlined in section 6.7 of RG-0027. A list of mechanical AMPs is given in said report, along with a summary of the gap analysis and recommendations.

- The ageing management evaluation (AME) for mechanical SSCs is documented in L1124-GN-RPT-023 and summarised in document 240-164487877 "*SALTO advanced information pack*". 240-164487877 specifically discusses the results of the ageing management review for mechanical SSCs and provides, among other information, a list of new AMPs to be developed and a list of existing AMPs that require improvement.
- Section 6.12 of RG-0027 indicates that an annual ageing management report should be submitted to inform the Regulator on the status of ageing management activities. The first annual ageing management report (331-672, revision 1) was submitted in 2023. Among other aspects, the report provides the status of the actions recommended in L1124-GN-RPT-030, including the list of new AMPs and the implementation target dates. The actions described in the annual AM report are verified through NNR inspections.
- The referred documents L1124-GN-RPT-030 and L1124-GN-RPT-023 were reviewed and accepted by the NNR as part of the Interim Ageing Management Report, 240-164487877 that were provided as information.

The reports referenced above were found to implement a consistent process for identification of relevant ageing effects and degradation mechanisms for in-scope mechanical SSCs. Comprehension of the SSCs, their ageing effects and degradation mechanisms consistent with section 6.7.1 (2) of RG-0027 was demonstrated where applicable by design considerations and the use of the existing data (operational data, ISI data and monitoring/estimation of the SSC environment) as well as operational experience.

In the various AMPs submitted for regulatory review, the evaluation of the ageing effects is considered as well as their impact on the in-scope mechanical SSCs and their ability to perform their intended function(s).

Existing AMPs that needed alignment to the nine (9) AM attributes as per RG-0027 were submitted for regulatory review. Similarly, new AMPs identified through the gap analysis underwent the necessary regulatory review process.

3) Relevant AMPs

Summary of the RPV AM Programme considerations at KNPS:

As part of the SALTO process discussed above, the majority of the TLAAs applicable to the RPV were revalidated for the envisaged period of LTO in line with RG-0027. In areas where TLAAs have not been or could not be revalidated for the envisaged period of LTO, AMPs have been developed to provide the required assurance of the ongoing integrity of the RPV which is typically achieved by implementation of the identified inspection, testing, and maintenance of the RPV.

In alignment with IGALL, degradation mechanisms considered for the RPV include, but are not limited to material loss due to effects of boric acid corrosion, wear, pitting corrosion and crevice corrosion; cracking/crack growth due to cyclic loading and stress corrosion cracking (SCC); cumulative fatigue damage and loss of fracture toughness due to neutron irradiation embrittlement.

In this regard, the following required IGALL AMPs are considered for monitoring ageing effects on the RPV:

- AMP101 Low-cycle Fatigue Monitoring
- AMP102 In-Service Inspection / Periodic Inspection
- AMP103 Water Chemistry
- AMP110 PWR Boric Acid Corrosion
- AMP111 PWR Cracking of Nickel-Alloy Reactor Coolant Pressure Boundary Components
- AMP118 Reactor Vessel Surveillance
- AMP160 Neutron Fluence Monitoring

Eskom conducted a comparison between the required IGALL AMPs for the RPV with existing ageing related programme at KNPS which revealed that the existing programmes currently address the effects of various degradation mechanisms. The programmes in place or degradation mechanisms monitored includes but are not limited to: Chemistry Monitoring. Boric Acid Corrosion, Flow accelerated corrosion, Cumulative fatigue (calculations), In-service inspection programme (including bolting), Inspection of RPV internals and RPV surveillance programme (fracture toughness surveillance).

The requirements of the AMPs: AMP101, AMP102, AMP103, AMP110, AMP111, AMP118 and AMP160 were mostly addressed by existing programmes. For alignment with the guidance of RG-0027, required updates are subjected to regulatory processes. Some of the IGALL recommended AMPs were found to not be applicable to KNPS due to design or other considerations.

Most of the existing AMPs e.g. the In-Service Inspection (ISI) programme at KNPS, are in implementation, some since commissioning of KNPS and have been updated through the current operating period. As an example, the ISI programme provides for inspection of the RPV in line with the US Code of Federal Regulations 10 CFR 50.55a for the application of ASME (primarily Section XI and applicable code cases) requirements. The programme further integrates international operating experience as well as KNPS specific concerns by augmenting the Code requirements with additional inspections to address/monitor specific degradation concerns and potential risks to RPV integrity as consequence of the operating environment, design & manufacturing, and ageing related effects. The existing programmes were recently reviewed by Eskom for confirmation of alignment with RG-0027 including the attributes of an effective AMP.

To provide for monitoring of the effects of energetic (>1 MeV) neutron irradiation embrittlement of the RPV beltline and changes in the relevant mechanical properties, the said surveillance programme includes laboratory analysis and testing of existing sample RPV beltline material irradiated during operation. The results thereof are used together with calculations of neutron fluence projections to predict the neutron irradiation embrittlement ageing effects on the RPV beltline and the ability of the RPV to fulfil its intended safety function(s). In support of the application for LTO these programmes were reviewed and updated to align with the provisions of RG-0027 including the generic attributes of an effective AMP. The associated documents were submitted for regulatory review and acceptance.

The effects of PWSCC on alloy 182 repairs were also considered and analyses on ability of the associated components to fulfil their safety function(s) were performed.

The Eskom gap analysis identified further AMPs to manage various degradation aspects of the RPV subcomponents other than the RPV shell particularly RPV Internals (RPVI). The major units of RPV Internals are the upper internals assembly and the lower internals assembly. The upper internal assembly include e.g. upper core support plate, thermocouple conduits, rod cluster control guide tubes while the lower internals assembly include e.g. the core barrel, neutron shield elements, core support and radial support system.

Koeberg specific RPVI degradation mechanisms include but are not limited to: environmentally assisted fatigue (EAF), irradiation assisted SCC (IASCC), swelling, SCC, irradiation embrittlement, internal vibrations, wear and thermal stress relaxation. The IGALL AMPs required to ensure ageing management of RPVI are:

- AMP101 Low-cycle Fatigue Monitoring
- AMP102 In-Service Inspection / Periodic Inspection
- AMP103 Water Chemistry
- AMP113 PWR Vessel Internals
- AMP122 Flux Thimble Tube
- AMP160 Neutron Fluence Monitoring

As in the RPV case, existing programmes mostly address the IGALL AMP requirements. Provisions for the following AMPs were in place: AMP101, AMP102, AMP103, AMP113, and AMP160. While some AMPs required updates for alignment with the requirements of RG-0027, new AMPs were also developed to address identified degradation mechanisms. Some degradation mechanisms were addressed by means analyses to justify ability of the associated subcomponent(s) to fulfil their intended safety function(s).

The AMPs typically include the use of monitoring techniques and equipment to monitor or detect subcomponent surface and/or volumetric ageing related changes. The impact of the identified ageing effects on the RPV or its applicable subcomponent(s) was considered with reference to existing data (including data trending) and/or operational experience where applicable. The associated documentation was submitted for regulatory review and acceptance.

8.4.2.2 Electrical SSC's

1) Health of Major SSCs

The process for identifying important to safety SSCs that should be subjected to ageing management is provided in the LTO safety case. The process is systematic and in alignment with section 6.6 of RG-0027. The in-scope Electrical SSCs are grouped under the Electrical and Instrumentation and Control (I&C) commodity group. Eskom followed a systematic process to identify important-to-safety Electrical and I&C SSCs that should be considered for

ageing management under the LTO programme. The Eskom scope setting methodology was reviewed and accepted by the NNR, refer to section 8.4.1 above.

The scoping process identified all electrical and I&C SSCs that perform fundamental safety functions (Class 1E SSCs), SSCs whose failure may prevent class 1E SSCs from fulfilling their intended functions (CSR, SR), and SSCs credited in safety analysis (i.e. design basis, design extension related, availability related, etc.).

Eskom demonstrated that the fundamental safety functions at KNPS remain unchallenged for the LTO period. The control of reactivity function is carried out with SSCs such as the control rod control system (RGL), the reactor protection system (RPR), the reactor chemical and volume control system (RCV), etc. The removal of heat function is carried out with SSCs such as the feedwater system (ARE), Emergency feedwater system (ASG), residual heat removal system (RRA), etc while the confinement of radioactive materials safety function SSCs includes the containment spray system (EAS).

The design and actual conditions of these SSCs were assessed in the 3rd PSR and 18 deviations relating to the core cooling and confinement of radioactive materials were identified in the 3rd PSR global assessment. The plans to address the 3rd PSR deviations are included in the LTO Integrated Preparation Plan (IPP) and LTO Integrated Implementation Plan (IIP).

2) Analyses of AMPs

For in-scope electrical SSCs, Eskom identified AMPs required to detect, monitor, prevent and mitigate ageing effects and degradation mechanisms of the SSCs. The Eskom approach is in line with section 6.7.2 of RG-0027 for identification of AMPs. Eskom conducted the review of the AMPs against the attributes of an effective ageing management programme. The review results are documented in ageing management evaluation (AME) Technical Report (L1124-GN-RPT-025) for EQ and non-EQ components. The review outcomes established that requirements for 12 AMPs are fully covered by the current Koeberg maintenance programme while three AMPs were initially partially addressed.

As per the AME technical report recommendations for new AMPs, Eskom has developed these new AMPs. The AMP for Switchboards, Associated Switchgear Components and Metal Enclosures (AMP manual 240-164966115) was developed based on IGALL AMP 212 and 215 guidelines and has been reviewed.

