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The Green Building, Bell Crescent, Westlake Business Park, Westlake, Cape Town, South Africa PO Box 106, Kalk Bay, 7990 info@safcei.org.za +27 21 701 8145

To: **The National Nuclear Regulator**

Attention: **The Programme Manager: Nuclear Power Plants**

By email: KoebergLTO@nnr.co.za

30 January 2024

Re: SAFCEI – REPRESENTATIONS ON ESKOM KOBERG NPS NUCLEAR POWER STATION (KNPS) LONG TERM OPERATION (LTO) APPLICATION – UNREDACTED LTO SAFETY CASE

Contents

EXECUTIVE SUMMARY

SAFCEI is a registered non-profit organisation that was established by multi-faith environmental and social justice advocates to confront, among other things, environmental and socio-economic injustices, and to support and encourage faith leaders and their communities in Southern Africa to take action on eco-justice, sustainable living and climate

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change issues. SAFCEI includes an Energy and Climate Justice Programme that focuses on climate change and energy.[1]

On 16th March 2023 SAFCEI submitted written representations to the NNR relating to health, safety and environmental issues connected with Eskom's application to the NNR for approval to operate the Koeberg Nuclear Power Station (Koeberg NPS) for a further 20 years beyond its current 2024 end-of-life (the long term operation (LTO) application). Public comment on the application was invited and one of the central concerns raised by SAFCEI in response was that the document set made available to it for comment included a heavily redacted LTO Safety Case, and a number of important source documents relied upon by Eskom in the LTO Safety case had not been made available to I&APs. Furthermore, while some required safety improvements have been implemented, others remain planned for implementation either before LTO or during the period of the LTO.

In November 2023, the NNR published a notice indicating that it had reviewed comments received, and that the Eskom Board had decided that further public debate on the LTO application was necessary. An updated public information document and safety case (revision 3) were indicated as being available, public meetings were scheduled for February 2024 and affected persons were invited to submit written representations by 15 January 2024 (subsequently extended on request to 1 February 2024). These submissions are made in response to this invitation, and address issues that require comment now that previously redacted portions have been disclosed.

In brief SAFCEI's main concerns relating to the proposed LTO of Koeberg NPS are as follows:

The safety case for the long term operation of the Koeberg Nuclear power station is required by regulation to be prepared using the results of safety analyses, with due consideration of the ageing of structures, systems, and components (SSCs); and must provide an overall assessment of the safety of the nuclear installation and justification for continued safe operation for the period of long term operation. However the unredacted LTO Safety Case shows that requirements have not been met. In particular:

- The LTO Safety Case reveals extensive details of the defence-in-depth program at the Koeberg NPS, but in a number of safety critical respects Eskom has failed to make the necessary preparations which would enable its defence-in-depth program beyond the current licence which expires in June 2024. These failures relate to three main areas of defence-in-depth namely cooling of the reactor, pressure monitoring inside the reactor vessel, and integrity of the containment buildings. These failures were evident to the IAEA in its 2022 SALTO mission. They require analysis, rectification, and independent validation before a licence can be lawfully granted as envisaged by

[1] This submission has been drafted with the assistance of Mark Chernaik of the Environmental Law Alliance Worldwide (ELAW) and includes research published by Dr Tristen Taylor entitled "Koeberg's Dangerous Lifetime Extension"[1] which is attached in full to this submission.

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the regulations for LTO. However Eskom proposes that most of these upgrades be delayed to after the licence is granted, which is legally untenable.

- Regarding the issue of cooling – the capacity of the reactor to ensure that the core is always cooled appropriately in the future depends on the effective functioning of rods which over time become embrittled. The LTO Safety Case is unable to provide assurances of effectiveness of this technology as it has failed to indicate that an embrittlement analysis had been completed at the date of its publication. It also has not demonstrated that it has an adequate proactive aging management system that has been independently assessment (for example by the IAEA following on the SALTO mission or other suitable entity)

- Regarding the issue of the internal functioning of the reactor, control of pressure is critical to defence-in-depth in order to prevent accidental releases of radioactive emissions, which could have a catastrophic impact. The failure to contain pressure is what ultimately led to the releases of catastrophic amounts of radioactive material in the Three Mile Island and Fukushima nuclear disasters. Monitoring of temperature and pressure in the reactor is critical to containing pressure and preventing unplanned radioactive emissions. But the Koeberg NPS does not have a pressure monitoring system that is functioning properly and will only be looking to provide one after the LTO licence is granted.