The AMP for the Electronic Equipment Whiskers and Capacitors (AMP manual 240-165424554) was developed based on IGALL AMP 213 and 218 guidelines for electronic equipment and has been reviewed. The AMP for lightning protection and grounding was developed based on IGALL AMP 220 guidelines. The environmental conditioning monitoring programme (ECMP) for electrical and I&C cables subject to EQ requirements was developed (ECMP manual, 240-165386950) based on IGALL AMP 210 guidelines. The AMPs have been reviewed by Eskom and found to be acceptable.

As per the AME technical report recommendations for existing AMPs, Eskom updated their existing AMPs to address the gaps identified. The cables ageing management programme (CAMP) was updated to address the following issues:

1. Include all cables important to safety identified in the SALTO cable listing into the scope of the CAMP.
2. Ensure the requirements of IGALL AMP 201, AMP 202, and AMP 203 are fully covered for Medium, Low, and I&C voltages.
3. Ensure ageing factors, mechanisms, and effects are fully consistent with the AMM and that the AMM is referenced in the AMP.
4. Grouping of cables based on the selection criteria for cables to be tested or inspected.
5. Justifying why the 132 kV cables from the 132 kV switchyard to the standby transformers are not included in the CAMP
6. Add criteria for the sample selection of cables for testing to the medium voltage (MV), low voltage (LV), and I&C CAMP manuals.

Eskom further developed maintenance procedures and in-service inspection processes for the in-scope SSCs. The review of maintenance practices for electrical penetrations concluded that the ageing management programme used for electrical penetrations is adequate. The review of maintenance procedures for 6.6kV/380V dry-type transformers was carried out based on IGALL AMP 211 and updated to include thermal monitoring and updates to maintenance procedure KWM-EM-MAC-010 to include a visual examination of the transformer core and instruction to apply Glypal coating to any damaged coating area to prevent future corrosion. Implementation of these updates is part of the NNR verification process.

The review of maintenance practices for Lead Acid batteries concluded that the ageing management procedure for the batteries adequately covers IGALL AMP 216 guidelines. The

review of maintenance practices for solenoid valve actuators, motor actuators and motors concluded that the existing maintenance programmes adequately cover the ageing management requirements for the components. The review of the ageing management process for GEX, GEV and LGR transformers concluded that the processes adequately cover the guidelines provided in IGALL AMP 211. Eskom conducted one-time inspections on electrical enclosures (panels, distribution cabinets and control boxes) and electronic components (sensors, transmitters and electrical cards). The one-time inspection reports were submitted to the NNR as part of the LTO IPP review submission and were verified as part of the safety case commitments verification process.

The following outstanding recommendations for the electrical and I&C systems and are being tracked as part of the normal regulatory oversight programmes:

1. Initiate a once-off phased replacement of the critical Moulded Case Circuit Breakers (MCCBs) and for MCCBs that have been involved in a fault interruption event.
2. Creation of the required service notifications to implement periodic tasks including updates to the relevant maintenance working procedures for electronic equipment.
3. Actions to implement and integrate the requirements of the lightning protection AMPs.
4. Implementation of the ECMP.
5. Temperature and radiation monitoring devices Data to be retrieved in outages 226 and 127 for analysis.
6. Include thermal monitoring of the dry-type transformers due to the elevated temperature and the ORT impact, post SGR.
7. Visual examination of the transformer iron core for signs of coating damage and an instruction to apply Glyptal coating to any damaged coating area to prevent future corrosion of the transformer iron core.

8.4.2.3 Civil SSC's

1) Health of Major SSCs

- **Containment**

Containment has been identified as a Civil SSCs important to safety with ageing mechanisms that pose a potential risk if not treated in a timely manner. The containment buildings are subject to chloride-induced reinforcement corrosion for which historic repairs were already implemented. The long term proposed solution however is to implement an impressed current

cathodic protection (ICCP) system into the concrete of the containment buildings to neutralise the corrosion effects of the chlorides. This modification is currently still in its testing phase.

The main issue is the long circumferential crack near the edge on the containment dome that have been repaired and is being monitored. Eskom has justified that the crack has no impact on the structural integrity or leak tightness of containment. It has also demonstrated that the crack is not growing. Despite the cracks and the corrosion concerns, it has been determined that the containment building safety functions have not been compromised and are acceptable for operation based on current monitoring results and subject to the implementation of the approved AMPs.

To support the statement of health and operability of the containment buildings, consideration is given to the results of previous integrated leak rate test (ILRT) that is being performed every ten years as per the approved IST programme and the safety analysis (time-limited ageing analysis) that found the structural integrity of the containment buildings is ensured and not compromised for the planned period of LTO.

There are currently proactive measures in place for the management of concrete degradation on Unit 1 and Unit 2. Planned inspections and repair works will address any anticipated degradation subject to regulatory oversight. In addition, to arrest the chloride-induced reinforcement corrosion phenomena, the planned ICCP modification will be installed.

In preparation for LTO, Eskom had developed and implemented all the required AMPs that were identified for the Civil in-scope SSCs.

- **Containment Instrumentation**

Throughout the years the containment buildings have experienced a gradual and systematic deterioration and loss of its monitoring instrumentation. The instrumentation includes the embedded strain gauges, dynamometers, pendulums and temperature gauges. These instrumentation are not required for the online operability determination of containment but for the purpose of long-term monitoring of containment health.

Although there is some instrumentation defective it was verified that the remaining monitoring devices can provide information on long-term trends of the containment structural behaviour.

However, due to the limited remaining instruments there is a concern due to some of the equipment becoming non-functional.

A modification to upgrade and replace the defective monitoring instrumentation has been approved and initiated by Eskom. This modification will initially supplement, but eventually supersede the current containment online monitoring equipment. The modification is planned to be implemented during the X29 outages, i.e. maintenance outages 129 and 229.

In the interim, monitoring devices will be installed on the containment structures during the ILRT to be performed during the X27 outages as an additional measure over and above the planned monitoring already part of ILRT.

- **Aseismic Bearings**

The AMP for the aseismic bearings was originally developed in 1989 and updated in 1995. The Technical Manual for the monitoring of the aseismic bearings outlines the Monitoring Programme for the aseismic bearings and details the steps involved in the design and construction of KNPS.

Eskom developed report 331-675: Overview of the Ageing Managing Programme for the Aseismic Bearings. The report provides a comparison between the current AMP and IAEA IGALL AMP 314 Seismic isolation and NUREG/CR-7253: Technical Considerations for Seismic Isolation of Nuclear Facilities.

The IAEA IGALL AMP 314 "ageing management programme provides guidance for developing a plant specific ageing management programme for seismic isolation systems for nuclear facilities in order to ensure there is no loss of intended function during operation".

Report 331-675 supports Eskom report 331-645 "*Elastomeric Aseismic Bearings – Current Position and the Way Forward*". In this report, Eskom has concluded that the design intent of the aseismic bearings is not challenged considering the current design basis and that the aseismic bearings are fit for purpose. There is also consensus that the bearings' shear modulus is acceptable and has been confirmed by the most recent test results.

Koeberg testing and monitoring programme for the aseismic bearings includes visual inspections and shear modulus testing. Visual inspection is performed to assess the

degradation and ageing of the in-situ bearings directly. This is done because it was not feasible to remove an in-situ bearing for testing to determine the level of degradation and ageing. Eskom's position is that there is no significant damage, ageing, and material degradation to the bearings because of the external wrapper. The humidity and temperature conditions in the aseismic vault are not severe enough to lead to any of the degradation mechanisms of the neoprene material. This includes oxidation which is the main degradation mechanism of the neoprene material.

2) Relevant AMPs

An AMR was conducted for in-scope SSCs (commodity groups and stand-alone items) to demonstrate the comprehensiveness of ageing management of civil SSCs at KNPS. The AMR assessed the ageing effects and associated degradation mechanisms that may be expected. The AME report L1124-GN-RPT-024 documents the results of the AMR and indicates potential ageing management gaps and recommendations that were reviewed by the Eskom technical team and subject matter experts.

The existing KNPS AMPs were checked for consistency against the nine attributes as required by IGALL and in alignment with guidance in RG-0027. Results of this assessment revealed that the following AMPs had gaps that require resolution:

- AMP 301 In-Service Inspection for Containment Steel Elements
- AMP 305 Masonry Walls
- AMP 306 Structures Monitoring
- AMP 307 Water Control Structures
- AMP 308 Protective Coating Monitoring and Maintenance Programme
- AMP 309 Non-Metallic Liner
- AMP 311 Containment Monitoring System
- AMP 313 Containment Pre-stressing System

The following AMPs had no identified gaps:

- AMP 302 In-Service Inspection for Concrete Containment
- AMP 303 Safety Class 1, 2 and 3 Piping and Metal Containment Components Supports
- AMP 304 Containment Leak Rate Testing
- AMP 310 Ground Movement Surveillance
- AMP 312 Concrete Expansion Detection and Monitoring Programme

Following the evaluation and approval of the AME findings, the recommendations were assessed to determine the necessary steps for addressing them, consolidating the technical reviews, decisions, gap confirmations, and prescribed corrective measures to address the identified gaps.

The civil AMP review is documented in report L1124-GN-RPT-030 and the AME report L1124-GN-RPT-024. The comparison review resulted in the following:

- The requirements of five IGALL AMPs were found to be adequately covered by the existing Koeberg AMPs.
- The requirements of seven IGALL AMPs were found to be partially covered by the Koeberg existing AMPs.
- The requirements of one IGALL AMP (AMP 309) was not adequately covered by the Koeberg AMPs and needed to be developed.

3) New AMPs

The review of the civil AME deliverables and corresponding corrective actions were captured in 08016.ROD.024. Two new AMPs were required to address the gaps identified in 08016.ROD.024.