- Regarding the final frontier of defence-in-depth, the containment vessel, the program for addressing chloride ingress will only be completed after LTO authorisation has been granted and the opinion of the experts on efficacy of the repair program is not therefore available prior to the granting of authorisation. Monitoring of the reactor containment vessel is also not possible yet as this still has to be installed.

- On the basis of the above three concerns alone, defence-in-depth cannot be assured and SAFCEI submits that the extension of the authorisation for the Koeberg NPS should not be granted. The issues that are outstanding are required to be addressed and independently verified before a licence for long term operation can be granted.

- The unredacted LTO Safety Case also confirms concerns previously raised that international best practice is not being planned. This can be inferred from disclosures made to date by Eskom as to its budget for long term operation of the Koeberg NPS, compared to the planned expenditure in France for upgrading similar reactors, to the level of best practice, as France is a best practice jurisdiction. Of particular concern is the fact that Eskom may not be installing all the safety features of best practice, but is not disclosing details in this regard to the public.

- The above submissions have drawn on the invaluable research of Tristen Taylor in his recently published article entitle "Koeberg's Dangerous Lifetime Extension" and which will be submitted together with SAFCEI's comments.

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1. LEGISLATIVE OVERVIEW

The application for the long-term extension of the licence for the Koeberg NPS is made in terms of the National Nuclear Regulator Act[2] (the Act) and regulations promulgated under the Act for the Long Term Operation of Nuclear Installations Regulations[3] (LTO regulations).

The unredacted LTO Safety Case states that it has been produced in support of the application for long-term operation (LTO) and "demonstrates that the regulatory requirements for LTO are met and that it is safe to continue operating for an additional 20 years, from 2024 to 2044 (Unit 1) and 2045 (Unit 2)."[4]

However SAFCEI submits that this conclusion is not supported by the unredacted LTO Safety Case.

The following provisions of the LTO Regulations are relevant to the arguments made in this submission:

> "ageing management" means engineering, operations and maintenance actions to control within acceptable limits, the ageing degradation of structures, systems and components;
>
> "safety case" means a logical and hierarchical set of documents that demonstrates compliance with the Regulatory requirements and criteria and describes the radiological hazards in terms of a nuclear installation, site and the modes of operation, including potential undesired modes. It encompasses the authorisation basis, and safety related documentation applicable during different authorisation stages and will include the safety assessment, operational safety related programmes and supporting documentation; and "safety related programmes" collectively refers to all nuclear safety related activities conducted during the operational phase of the nuclear installation and may also be applicable during interim authorisation stages.

The requirements to be demonstrated by the safety case are set out in the LTO regulations, as follows (underline added for emphasis):

> 4 (a) demonstrate compliance with relevant regulatory safety criteria and requirements;
>
> (b) be prepared using the results of safety analyses, with due consideration of the ageing of structures, systems and components and the periodic safety review;
>
> (c) provide an overall assessment of the safety of the nuclear installation and justification for continued safe operation for the intended period of Long Term

[2] Act 47 of 1999

[3] National Nuclear Regulator Act, 1999 (Act No.47 Of 1999): Regulations On The Long Term Operation Of Nuclear Installations NO. R. 266 26 March 2021 published in No. 44394 GOVERNMENT GAZETTE, 26 MARch 2021

[4] Safety Case for Long-Term Operation of Koeberg Nuclear Power station page 7

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(d) demonstrate availability of financial and human resources as well as knowledge management for the period of Long Term Operation, which knowledge management shall include an integrated, systematic approach to identifying, managing and sharing an organisation's knowledge and enabling groups of people to collectively create new knowledge to help achieve the organisation's objectives;

(e) identify necessary safety improvements which may include, but are not limited to, refurbishment, provision of additional structures, systems and components and additional safety analyses and engineering justifications, to ensure that the licensing basis remains valid during the period of LTO

Factors which must be considered by the NNR when deciding an application for LTO, and which are therefore relevant considerations for lawful administrative action as contemplated in section 6(2)(e)(iii) of PAJA are provided in regulation 5, and include but are not limited to the following:

5 (a) Safety related programmes relevant for ensuring the safe Long Term Operation of the nuclear installation beyond the timeframe established by the current licensing basis or the nuclear installation licence:

(b) effectiveness of the ageing management programme necessary for ensuring that required safety functions of structures, systems and components are fulfilled over the period of Long Term Operation of the nuclear installation;

(c) revalidation of the time limited ageing analyses to ensure continued acceptability of the analysed structures, systems or components for the planned period of Long Term Operation.

Non-compliance with the above requirements, in particular those that are underlined, will be the focus of this submission.

2. DEFENCE-IN-DEPTH

Version 3 of the LTO Safety Case has unredacted around ten pages on the defense-in-depth program at the Koeberg NPS, including the section on severe accident conditions that should be considered for practical elimination.[5]

It is not the intention of this submission to comment on every aspect of defense-in-depth that has been revealed in the unredacted document. However, what is of concern is that several features of safety management at Koeberg have not been demonstrated to meet the requirements on which defense-in-depth depends. Three critical aspects will be discussed in this submission namely:

(i) cooling systems – thermal aging and neutron embrittlement;

[5] LTO Safety case pages 229 – 235; 237 -241

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(ii) integrity of the reactor containment structure; and
(iii) ability to monitor containment structure integrity and internal pressure.

The submission will demonstrate in regard to these three critical aspects that necessary upgrades, repairs, management systems and analyses fundamental to defense-in-depth have not been completed and independently verified by the IAEA (or otherwise) prior to submission of the LTO safety case. Without this information and analysis, the LTO Safety Case cannot provide an overall assessment of the safety of the nuclear installation and justification for continued safe operation for the intended period of long term operation as envisaged in regulations 4 (b) and (c), contrary to what is asserted by its authors who state without foundation that:

> No safety concerns were identified during the LTO assessments that would preclude the plant from entering LTO, and as confirmed by the PSR, Koeberg is safe to continue operations into LTO. It has been demonstrated that nuclear safety will be maintained in accordance with the licensing basis and international good practices for the intended period of LTO, with the timely implementation of safety improvements contained in the LTO IIP .[6]

This conclusion flies in the fact of recommendations and suggestions made in the IAEA SALTO[7] report of 2022 which will be referred to in detail in this submission, and which have not yet been addressed.

Information that is critical to analysing reactor safety so as to enable the proper functioning of the defence-in-depth measures will only be available after the LTO licence is granted, if at all. The result is the application does not comply with the regulatory scheme, in particular regulation 4(b) and (c). As a result the NNR is not able to apply its mind to the mandatory considerations provided for in regulations 5(b) and (c) and cannot authorize this application in a manner compliant with the requirements for lawful administrative action set out in section 6(2)(e)(iii) of the Promotion of Administrative Justice Act (PAJA).[8] An authorisation based on the current LTO Safety Case will stand to be judicially reviewed and found to be non-compliant and unlawful.

3. SPECIFIC ISSUES

A. REACTOR PRESSURE VESSEL INTERNALS - THERMAL AGING AND NEUTRON EMBRITTLEMENT

Defence-in-depth at the Koeberg NPS is compromised by the fact that the management of obsolescence is inadequate, and concerns in this regard raised by the IAEA in 2022 may not have been addressed in time before the NNR considers that application for LTO in July 2024.

[6] LTO Safety Case page 13
[7] IAEA REPORT OF THE SAFETY ASPECTS OF THE LONG-TERM OPERATION MISSION(SALTO) TO THE KOEBERG NUCLEAR POWER PLANT UNITS 1 AND 2 SOUTH AFRICA 22=31MARCH 202002
[8] Act 3 of 2000

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There are two main areas of concern around the issue of aging management:

(i) assessment of neutron embrittlement; and
(ii) the management of aging through proactive measures.

Neutron embrittlement Study

Reactor pressure vessel internals are subject to embrittlement which could compromise reactor safety significantly. This is because they provide critical safety functions of protecting the reactor core, maintaining stability for the insertion of control rods and providing passage for coolant to flow.

The LTO Safety Case released for public comment does not include "the results of safety analyses with due consideration of the aging of structures, systems and components and the periodic safety review," in particular the neutron embrittlement study. The fast fracture analysis is mentioned as being anticipated for completion in January 2024 and therefore does not form part of the report.[9] In in its current form the LTO Safety case is therefore not compliant with regulations 4(a), (b) and (c) of the LTO regulations.