- AMP 306: A new civil ageing management programme requirements manual 240-165425812, was developed to address the partial gaps relating to IGALL AMP 306 (inclusive of AMP 301, 305, 307, 308, 311, and 313).
- AMP 309: A new liner monitoring programme manual 240-166959159 was required to address the ageing management gap with respect to IGALL AMP 309.

In preparation for LTO, Eskom had developed and implemented all the required AMPs that were identified for the Civil in-scope SSCs.

8.4.3 Revalidation of safety analyses (TLAA)

The process for the TLAAs involve KNPS specific safety analyses of in-scope SSCs in the KNPS design basis that consider time and ageing. These time limited assumptions are typically based on an initially assumed period of operation and/or anticipated operational transients, design considerations, or licence term. During the design of KNPS several assumptions were made which formed the input for the design, calculations, material selection, operating and maintenance instructions. The most significant to these is the intended operational life of the units of 40 years. When operating KNPS within the initial anticipated design life, life limiting assumptions can be managed as the limitations are

assumed to be enveloped. When the original KNPS life is to be exceeded, all limiting assumptions must be reviewed and revalidated for the intended KNPS life. A list of applicable TLAAs must be established, revalidated and controlled and the complete list of TLAAs documented.

As part of the SGR Project, the impact of reversing Operation at Reduced Temperature (ORT) and the possible Thermal Power Uprate (TPU) were analysed. These analyses, performed as part of the SGR project covered several of the TLAAs identified during the SALTO project. Successful justification for 60 years that was performed as part of the SGR Project work was credited in the SALTO assessment. The NNR accepted these results as part of the review of the deliverables of the SGR project submitted in the period from 2014 to 2024. The outstanding TLAAs that were identified but not yet validated for 60 years, were recommended for development, analysis, or re-analysis. Where these were not completed at the time of the safety case submission to the NNR, it was included as commitments in the safety case.

All identified TLAAs are to be validated for 60 years and follow the guidance on the six criteria as per RG-0027. Where validation for 60 years is not achievable and validation of SSCs is based on other required actions i.e. replacement, or implementation of further actions in operations, maintenance or AMP, these actions are credited in the TLAA justification process. The NNR monitors these actions through its normal compliance assurance activities.

The overall TLAA process approach implemented by Eskom was accepted by the NNR in 2019. The activity steps are shown below in Figure 3:

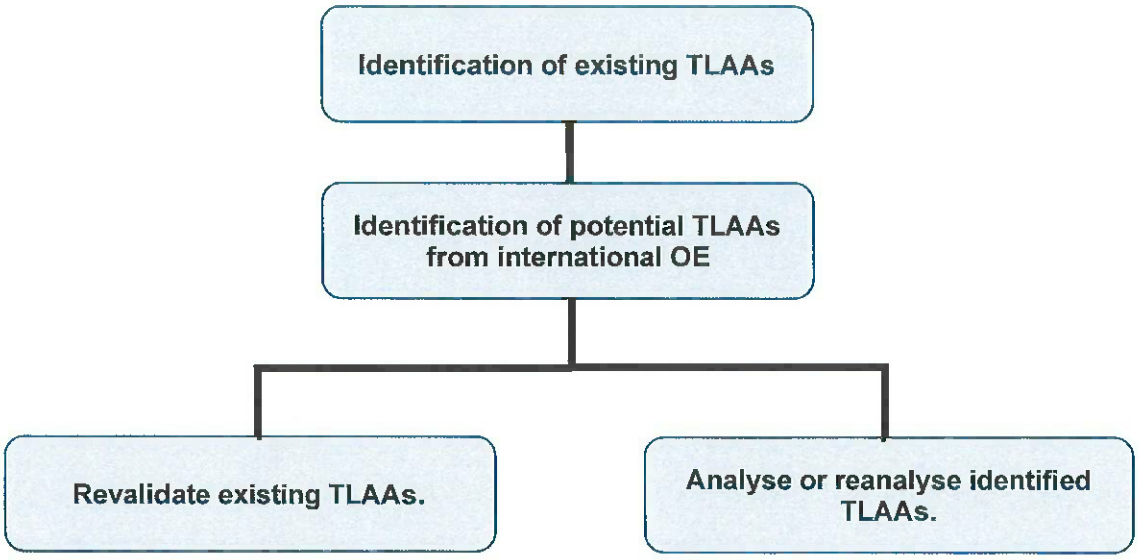


Figure 3: TLAA process

The NNR involvement in and verification activities related to the activities above are further articulated below.

The identification of TLAAs entailed a process where a review of the Safety Analysis Report (SAR) and design basis information for potential time limited calculations needs to be performed. It was an extensive process and it had to be ensured that all possible design basis information were screened for potential TLAAs. Once any potential information was found, it was verified against the IAEA and NNR requirements for validity of a TLAA.

The identification of new TLAAs was informed from a review of the IGALL listing of TLAAs reported by the IAEA in SRS-82 and from the IAEA IGALL master table, as well as OE received from the Original Equipment Manufacturer (OEM).

The final list of applicable TLAAs as compared against the IGALL list as well as the additional TLAAs identified from OEM input was accepted by the NNR in 2019 as part of the interim assessment report. The NNR expectation is that if updates are made by the IGALL programme of the IAEA any newly declared TLAA information be reviewed for applicability and processing. The process of periodic updating of programmes and processes is a nuclear industry norm that is applicable to all processes at a nuclear power plant. The NNR monitor these actions through its normal compliance assurance activities.

The exercise to revalidate existing TLAAs was conducted during the Definition phase (phase 1) of the SALTO project. Any new TLAAs requiring analyses or existing TLAAs that could not be revalidated were dealt with under the Execution phase (Phase 2) of SALTO.

In accordance with the NNR accepted licensing framework for SALTO, the SAR and related licence basis changes identified through SALTO should be submitted to the NNR for approval.

The summary of and the revalidation of existing TLAAs were initially submitted to the NNR at the end of Phase 1 of SALTO as part of the Interim SALTO AM Assessment Report, which was accepted by the NNR in 2022.

The new and/or reanalysed TLAAs were submitted to the NNR as they were completed throughout 2022 to 2024 in preparation for the final SAR updates in January 2024 and prior to submittal of the final AM Assessment Report in January 2024.

The list of IAEA IGALL TLAAs referenced by Eskom as reviewed to be applicable to Koeberg were verified by the NNR and found to comply with the TLAAs applicable to PWRs listed. Additional TLAAs stemming from Original Equipment Manufacturer (OEM) recommendations were accepted by the NNR. The NNR final acceptance status following review of the list of TLAAs, are summarized in Annexure D.

The results of the TLAA process review and the NNR position with regards to acceptance of the identified TLAAs as well as compliance verification against the IGALL list of TLAA's are further summarised for the various discipline areas below:

8.4.3.1 Mechanical SSC's

Sections 6.2.5 and 6.9 of RG-0027 describe the guidance for the authorisation holder related to TLAAs. Key among this guidance is for the holder to identify all applicable TLAAs and demonstrate that in-scope SSCs that are required to undergo this analysis are valid for the proposed KNPS life or demonstrate that ageing management activities are in place to manage ageing effects and ensure safety functions of the SSCs are maintained.

- A review of the IGALL TLAAs relevant to mechanical SSCs was conducted to determine their applicability to KNPS. The outcome of the review was document 240-132364298, titled "*Initial list of Time limited ageing analyses for Koeberg Nuclear Power Station*". In addition to identifying applicable IGALL TLAAs, the document also points out areas where similar analysis has been conducted to validate SSCs for the intended 60 years of operation under LTO including analysis conducted in the SGR project framework. Outstanding TLAAs are also highlighted in the document.
- Document L1124-GN-LIS-010 presents a comprehensive listing of TLAAs and categorises whether they have been validated or if they require analysis. This information is further reflected in document 240-164487877.

The list of mechanical TLAAs that required revalidation included analysis of the effect of environmentally assisted fatigue (EAF) on affected components. Eskom submitted the methodology related documentation for NNR consideration. As part of the methodology, major primary components were screened to identify locations impacted by EAF (the so-called sentinel locations) with consideration of the Cumulative Usage Factor (CUF) and Cumulative Environmental Usage Factors (CUFen). As part of the screening, process components that required further detailed analysis included: RPV internals (RPVI), Reactor primary pumps, Main coolant lines, Control rod drive mechanism and Auxiliary lines. Further analysis for the

effects of EAF in these components were carried out. The required documentation was subject to regulatory processes.

Complementary to the list in L1124-GN-LIS-010, Appendix A1.1 in the LTO safety case further provides the list of reanalysed TLAAs planned for submission to the NNR. These TLAAs were submitted to the NNR in 2023 followed by updates to the SAR to reflect the additional TLAAs as they form part of the licensing basis.

8.4.3.2 Electrical SSC's

Eskom's approach for review of TLAA for Electrical SSCs was established to be in line with the guidance in section 6.9 of RG-0027 for TLAA re-analysis requirements and methodology. The existing Koeberg TLAAs were identified, verified, and documented in L1124-GN-RPT-022 report. In accordance with the guidance in section 7.8 of RG-0027, the SALTO consortium appointed by Eskom carried out the re-validation of TLAAs for qualified equipment (EQ) based on the initial qualification documentation of KNPS. The re-analyses methodology applied was as per IAEA IGALL TLAA 201 for EQ Electrical and I&C Components. The re-validation results (report No.: L1124-GN-RPT-018) provided the thermal and radiological qualified life of the Electrical SSCs for the LTO period.

For components with incomplete qualification documentation, the qualified life could not be re-validated and therefore limited to the current licensed term (40 years) with a re-analysis required for the period of LTO. Some of these components are EQ cables, electrical penetration assemblies, in-core thermocouple cables and connectors. Eskom conducted the re-analysis of the TLAAs for the identified components following the guidelines from international best practices (i.e. IAEA IGALL TLAA 201, IEC-IEEE 60780-323). The re-analysis for electrical penetrations was reviewed and accepted by NNR.
The Unit 1 thermocouple cables and connectors require replacement and are scheduled for replacement in outage 127 while the Unit 2 thermocouple cables and connectors were replaced in outage 225 (Modification 13020).
The re-validation of the EQ cables by analysis methodology was submitted to the NNR and following review accepted by the NNR.

8.4.3.3 Civil SSC's

As per the requirements set out in RG-0027 for in-scope SSCs, KNPS is required to identify all TLAAs and be able to show that all analyses will remain valid for the planned period of LTO or that the SSCs will be replaced or that additional operational maintenance or AM actions will be implemented.

The IGALL and new TLAAs for Civil Structures are:

- TLAA 301 Concrete Containment Tendon Pre-Stress
- TLAA 302 Effects of creep and shrinkage of concrete structures
- TLAA 303 Cumulative Fatigue Damage of Containment Liners and Penetrations
- TLAA 304 Foundation Settlement due to Soil Movement

Each TLAA underwent research and evaluation, leading to the creation of a report for every component or component type outlining the ageing mechanisms and effects on the components and their parts. The applicable IGALL TLAAs were identified for each of these components, along with any other potential degradation mechanisms linked to time-limited assumptions. Original analyses were then examined, and wherever possible, their TLAAs were validated and justified for a 60-year timeframe.

Civil TLAAs validated for 60 years:

- IGALL TLAA 302 Effects of creep and shrinkage of concrete structures
  The Effects of creep and shrinkage of concrete structures and IGALL AMP 306: Structures monitoring encompasses the inspection of creep and shrinkage mechanisms. The identified partial gaps related to IGALL AMP 306 were addressed, revealing that creep and shrinkage of concrete structures pose no concerns for LTO. Additionally, the OEM supplied an expert viewpoint stating that the stresses induced by creep and shrinkage in structures other than the containment building, as covered in TLAA 301, are deemed negligible

- IGALL TLAA 303: Cumulative Fatigue Damage of Containment Liners and Penetrations
  The containment liners for KNPS containment Units 1 and 2 were assessed for risk of cumulative fatigue damage and penetrations. It was determined that the risks were practically non-existent, and hence it was concluded that TLAA 303 for the containment liner and penetrations in KNPS, is validated for 60 years.

- IGALL TLAA 304: Foundation Settlement due to Soil Movement

It was found that the risks associated with the residual and differential settlements were negligible. It was concluded that TLAA 304 is validated for LTO.

New TLAAs requiring analysis to be validated for 60 years

- IGALL TLAA 301: Concrete Containment Tendon Pre-Stress

TLAA 301 for the concrete containment tendon pre-stress has been revalidated for LTO. Importance was placed in ensuring the monitoring system's functionality and that the inspection reports' recommendations must be followed.

The re-analysis performed in 331-691 confirmed that the containment structures would be maintained under compression during a design basis loss of coolant accident (LOCA) over the projected 60-year period. This study served to verify and validate TLAA 301 for LTO. Document 331-691 was submitted to the NNR and the NNR review initiated multiple review comments. The majority related to the possible limitation and restrictions in the dome portion of containment. For the final review conclusion, Figure 1, depicting a summary of the results for TLAA-301 has reference:

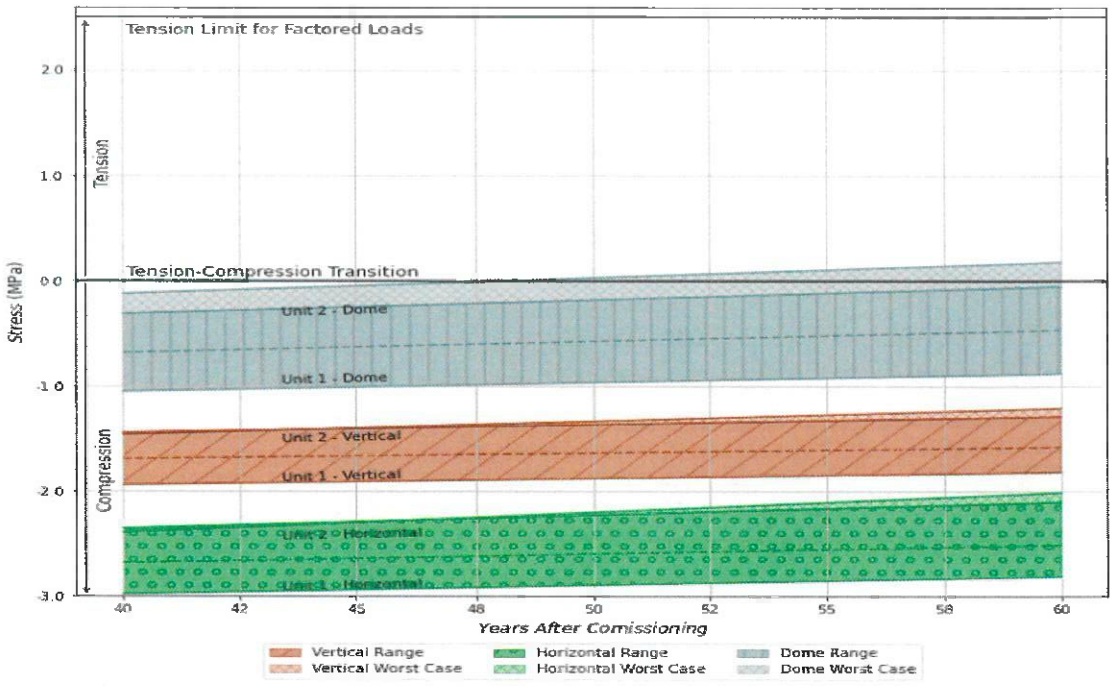


Figure 4: TLAA 301 results summary

As shown in the graph above, the results from the Eskom review identified that safety criteria are met for the different parts of containment and for the containment dome. Safety criteria are however marginally met with very little or no safety margin at 60 years for Unit 2. The calculations performed by Eskom relied on limited quality data as the data originated from the limitation of the monitoring technology available and applicable at the time of design and construction. The data limitations including inconsistencies and gaps prompted Eskom to rely on engineering judgement and data analysis to re-interpret the data. These methods introduced discretionary criteria that are not part of surveillance procedures.

The quality of the data used has a direct influence on the evaluation performed by the NNR and the determination of whether TLAA 301 is validated. Accordingly, this is considered when performing the safety evaluation. The quality of the data used as well as the fact that the structural safety margins for the dome have been eroded to the minimum leads the NNR to arrive at a review conclusion that the safety of the containment building is not fully demonstrated for Unit 2 for the period of LTO. The complete absence of dome data for Unit 2 and the use of dome data for Unit 1 introduced discretionary criteria and interpretation by Eskom. However, the NNR have concluded that from the margins shown in Figure 1 above, there is assurance that TLAA 301 was validated for the containment building of Unit 1, considering the uncertainties introduced through data analysis and use of engineering judgement.

For the containment building of Unit 2, the margins shown in Figure 1 above, does not provide assurance that TLAA 301 was validated for the complete period of LTO but only for a period of 8 years, considering worst case scenarios, assumptions, uncertainties introduced through data analysis and use of engineering judgement.

This leads to the overall NNR conclusion that TLAA 301 is fully validated for Unit 1 for the proposed 20 years and for Unit 2 for 8 years.

8.5 Summary

In addition to the performance of the AMR and TLAA related activities in accordance with the IAEA requirements and guidance in RG-0027, Eskom also developed an obsolescence programme with the aim of the proactive management of possible technical obsolescence issues, i.e. the potential lack of spare parts, technical support and/or industrial capabilities.

The programme allows for the timeous identification of possible issues related to SSC's important to safety and spare parts required to maintain these. In alignment with guidance in RG-0027 the programme was submitted to the NNR in 2017 and the latest revision finally accepted by the NNR in 2023.

Based on the above statements with regards to the review of aspects related to AM under SALTO, the NNR may conclude that for the planned period of operation there is adequate demonstration of the review of and implementation of programmes to ensure the management of KNPS ageing throughout its planned period of LTO if the integrity of the information can be assured.

The conclusion is supported by and based on the following:

- Current NNR oversight activities with regards to AM implementation activities.
- Information from NNR participation in IAEA IGALL working groups and SALTO missions.
- Information on specific ageing related issues with other Regulators through Bilateral cooperation.
- Eskom demonstrated compliance with IAEA AMP and TLAA requirements.
- NNR review of TLAAs and AMPs submitted for review and assessment.
- Identification and justification of identified TLAAs.
- Establishment of and entrenchment of AM into the organisational processes.
- Re-establishment and refreshment of design basis information.

9 PERIODIC SAFETY REVIEW

9.1 Introduction

As referenced in section 5, historically Koeberg have only done two safety re-assessments (SRA's) under the umbrella of a 3rd PSR. The first in 1998 and the second in 2011. These re-assessments unfortunately did not include a review of all the Safety Factors as required by international guidance in the Safety Guide SSG-25 for 3rd PSR. The objectives of the 3rd PSR to be conducted for LTO purposes was to identify the extent to which the nuclear power plant conforms to modern codes, standards, and practices and to ensure that the current applied codes, standards and practices, are not obsolete and do not pose a nuclear safety risk to the KNPS.

The review was used to identify any deviations to existing regulations and safety standards and to identify changes in any high-level design codes and standards used when the KNPS was constructed (and/or modified) when compared to the latest revision or equivalent nuclear design codes and standards and other international standards organizations. These include, but were not limited to, ANS, ASME, IEEE, IEC, WANO, US-NRC, and INPO on which the current KNPS design and/or operation is based.