The lack of a completed neutron embrittlement study prior to consideration of the application for LTO results in the NNR being unable to apply its mind to the following two factors required for consideration in terms of regulation 5, and as envisaged by PAJA and under section 6(2)(e)(iii):

> 5. (b) effectiveness of the aging management program necessary for ensuring that the requires safety fundings of structures, systems and components are fulfilled over the period of Long Term Operation of the nuclear installation;
>
> (c) the revalidation of the time limited aging analyses (TLAA's) to ensure continued acceptability of the analysed structures, systems or components for the planned period of Long Term Operation.

Should this analysis be completed by the end of January and submitted to the NNR, public comment on its findings will have been precluded, in this critical aspect of reactor safety. If the NNR considers this report without public input and authorises the LTO it is submitted that it will fall foul of the duty to undertake procedurally fair administrative action, rendering the authorisation susceptible to being set aside on judicial review.

[9] Table A.1-1: (Ageing Management LTO Preparation Activities) on page 196 of the Safety Report lists January 2024 as the completion date for Fast Fracture analysis component of the thermal ageing and neutron embrittlement study.

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Neutron Embrittlement Generally

The process of neutron embrittlement and why it must be considered in licence renewal processes is described by in an article by USA NRC scientists:[10]

> In light water reactors (LWRs), austenitic stainless steels (SSs) are used extensively as structural alloys in the internal components of reactor pressure vessels because of their relatively high strength, ductility, and fracture toughness. Fracture of these steels occurs by stable tearing at stresses well above the yield stress, and tearing instabilities require extensive plastic deformation. However, exposure to neutron irradiation for extended periods changes the microstructure (radiation hardening) and microchemistry (radiation-induced segregation or RIS) of these steels and degrades their fracture properties [1-11]. Loss of fracture toughness due to radiation embrittlement was not considered in the design of LWR core internal components constructed of austenitic SSs, but it has been considered in addressing nuclear plant aging and license renewal issues.

In its 2022 SALTO report the IAEA recorded under the heading "Overall Problem" that "the management of the LTO program is not effective to timely complete all actions to prepare for the LTO." It raised the concern that a time limited ageing analysis was not yet complete at Koeberg for the reactor pressure vessel internals. The validation of the TLAA of 8 mechanical SSC's had not been finalised yet, some were at that time *still not contracted,* for example TLAA 106 - environmentally assisted fatigue, RPV internals neutron embrittlement – fast fracture analysis.

In structural engineering and material science, a fast fracture is a phenomenon in which a flaw (such as a crack) in a material expands quickly, and can lead to catastrophic failure of the material. It proceeds in high speed and requires a relatively small amount of accumulated strain energy, making it a dangerous failure mode.[11] As reactors age, neutron radiation embrittlement of reactor pressure vessel internals increases and, if severe enough, could result in a catastrophic fast fracture under certain circumstances. Thus, it is vital to know the state of neutron embrittlement.[12] The risk of catastrophic nuclear accidents resulting from core embrittlement is described in his publication *Normal Accident* [13] by Charles Parrow:

> For all nuclear power plants, the steam generator and the core embrittlement problems are awesome. Small failures can interact and render inoperative the safety systems designed to prevent a steam generator failure from being catastrophic. Trivial events can place stress on the embrittled core in ways unimagined by designers.

[10] A REVIEW OF IRRADIATION EFFECTS ON LWR CORE INTERNAL MATERIALS – NEUTRON EMBRITTLEMENT, VOID SWELLING, AND IRRADIATION CREEP O. K. Chopra1 and A. S. Rao2 1Environmental Science Division Argonne National Laboratory Argonne, IL 60439 2Division of Engineering US Nuclear Regulatory Commission Washington, DC 20555. https://www.nrc.gov/docs/ML1020/ML102010621.pdf

[11] Wikipaedia https://en.wikipedia.org/wiki/Fast_fracture; referring to Todinov, Michael (2016). *Reliability and Risk Models: Setting Reliability Requirements*. Chichester: John Wiley & Sons. p. 235. ISBN 9781118873328

[12] Taylor page 22

[13] Charles Parrow, *Normal Accidents, Living with High-Risk Technologies* Basic Books, 1984, pg. 60 .

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The lack of a neutron embrittlement study of the reactor core is a key weakness of Eskom's application and and undermines its ability to apply defence-in-depth. In fact, the unredacted Safety Report admits such on pages 106-107 in Table 9-4: Actions for TLAAs not Validated for Entire LTO Period – despite a regulatory duty under regulation 5(c) to include the revalidation of TLAA's for consideration by the NNR.