The review against local standards, i.e. SANS and other standards was limited to those standards incorporated into the national regulations that are applicable to nuclear safety. An assessment of the Occupational Health and Safety Act regulations and the National Environmental Management Act regulations was also conducted.

Following the Fukushima Daiichi event in 2011, Eskom also conducted an external event safety re-assessment for which some of the actions were still outstanding at the time of conducting the 3rd PSR for LTO. The 3rd PSR hence integrated the findings from the EE-SRA into the outcome of the LTO 3rd PSR.

Ageing management is directly related to most of the safety factors evaluated in the 3rd PSR and IAEA SSG-48 also stipulates that if the periodic safety review is used as a licensing tool that the safety assessment performed for safety factors 2 – 5 should consider the entire planned period of long-term operation.

It was concluded from the above that if the 3rd PSR is used as a licensing tool that each safety factor should be reviewed taking ageing management into consideration as well as the total

period of planned long term operation. These concepts were entrenched in the regulatory framework and is the reason that the projects for LTO are crediting certain information as well as interacting between each other. It is determined to be an integrated approach. Based on the results of the 3rd PSR, the holder shall implement reasonably practicable corrective actions, modifications and safety improvements for compliance with applicable standards and internationally recognized best practices.

9.2 Summary of application

The PSR process started with the submittal from Eskom of the PSR Basis Document, providing the basis for the Koeberg 3rd PSR, taking cognisance of the fact that KNPS intends to apply for a licence extension to operate for 60 years (3rd PSR will include period of LTO). The submittal was received from Eskom in compliance with the process and timeline. The basis document included the important freeze dates related to external and internal documents of August and October of 2019. The period of validity of the 3rd PSR was set at 10 years in compliance with NIL-01, Variation 19, and in alignment with guidance in RG-0028. It was however conducted for and considered the full period of LTO.

The 3rd PSR review was conducted against the national nuclear safety and radiation protection requirements, as stipulated in the relevant acts, associated nuclear regulations, NNR licensing and regulator directives, and Koeberg's Nuclear Installation Licence. Refer to Annexure A for list of standards and regulations evaluated against.

9.3 Regulatory Basis

The regulatory requirements against which the individual activities conducted under the Periodic Safety Review were evaluated are:

a) Regulations in terms of section 36, read with section 47 of the NNR Act on the Long-Term Operation of Nuclear Installations (R266).
b) Regulations in terms of section 36, of the National Nuclear Regulator Act, 1999 (Act no. 47 of 1999), on Safety Standards and Regulatory Practices (GN R388).
c) NNR Interim Regulatory Guide RG-0028 Revision 0: Periodic Safety Review of Nuclear Power Plants.

9.4 Technical Assessment

During previous Safety Re-assessments (SRA's) the NNR had approved the SRA strategy at start of the project, as well as approved the individual safety factor reviews and the subsequent grading of the SRA findings.

With the implementation of the new process in accordance with the guidance in RG-0028 the NNR is required to accept the PSR Basis document as well as the PSR Review methodology. Eskom should therefore obtain NNR acceptance and/or confirmation on the scope and objectives of the PSR, including the current national and international standards and codes that will be used, before finalising the basis document. Eskom submitted this scope and objectives for the 3rd PSR to the NNR in 2018 and after NNR final acceptance in December 2020 Eskom concluded on the 3rd PSR Basis Document.

At the end of the PSR the NNR is required to accept the PSR Implementation report where the outcome of the PSR is reported. In accordance with the adopted PSR Licensing Framework, the following were identified to be submitted to the NNR for acceptance:

- PSR Basis document **(a)**
- Safety Factors Requirements and Review Methodology Reports **(b)**
- Any prompt corrective actions to address high-risk deviations - only if any identified.
- Integrated Implementation Plan **(c)**
- Final PSR Report **(d)**
- Summary of outcomes of the SF reports
- Summary of the Outcomes of the Global Assessment
- Final Integrated Implementation Plan

The individual Safety Factor Review Reports and Global Assessment Report were submitted to the NNR for information, and it was reviewed by the NNR to assist in the acceptance of the final PSR report.

9.4.1 Topical issues for 3rd PSR

- Evaluation of effects of climate change

Under the topic of "Safety Factor 7: Hazard Analysis" in the NNR Technical Assessment Guide Long Term Operation of Nuclear Power Plants (TAG-003), it is stated that it be verified that changes in the prevailing climate both at present and for the duration of LTO, are adequately considered. Climate change assessment is also listed as one of the inputs to Hazard Analysis in the NNR Regulatory Guide, RG-0028, "Interim Regulatory Guide: Periodic Safety Review of Nuclear Power Plants".

The Site Safety Report for KNPS, named Duynefontein Site Safety Report (DSSR), was updated to, amongst others, consider impacts due to climate change. The updated DSSR was formally submitted to the NNR in three phased submissions dated 30 September 2021, 17 December 2021 and 20 July 2022, respectively. Subsequent to formal correspondence between the NNR and Eskom on the latter three submissions, a consolidated updated DSSR was submitted to the NNR on 12 April 2024.

Impacts due to climate change may include higher ambient temperatures, higher wind speeds, rare meteorological phenomena that occur infrequently, more intense and frequent drought, increased sea temperature, increased sea level, increased likelihood of marine invasives (contributing to increased risk of the blockage of cooling intakes), higher rainfall and thunderstorm events. The extent of such impacts for the KNPS nuclear site are evaluated and reported in the DSSR and its supporting documents.

Since impacts due to climate change is expected to increase with time, the effects of climate change on all relevant meteorological, oceanographic and coastal engineering parameters have been estimated. The DSSR reports that key climate indicators reflect trends consistent with a warming climate, including increased land and ocean temperatures and increased sea level and greenhouse gas concentrations in the atmosphere. The effects of climate change are already evident in marine ecosystems and include increases in ocean temperatures and changes in wind speed and direction, ocean chemistry and direction and strength of currents.

The effect of climate change was evaluated in a conservative way over both the operating life and the decommissioning period of the existing KNPS and the proposed new nuclear installations at the site.

Guidance for studies was taken from the latest publications from the Intergovernmental Panel for Climate Change (IPCC), along with peer-reviewed journal articles where IPCC projections are outdated or unavailable. The estimation of the influence of climate change has been based on the most reliable scientific information available at the time of these studies but must be

continually reassessed as new data and research results become available (at least every five years). The DSSR would only need to be updated should one or more of the relevant climate change parameters change significantly.

An example of conservatism applied in the evaluation of the effects of climate change is as follows:

The IPCC presents climate change projections for a range of Representative Concentration Pathways (RCPs). The RCPs are based on different greenhouse gas concentration trajectories over the 21st century and are all plausible and illustrative with no probabilities attached. The most conservative pathway based on no change in climate change strategies (RCP8.5) was adopted for climate change projections. For conservatism the upper end of the confidence intervals was applied where these are provided in the projections.

Climate change is a key area of uncertainty that will affect the meteorology of the site. Section 5.8 of the DSSR presents an evaluation of the prevailing meteorological, corrosion and climatological characteristics for the Duynefontein site, with specific attention also to the extreme values of meteorological variables such as rainfall, air temperature and wind speed, and rare meteorological phenomena that occur infrequently. Future projections of these parameters due to climate change are also presented.

The DSSR reports on analyses of climate change projections published by the South African Weather Service and the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (ARP5) (Intergovernmental Panel on Climate Change, 2013), as well as detailed analyses of downscaled global climate model simulations for the site, which were performed by the Council for Scientific and Industrial Research (CSIR).

Meteorological parameters are also monitored at the Koeberg Weather Station. The chosen values for the rainfall, wind speed and atmospheric stabilities were based on the time covered by the database at the 120 m meteorological mast. Temperature parameters were based on both the 120 m mast (observed at 10 m height level) and the Duynefontein Weather Station (2 m height level). The former database was used due to the length of the observation record for predicting extreme values (return periods). An attempt was made to estimate the impact that climate change may have on these extreme projections. Although the climate change projections indicate a decrease in rainfall and possibly the number of extreme rainfall events, the assumption was made that the projections would be the same as currently experienced.

- Extreme Winds including Tornadoes

The Duynefontein region is not on a hurricane (tropical cyclone) track or adjacent to a warm ocean. Therefore, it is not expected that the site will experience a cyclone, or at least there is a very low probability. Tropical cyclones are generated in areas, where the ocean surface temperature is greater than 27°C and between latitudes 5°S to 30°S. The site is located south of 33°S and is therefore not subject to tropical cyclones.

Although the site is not prone to hurricanes, hurricane force winds are said to have occurred on the site. Hurricane force winds refer to a wind speed scale described by the Beaufort Scale as winds with speeds above 118 km/h (32.8 m/s). This wind speed (as a gust) has been exceeded 5 times (1986, 1987, 1993, 1994 and 2002) over the 40-year monitoring period at the site. The highest gust of 38.8 m/s occurred in 1987. The measured highest hourly average wind speed for the site for the 40-year monitoring period (1980 - 2019) is much lower at 17.2 m/s.

From the analysis of wind gusts observed at the 10 m level of the 120 m mast for the period 1980 to 2020, the wind gust corresponding to return period of 100 years is 43.6 m/s, 1 000 years is 53.0 m/s, 10 000 years is 62.4 m/s, 100 000 years is 71.9 m/s and 1 000 000 years is 81.3 m/s. The maximum mean hourly velocities for these return periods are 21.9 m/s, 26.7 m/s, 31.5 m/s, 36.3 m/s and 41.1 m/s respectively. The Koeberg design basis wind for Class I buildings is 62.5 m/s (maximum 3-second gust) and the design basis wind speed for buildings other than Class I is 38.3 m/s (maximum mean hourly velocity). The actual measured extreme wind speeds at Koeberg over the 40-year period has not exceeded the design basis wind speeds for the Class 1 or non-Class 1 Koeberg buildings.

The IAEA SSG-18, "*Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations*", recommends using the 3-second gust wind speed at 10 m above the ground that has a 1% annual frequency of exceedance (100-year mean recurrence interval) to specify wind loads. The design basis wind speed (3-second gust) for Class 1 buildings at 62.5 m/s is only exceeded at a return period of 10 000 years and for non-Class 1 buildings (maximum mean hourly velocity) at a return period of between 100 000 and 1 000 000 years. The extreme winds (cyclones), therefore, presents a low risk to safe operations at Koeberg.

Tornadoes and hurricane wind speeds were not considered in the earliest Koeberg Site Safety Report Rev.0. The recently conducted meteorological study reported on in the DSSR indicates that the tornado activity has increased since 1987 within an 80 km radius from the site. Less severe category EF2 tornadoes have an expected probability above 1×10^{-7} per year and more severe category EF3 tornadoes well below 1×10^{-7} per year. Using the EF scale, the estimated maximum tornado wind speeds (3-second gust estimates) are between 61 m/s and 75 m/s. This exceeds the facility design basis 3-second gust velocity of 62 m/s.

Design considerations regarding winds are wind loading on walls and missile protection. Even though most safeguard equipment is situated in concrete buildings, which would provide significant protection from airborne missiles, weaknesses in design related to this hazard were identified during the EE-SRA, which identified design vulnerabilities such as loss of offsite electrical supplies, and the vulnerability of the Emergency Diesel Generator radiators and some ventilation intakes. Geographical separation of unit Emergency Diesel Generators provide a certain degree of protection to the leeward side as well as the availability of mobile diesel generators and accident procedures for the loss of off-site power. Nonetheless, regarding the identified design vulnerabilities, Modification 12029, "Tornado and High Wind Enhancements", was therefore raised.

Oceanography and coastal engineering studies have been undertaken for the existing KNPS and the proposed development of new nuclear installations at the Duynefontein site.

Projections for sea level rise (SLR) were based on the IPCC's Special Report: The Ocean and Cryosphere in a Changing Climate (SROCC), which provides an update of the projections presented in the IPCC 5th Assessment Report with newly derived contributions from Antarctica. The SROCC provides projections of the global mean sea level and regional mean sea level rise to 2100 relative to 1995.5 (1986-2005).

- Coastline erosion

The potential instability of the coastline near the site was assessed by evaluating the effects of several physical processes over different timescales. The model was run for extreme storms with exceedance probabilities of 1.0×10^{-2}, 1.0×10^{-4}, 1.0×10^{-6} and 1.0×10^{-8} per year. The model was run for present day (year 2021) and possible future end of decommissioning (year 2064) to include the effect of climate change on waves, water levels and coastline stability.

The results show that coastline erosion increases over time due to long-term coastline trends, sea level rise and larger waves. In 2021 it is predicted that the erosion line south of Koeberg reaches the root of the revetment protecting the outfall structure at 1.0×10^{-2} per year. The predicted long-term accretion south of Koeberg reduces the risk to the outfall structure by year 2064. In 2021 it is predicted that the erosion line north of Koeberg reaches the root of the northern breakwater at 1.0×10^{-8} per year, with this probability increasing to 1.0×10^{-2} per year by 2064.

For the 1.0×10^{-2} per year and 1.0×10^{-4} per year events, the rate of erosion because of sea level rise will not pose an immediate risk of damage to the breakwater and intake structures. The maximum coastline erosion occurred on the northern side of the site, except for the 1.0×10^{-8} per year storm where the dune ridge was breached south of Koeberg, but the probability is low.

Regular surveys have been performed to monitor long-term erosion, accretion of the beach and seabed in the vicinity of the cooling water intake basin and breakwater structures. The surveys will continue during the period of LTO.

The effect of climate change on all relevant oceanographic and coastal engineering parameters has been included in the studies. The assessment of coastline stability and flooding from the sea are based on the SLR corresponding to the RCP8.5 upper end of likely range (predicted to be 0.44 m in year 2064 and 1.80 m in year 2130), rather than the maximum plausible SLR (predicted 0.79 m in year 2064 and 3.26 m in year 2130). This predicted additional 0.35 m in year 2064, and 1.5 m in year 2130, provides adequate safety buffer.

- Storm Wave Run-up

The recent studies indicate that the likelihood of a storm wave run-up breaching the terrace has increased. While the original terrace design height was based on a 1.0×10^{-6} per year return frequency, the latest data indicates the return frequency of exceeding the terrace height now lies between 1.0×10^{-4} per year and 1.0×10^{-6} per year. However, the impact is concentrated on the north and south of the nuclear terrace and does not impact SSCs. Only at 1.0×10^{-8} per year does the wave run-up flood the terrace adjacent to the reactor buildings. Therefore, the likelihood of a storm wave run-up exceeding the terrace level and impacting on the facility is considered low.

- Marine invasives

The potential increased likelihood of marine organisms blocking the cooling water supply due to climate change can be dealt with through appropriate design and management measures. The KNPS procedure for dealing with marine ingress has successfully mitigated effects to the nuclear cooling system. There is no indication of a more severe ingress to be expected in the future and that the KNPS procedures and measures will not be able to manage such an event. Nevertheless, climate change shall be considered as an area of uncertainty that can affect the ecology of a nuclear installation site, for example through extreme flood events and changes in sea temperature that may affect population densities of marine organisms and therefore increase the risk of the blockage of cooling uptakes.

- Water supply

KNPS is supplied with potable water from the municipality. To mitigate climate change impacts, Eskom has a strategy for improving potable water resilience at KNPS which includes the following:

- Prepare the KNPS for running out of site water.
- Reduce site water consumption.
- Use of boreholes installed in the Koeberg Nature Reserve more than two decades ago.
- Installation of a water treatment plant.
- Consideration of sea water desalination.

Both, the City of Cape Town (CoCT) and the Department of Water and Sanitation own and operate dams in the Western Cape in an integrated manner to provide the users with relevant assurance of supply and in KNPS with increased assurance, as a strategic water user.

The potential threat of quantity to supply to KNPS is no longer as imminent as during the 2015-2017 drought. Based on the most recent report by the CoCT in their water strategy development plan (gazetted in early 2021), the CoCT will increase supply through various options, including groundwater augmentation, wastewater re-use and desalination. Demand management through water restrictions will also be implemented sooner to reduce the probability of reaching a "Day Zero" scenario.

9.4.2 Regulatory acceptance

The NNR final acceptance status following review of the PSR deliverables that was to be submitted to the NNR are articulated below:

(a) The PSR basis document was submitted to the NNR in 2022 and defined the scope, strategy, and review methodology for conducting the 3rd PSR.

The PSR basis document serve as the formal agreement between Eskom and the NNR regarding the review of the status of the KNPS as well as ability of the KNPS to meet the requirements and standards for the period of LTO. As the 3rd PSR is conducted in support of the justification for LTO, the assessment was done for 20 years, beyond the 10-year period considered in a typical PSR, into those areas that are required to support the justification of LTO. In accordance with IAEA and guidance in RG-0028 there are fourteen safety factors to be reviewed that cover all aspects important to the safety of an operating nuclear power plant, all of which envelope radiation protection. The 3rd PSR documentation freeze date was stipulated as 01 August 2019 for external and 01 October 2019 for internal documents. The SGR information was included into the 3rd PSR, with the assumption that the SGR will be completed by 2021 (The current delayed installation does not affect the assumption or results of the 3rd PSR). The basis document indicated that radiation protection is not reviewed as a separate safety factor and arrangements for radiation protection and its effectiveness will be reviewed as specific aspects of the safety factors relating to KNPS design, actual condition of SSCs important to nuclear safety, safety performance, procedures, and the radiological impact on the environment. Nuclear security review was conducted separately and documented in a separate confidential report.

As per the guidance in RG-0028, the NNR final acceptance of the PSR basis and methodology for the performance of the 3rd PSR was done in 2022. This included the list of standards and requirements applicable to the review and listed in Annexure A, and importantly the documentation freeze dates of 2019.

(b) The PSR Safety Factor Requirements and Review Methodology for the 14 individual safety factor reviews was submitted to the NNR in 2021.

The submittal expanded on the topic of the review methodology for each Safety Factor, the NNR considered the information as the expansion of and in compliance with the accepted

requirements and standards listed in the earlier accepted PSR basis document. The PSR basis document together with the safety factor requirements and review methodology comprises the overall PSR basis concept and ensure alignment to the guidance in RG-0028.

The review methodology was finally accepted by the NNR in 2020 and laid the foundation of how and to what depth the individual reviews would be conducted.

(c) & (d) The Integrated implementation Plan and final PSR Report, containing the outcome of the **safety factor review reports**, outcome of **Global Assessment** and final **IIP** for proposed safety improvements was submitted to the NNR in July 2022.

In accordance with guidance in RG-0028 the level of KNPS safety should be determined by a global safety assessment that reflects the combined effects of all safety factors taking into consideration both negative and positive findings.

Eskom presented to the NNR the global safety assessment roadmap for the 3rd PSR project and submitted the applicable methodology to the NNR in 2021. The NNR accepted the methodology in November 2021. The Global Assessment and IIP report conclude that it is safe to continue to operate the KNPS as the overall nuclear safety at KNPS is at an acceptable level. The report was submitted to the NNR in July 2022. Any issues identified with regards to non-conformance to any of the standards was documented by Eskom as a deviation and appropriately graded and evaluated during the Global Assessment review.