Actions for TLAAs not validated for the entire LTO period:

(sections indicated in italics have been unredacted)

TLAA title	Component	Actions
Reactor pressure internals(RPVIs) thermal aging and neutron embrittlement	Reactor pressure vessel internals	*Parts of the RPVIs sensitive to flaws include the core barrel upper shell-to-flange weld and core barrel shell welds in the core region. Should the results not support a 60 year life the following options shall be considered:* *a) introduction of remote weld inspections (new ISI augmented module)* b) *core barrel replacement*

So far the LTO Safety Case merely indicates that a fast fracture analysis is "in progress"[14] and that Koeberg "has test samples in the RPV to assess neutron embrittlement of the vessel."[15] The logical implication from what is presented in the above unredacted table 9-4 is that there are key results Eskom does not have that might fail to support a 60-year life for the Koeberg NPP. Those results should be known prior to the licensing decision. Introduction of remote weld inspections, or a core barrel replacement, might not be feasible or sufficient to allow for a 60-year life of the Koeberg NPS free of the risk catastrophic fractures if the reactor vessel internals are significantly embrittled. The results of the analysis need to be implemented and validated/independently assessed for the period of the extended operation.

What makes matters more serious is the statement by the IAEA in the SALTO report included in the 15 recommendations and suggestions regarding aspects of the LTO that:

[14] LTO Safety Case page 196
[15] Id Page 230

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> "SAFETY CONSEQUENCE: Without complete implementation of ageing management programmes for civil SSCs [structures, systems and components], preservation of safety functions cannot be ensured." [16]

It is clear that the following conclusion in the LTO safety case, and in particular as regards the neutron embrittlement analysis, is premature without merit and misleading:

> No safety concerns were identified during the LTO assessments that would preclude the plant from entering LTO, and as confirmed by the PSR, Koeberg is safe to continue operations into LTO. It has been demonstrated that nuclear safety will be maintained in accordance with the licensing basis and international good practices for the intended period of LTO, with the timely implementation of safety improvements contained in the LTO II.[17]

Accordingly, the NNR should not authorise the LTO until the core embrittlement study has been completed, analysed with regard to safety, implemented and independently assessed for the period of the extended operation, by the IAEA or other appropriate independent body, with public input.

Validation of analyses

It is submitted that an analysis of neutron embrittlement by Eskom alone is also insufficient for compliance with the LTO regulations. Validation by independent entities such as the IAEA and World Association of Nuclear Operators (WANO), should take place before the LTO application is considered.

Page 41 of the Safety Assessment states:

> Eskom is affiliated with nuclear agencies such as the Institute of Nuclear Power Operations (INPO), the World Association of Nuclear Operators (WANO), and EPRI, among others, and, thus, follows and implements WANO/INPO lessons learnt through formal WANO peer reviews, and assessing significant operating event reports (SOERs), etc. to improve the safety of the plant.

It is therefore submitted that Eskom should be following the WANO guidelines regarding independent oversight, which state on page 9:[18]

> All the activities that may influence or contribute to nuclear safety are to be considered within the scope of the independent oversight function and incorporated into the independent oversight programme.
>
> The independent oversight programme should review all of these individual elements against defined criteria or standards over a given period. The overall scope of activities being covered should be determined by the potential safety significance of each event and the available resources.
>
> The independent oversight programme should also monitor and assess whether the organisation is proactively managing risks, and preventing events through effective use of improvement programmes

[16] SALTO page 64
[17] LTO Safety Case page 13
[18] https://www.iaea.org/sites/default/files/20/09/wano-guideline-independent-oversight.pdf

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or whether its activities are driven by events. The programme should also monitor the quality of the learning derived from event and the quality of the root cause analysis done by the organisation.

These guidelines therefore make it clear that independent assessment is legally necessary, by the IAEA or other appropriate independent body, of the core embrittlement study.

Proactive management of aging

Another feature of Eskom's management of Koeberg which undermines defence in depth at the reactor is the fact that software for the proactive identification of ageing has been cancelled, and it is not clear from the safety report that it has been replaced with equally effective alternatives.[19]

The SALTO report[20] recorded under the heading of "Reviewed Area: Organization of ageing management and LTO activities" that the fundamental overall problem at Koeberg was "Management of the LTO programme is not effective to timely complete all actions to prepare for LTO."[21] Certain undertakings made by Eskom for the contents of the Safety Report are thereafter recorded including under F3:

- effectiveness of the ageing management programme necessary for ensuring that required safety functions of structures, systems and components are fulfilled over the period of LTO of the nuclear installation;
- revalidation of the TLAAs to ensure continued acceptability of the analysed structures, systems or components for the planned period of LTO;[22]

The SALTO report confirmed that aging management plans and TLAA's had not been revalidated at the time of its report 2022. The IAEA confirmed as a fundamental problem in Suggestion D-5 of the SALTO report that there is a "lack of proactive management of technological obsolescence."[23] Eskom had allowed its contract for software for proactive aging management to expire.[24]

In the SALTO report the IAEA recorded that plant had previously adopted the POMS as a tool for a proactive approach.