The NNR review of the 3rd PSR was guided by compliance to safety standards that are an integral part of every safety factor area under review.

One of the objectives of the 3rd PSR was to demonstrate that the actual condition of the SCCs important to safety meets their design basis, operational limits, and condition requirements. There are individual safety factors areas in the 3rd PSR that directly deals with the aspects of design, however the licensing basis is not isolated to a specific safety factor and is integrated throughout the 3rd PSR. The integrated nature of the review is therefore important to conclude on the status of the licensing basis. This includes an evaluation to determine the extent to which the licensing basis remains valid, for the extent of the current licence, and for the next 10 years, as well as the extent to which the licensing basis will remain valid until the end of long-term operation (LTO) up to 60 years, to support the LTO safety case.

From the SF reviews and the global assessment process, 113 deviations and 8 Global Issues (GIs) were identified. The global assessment process has provided a balanced view of the cumulative effect of the deviations on D-i-D, DSA, FSFs, FSPs, PSA, EP and Ageing Management (AM), and it was concluded from the global assessment outcomes that the KNPS is suitable for continued operations.

Safety improvements were proposed for each of the deviations and GIs. The improvements were verified, screened, and ranked according to their safety significance. The identified safety improvement actions were included in the Integrated Implementation Plan (IIP) to maintain risk within acceptable levels, ensure continuous improvement and to support safe operation over the next PSR period.

In accordance with the IIP there are 11 safety improvements that are existing commitments and safety improvements actions to resolve deviations that have a safety significance grading of High related to the NNR requirements. These actions should be completed in accordance with the LTO safety case commitments in the short term prior to 2027 and some prior to LTO. These improvements include the following:

1. Updating of SSC importance and classification listing.
2. Develop and execute a comprehensive recovery plan for concrete structures.
3. Completion of EQ TLAA for qualified equipment prior to LTO.
4. Develop and implement an environmental condition monitoring programme.
5. Complete all actions identified in the Interim Ageing Management Assessment report.
6. Update the SAR with AMP and LTO details.
7. Update RPV LOPP and programme manual.
8. Update all programmes used for AM to align with the 9 attributes.
9. Develop, implement and monitor the Technological Obsolescence Programme (TOP).
10. Update and authorise the SSR including the SSHAC seismic hazard assessment.

It should be noted that all the above actions are considered improvement actions on the current licensing basis and therefore not necessarily limiting for the LTO. The NNR accepted the outcomes of the 3rd PSR, the associated grading and direct impact thereof on potential LTO. The acceptance of the IIP stems from acceptance of the final report.

10 PUBLIC CONSULTATION

NNR implements two levels of public consultation when considering a nuclear installation licence application. Level one entails a stakeholder notification and comment phase and level two involves holding further public debate as required by the NNR Board. The primary aims of the NNR's public consultation process is summarised as follows.

- Notifying stakeholders and members of the public of the licence application received by the NNR.
- Inviting representations in the form of comments from members of the public; and
- Holding public hearings to provide registered interveners (interested and affected parties) with opportunities to make oral presentations on issues relating to health, safety and the environment connected with the LTO application currently under consideration by the NNR.

On 10 May 2021, the NNR received the application from Eskom to operate the Koeberg Nuclear Power Station beyond the time frame established in the current Nuclear Installation Licence NIL-01 (Variation 19). This application is referred to as Koeberg Long Term Operations (LTO).

In accordance with the provisions of section 21(3) of the NNR Act, (Act 47 of 1999) the NNR directed Eskom to serve notice of the application to stakeholders directly affected by the application and to publish notices in the Government gazette and local community newspapers which invited members of the public to make representations in the form of comments to the NNR. The closing date for submitting comments to the NNR was 31 March 2023, the NNR project team reviewed the comments received and determined that there was a need for further consultation based on the following:

1. Comments received on health, safety, and environment.
2. Outstanding technical Safety Case issues. (Commitments)
3. Increased public awareness on Koeberg related matters.

A recommendation was made to the NNR Board to conduct further public consultation on the application. The NNR Board took a decision to hold further public debate in the form of public hearings on health, safety and environmental issues connected with the application. The NNR Board held public hearings to provide members of the public an opportunity to make oral

presentations to the NNR on health, safety and environmental issues connected with the LTO application.

The 1st set of hearings comprising of 3 sessions were held on 3,10 and 17 February 2024 in the Western Cape. The 2nd set of hearings comprising of 5 sessions were held on 3 and 4 June 2024 in the Northern Cape and on 6,7 and 8 in the Western Cape provinces respectively.

High level summary of the consultation activities implemented in listed below:

#	Activity	Date
1.	NNR directed Eskom to publish notice of the application. Public invited to comment. Closing date for comments.	31 March 2023
2.	Public information sharing meeting in Atlantis	5 November 2023
3.	Public information sharing meeting Athlone	12 November 2023
4.	Public information sharing meeting Mitchells Plain	2 December 2023
5.	Public information sharing meeting in Tableview	9 December2023
6.	Public hearing in Tableview	3 February 2024
7.	Public hearing in Athlone	10 February 2024
8.	Public hearing in Atlantis	17 February 2024
9.	Public hearing in Kamiesberg, Northern Cape	3 June 2024
10.	Public hearing in Concordia, Northern Cape	4 June 2024
11.	Public hearing in Tableview	6 June 2024
12.	Public hearing in Athlone	7 June 2024
13.	Public hearing in Atlantis	8 June 2024

The decision to hold 2 rounds of hearings was informed by the selected request from some public representatives to have access to additional information that was not yet available for the 1st round of hearings. The 2nd round of hearings was also expanded to include the communities around Vaalputs that might be impacted by any decision related to potential LTO of Koeberg.

During the public hearings, the NNR panel received oral representations from pre-registered interveners and other members of the public provided oral comments at the hearings. The representations were made by civil society organisations, public interest groups, concerned citizens, members of the public and industry bodies/associations. The NNR also received representations in the form of hand delivered and online written comments from members of the public.

The NNR, following receipt of the representations received, performed an analysis of the data. The analyses enabled the NNR to highlight topical issues that are driving the public comments or concerns as well as assisting in determining the issues raised related to health, safety, and environment.

- **Relevance and applicability of representations received:**

The comments extracted from the representations received during the hearings were grouped into common themes. The top 5 themes identified related to health, safety and environment during the hearings relates to:

Health, Safety, Environment
Emergency planning issues
Public consultation process
Nuclear waste issues
Communities not informed
Lack of and access to information

The grouping approach serves to highlight the public's interest in specific safety issues connected with nuclear and Koeberg LTO. When the distribution is compared to the comments received during the period in January 2023 when the public were notified about the application and invited to comment on the application, it shows a close correlation to the distribution with a slight increase in comments related to safety and environment:

Categories	Received during 1st phase (Notice and comment) in March 2023	Received during 2nd phase (Public Hearings) in February & June 2024
Health	2.6%	2.1%
Safety	31.7%	33.7%
Environment	7.3%	8.2%
General	58.6%	55.9%

It is clear from the eight public hearing sessions conducted, that most comments originate from opinion pieces in the public domain, from media and from sources not independently or peer reviewed for accuracy and/or validity. It is shared between organisations and individuals to use during their representations.

An analysis of the representations made by the public found that the issues related to health, safety and the environment are either addressed or dispositioned by the nuclear installations licence conditions, the current licensing basis of KNPS, the safety case or are subject to ongoing review by the NNR.

The hearings also showed that there is difference in opinion between various sections of the public and communities:

a) Support for LTO - Some is in support of electricity generation from KNPS because the need for electricity and no-load shedding as they experience inconvenience and an increase in crime. They are concerned about the loss of jobs and impact on the economy. Support was also seen from unions and young participants. Especially those that understand the technology and wish for future opportunities to develop and be recognized as experts both locally and internationally.

b) Support with conditions - Some people have a caveat or view at the end of their presentation that if LTO is approved it must be done with respect to taking safety into considerations, ensure all open items are resolved, and compensation is considered for loss of land.

c) No support for LTO - The people oppose to KNPS continued operation commented from the point that nuclear is not welcomed or necessary because it is dangerous, pose a risk to health and is not managed safely. The arguments presented in support of this narrative are not always correct or applicable. A number of times reference have been made to perceived or existing weaknesses with the current legislation, regulatory space, known technical issues, licensee operations and conduct.

It is therefore submitted, based on the analyses of the public representations received, that there are no open or outstanding technical issues related to health, safety and environment directly linked to the safe long-term operation of Koeberg that has not been adequately addressed by either the safety case or current licensing basis of Koeberg to allay fears or mistrust in the management and regulation of nuclear safety. Although there is a technical demonstration of safety, it is not fully understood, or the outcomes thereof, even if accepted by the NNR, not trusted by the public.

Nuclear operation as with any other activity do pose a risk to the public. This is however part and partial of the nuclear regulation in South Africa.

The risk due to nuclear operation is regulated and it has been demonstrated that KNPS meets the NNR safety standards and criteria. The NNR therefore considers that there are no issues in the public domain that prevent proceeding with the LTO application. The peripheral issues and lessons learned from the hearings should however be systematically addressed to close out any negativity or gaps in public knowledge and trust in the public consultation process.

11 ASSESSMENT OF COMPLIANCE OF LTO APPLICATION BASED ON R266

The application for LTO must comply with regulatory requirements which are contained in the following primary documents:

- National Nuclear Regulator Act (Act No. 47 of 1999);
- R266, Regulations on the Long-Term Operation of Nuclear Installations;
- R388, Regulations on Safety Standards and Regulatory Practices; and
- R1219, Regulations on the Format for the Application for a Nuclear Installation Licence or a Certificate of Registration or a Certificate of Exemption

Recommended guidelines on how to comply with the above regulatory requirements are contained in the following regulatory guidance documents:

- RG-0027, Interim Regulatory Guidance on Ageing Management and Long-Term Operations Of Nuclear Power Plants;
- RG-0028, Interim Guidance on Periodic Safety Review of Nuclear Power Plant;
- RD-0034, Quality and Safety Management Requirements for Nuclear Installations.

Demonstration of compliance with regulatory requirements is a pre-requisite to the variation of a licence by the NNR; however, demonstration of compliance with recommended guidelines is not a pre-requisite.

Refer to Annexure C for a summary of the assessment of compliance of the LTO application with each subsection concluding by presenting a summary of the regulatory decision reached by the NNR after performing an assessment of the relevant requirement.

12 SUMMARY AND FINDINGS

The NNR regulatory framework recognises both deterministic and probabilistic principles for the regulatory control and the assessment and verification of safety of nuclear installations. It is accepted that no facility as complex as a nuclear installation can ever be made ultimately safe and thus there always remains a finite risk associated with such installations. Standards for what is safe enough have been established in terms of levels of risk that are associated with such installations and are deemed to be acceptably low. These standards are based on the following principles:

1. The risk presented by a nuclear plant must not significantly increase the total population risk.
2. The nuclear risks must be negligible when comparing with those associated with other major industrial enterprise.
3. Allowances must be made for a possible increase in the standards of safety demanded by society over the period of operation of the nuclear plant.

Of singular importance to the NNR is the assurance that KNPS is operated safely and within an acceptable level of nuclear risk. This is applicable to the present situation and will apply under extended operating conditions. It should be considered that the extension for the operational life of a nuclear power plant is not a watershed moment. Operation after 40 years should be a continuation of the first 40 years and the licence variation should be evaluated on the approved licensing basis under which the nuclear power plant is operating at the time that the extension application is lodged. Normally LTO should continue the existing licensing basis rather than requiring a backfit of units to meet the design requirement of a hypothetical new plant at the time of licence variation.

The LTO regulatory framework developed and implemented by the NNR require in addition to the justification for continuation of the existing licence basis an additional verification of design against modern standards at the time of application, and the identification of reasonably practicable measures for continuous improvement of safety.

The main activities informing the safety case, of which the integration thereof used to demonstrate compliance with the regulatory requirements in R266 is concluded on as follows:

12.1 Major modifications

All the major modifications identified have been reviewed and approved by the NNR for implementation. Some of the modification where there was manufacturing involved had early NNR involvement and oversight activities during manufacturing. In some cases, the oversight started with the manufacturing of material forgings. During modification installation and commissioning the NNR provide oversight, and this is done via pre-defined intervention points. The oversight extends to all aspects of configuration control to ensure that the licensing basis are timeously updated. Once the modification is installed the NNR conditions of licence require an effectiveness review to ensure that the installed modification deliver on its original technical requirements.

Major modification implemented included but are not limited to the following:

- New refuelling water storage tanks
- New reactor pressure vessel heads
- Steam Generator replacements.
- EERI modifications and improvements
- Containment modifications
- Spent fuel storage.

All the KNPS life extension modifications have been completed on Unit 1. The SGR modification is currently in progress on Unit 2. Some of the safety improvement modifications identified as part of safety reassessments such as the EERI modifications are scheduled for completion post LTO.

12.2 Management of ageing

The Koeberg ageing management programme is conducted in line with the IAEA Safety Standards to ensure the availability of safety related equipment throughout the lifetime of the KNPS. The programme has been updated through application of the SALTO process and methodology. This process is one of the major contributors towards justification of the ability of safety related SSCs to maintain its operability. KNPS has successfully completed a review of the IGALL report to confirm all the identified generic ageing and degradation mechanisms that should be evaluated for KNPS. The verification of the implementation of this updated

programme was subject to international peer reviews. The NNR participates in the IGALL working groups, with this additional knowledge and sharing of ageing related information it is confident that the introduction of the new programmes at KNPS is in alignment with and reflective of both international as well as direct OEM ageing related information and proven practices. KNPS ageing is also one of the aspects assessed during the 3rd PSR that concluded that there are no related deviations that disposition the acceptability of the historical as well new implementation of the management of ageing.

12.3 SALTO Safety assessments

The confirmation that an assessment on all SSC's identified with a time limited parameter has been performed is critical to the outcome of the safety assessment. The integrity of the TLAA process has been verified by the NNR to be aligned with international standards and the IGALL guidance for the TLAAs applicable to KNPS. The additional TLAAs identified by the OEM provides additional credibility to the adequacy of the scope of and the final list of Koeberg TLAAs. The technical revalidation of identified TLAAs was mostly informed by the work that was done under the SGR project in so far as the reanalyses that were performed for the modification. Where reanalyses of TLAAs were required, these were done as part of the SALTO project and identified for NNR acceptance either as part of the normal licensing basis updates or separately identified as commitments in the safety case. In the case of TLAA 301 related to tendon prestress of containment there is a restriction of 8 years on Unit 2.

12.4 Periodic safety review

Eskom has demonstrated with the 3rd PSR that the fundamental safety functions and associated safety systems at KNPS remain within the design basis for the period of LTO. The plans to address the deviations are safety improvements of the current licensing basis and are included in the LTO IIP and therefore do not impact on the justification required for LTO.

Eskom has demonstrated the adequacy of the design basis for the KNPS with respect to magnitude and frequency of the occurrence of environmentally imposed loads. It includes the adequacy of the design of buildings, and design and operation of equipment.

Eskom has demonstrated that for accident analyses and the safety features designed to prevent accidents or mitigate the consequences thereof that the facilities are adequate for the period of LTO and the risks to the public and personnel employed at the KNPS arising from normal operation and from nuclear accidents meet the criteria of the NNR.

In addition to the IIP proposed by the applicant the safety improvements and any additional commitments identified during review of the safety case must be resolved within the timeframes agreed by the regulator:

12.5 Safety related programmes

The integrity of and acceptability of the existing safety related programmes are continuously subject to NNR oversight and required to be updated based on experience gained, changes in NNR requirements and if gaps are identified during the conduct of a periodic safety review. The PSR conducted for LTO as well as the status of NNR oversight confirms that the justification provided in the safety case related to the adequacy and status of safety related programs are accepted.

12.6 Public consultation

Although it can be demonstrated that the impact from long term operation of KNPS may be technically justified the voices of the immediate and surrounding communities had to be heard in alignment with the PAJA Act and the NNR Act provisions on public consultation. The relevant issues raised by the public related to health, safety and the environment have been evaluated and adequately addressed in the condition of licence, current licensing basis or the safety case and associated deliverables. No issues raised during the public consultation processes required further analyses or response by the applicant.

During public consultation process, access to all information to make meaningful representation on the application was raised as a main concern. In some instances, the lack of information led to comments that are not technically valid or copied or relayed from a single source. In the spirit of transparency more information was systematically released and raises the question whether value is added to the broader public since at the hearings some members of the public also mentioned that they do not understand the information. Hence the role of the public information document (PID) was basically overlooked in the public consultation process as there was little to no comments from the public on the information in

the PID. In many instances the explanation to public question and information to resolve public comments are contained and explained within the PID.

The main issues raised by the interveners at the hearings, were related to issues of emergency planning, containment condition and the management of radioactive waste. It is submitted that following completion of the Integrated Leak Rate Test (ILRT) for Koeberg Unit 1 during Outage 127, the results be communicated to the public. It is also submitted to continue to invite representatives of the public as observers to the planned emergency exercises in the spirit of openness and transparency and also as matter of cause make emergency exercise reports available in the public domain.

Based on all the information reviewed and considered the NNR may accept the proposed continued operation of Koeberg Unit 1 for the period of LTO to 2044 and Koeberg Unit 2 for the period of 8 years to 2033 respectively. The acceptance is based on the demonstration of compliance to the requirements in R266, and by consideration of:

- Koeberg compliance with the safety standards, design basis, dose and risk criteria and fundamental principles of nuclear safety.
- NNR oversight and confirmation of compliance to the conditions in the nuclear licence.
- Independent feedback from international peers.

13 REFERENCES

[1] Regulations in terms of section 36, of the National Nuclear Regulator Act, 1999 (Act no. 47 of 1999), on Safety Standards and Regulatory Practices (GN R388). (SSRP)

[2] Regulations in terms of section 36, read with section 47 of the NNR Act on the Long-Term Operation of Nuclear Installations (R.266).

[3] NNR Interim Regulatory Guide RG-0027 Revision 0: Ageing Management and Long-Term Operations of Nuclear Power Plants.

[4] NNR Interim Regulatory Guide RG-0028 Revision 0: Periodic Safety Review of Nuclear Power Plants.

[5] NNR Technical Assessment TAG-003; Guide Long Term Operation of Nuclear Power Plants.

[6] Nuclear installation Licence no. NIL-01 (Var 19)

[7] 36-197, Koeberg Licensing Basis Manual, Rev 2

[8] Koeberg Nuclear Power Station Safety Analysis Report, Rev 5c.

[9] LTO Safety Case Review, PSR and SC screening/review presentation.

[10] IAEA, Specific Safety Guide, Ageing Management and Development of a Programme for Long-term Operation of Nuclear Power Plant, SSG-048

[11] LTO Safety Case Review Plan PLN-NPP-22-002, Rev 1

[12] 125839632: Koeberg Long-Term Operating (LTO) Scoping Methodology

[13] 240-156945472: SALTO Ageing Management Assessment Report (Interim)

[14] RG-0011: Interim Guidance for the siting of Nuclear facilities

[15] Quality & Safety Management Requirements for Nuclear Installations (RD-0034)