[19] Taylor page 31
[20] Id page 20
[21] SALTO report page 20.
[22] id

[23] International Atomic Energy Agency, SALTO, pg. 56
[24] Westinghouse, the designer of Koeberg, has developed software that keeps track of the expected lifespan of different components in a nuclear plant. The POMS (Proactive Obsolescence Management System) software has a database of 12 million equipment records and 30,000 vendors, which are contacted every year to check on parts availability. Over 170 nuclear units across the world are members of the POMS network
Westinghouse, "POMS: Proactive Obsolescence Management System", factsheet,https://www.westinghousenuclear.com/Portals/0/flysheets/DES%20POMS%20Sheet%20050523.pdf?ver=LrVz6cKll5Ae0A3az1mcMA%3D%3D;. Taylor page 30

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> The licence of POMS expired, and the plant is in the process of acquiring a new service for the obsolescence management tool. The plant does not have access to any tool to proactively identify obsolescence.[25]

The safety consequence hereof was recorded in the SALTO report

> Without a proactive technological obsolescence management, the plant risks unavailability of SSCs important to safety.

The following recommendation was made

> RECOMMENDATION/SUGGESTION: S) The plant should consider completing the implementation of a proactive approach to technological obsolescence.[26]

The Safety Case makes no mention of either POMS or a similar obsolescence management tool. It does say that Eskom now has an unspecified proactive Technological Obsolescence Programme that it is implementing.[27] What software the programme is using (if any) or any other substantive details about the programme are not provided. [28]

The Safety report therefore does not indicate the effectiveness of its aging management system as envisaged in F3 of the IAEA's SALTO report. The consequence is that proper aging management is not assured and as a result defence-in-depth is undermined. The following mandatory and crucial factor provided in the regulations cannot be considered by the NNR in the application for extension of the licence.

> 5(b) effectiveness of the ageing management programme necessary for ensuring that required safety functions of structures, systems and components are fulfilled over the period of Long Term Operation of the nuclear installation;

Until this matter is rectified by the provision of an independently assessed aging management system the NNR should not grant an LTO for Koeberg.

B. STRUCTURAL INTEGRITY OF THE KNPS

The integrity of the reactor containment buildings are critical to defence-in-depth. A lack of certainty as to the integrity of these buildings therefore compromises defence-in-depth. The containment buildings house the nuclear reactors, steam generators, reactor coolant pumps, and other primary system equipment, and act as the third barrier to prevent the release of radioactive material to the environment during normal operation and beyond design basis accidents. The containment building is the last barrier for defence-in-depth. The first and

[25] International Atomic Energy Agency, SALTO, pg. 56

[26] SALTO report page 57

[27] Eskom, Safety Case, pg. 120

[28] Taylor page 31

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second barriers are respectively the cladding around the nuclear fuel itself and the reactor coolant system.[29] If there is a partial or complete meltdown and the three barriers fail, the possibility of a Fukushima or a Chernobyl-style accident increases dramatically. [30]

Two areas of concern arise regarding the containment buildings. The first concerns the monitoring of the integrity of the buildings, and the second concerns the actual damage that is being caused to these buildings by chloride ingress, which was not anticipated in the original design of the reactor.
As SAFCEI will demonstrate below the unredacted LTO Safety Case confirms that there is a lack of certainty currently as to the integrity of these buildings. SAFCEI submits that the authorisation for LTO should not be granted until there is certainty in this regard.

Monitoring of the containment buildings

The IAEA SALTO report of 2022 flagged as a concern the monitoring system for the containment structure. Recommendation E-2 states that the plant should ensure full functionality of the containment structure monitoring system. This recommendation is intimately connected to Suggestion E-1: The plant should consider improving revalidation of time limited ageing analyses for concrete structures and Suggestion E-2: The plant should consider completing and implementing the ageing management programmes of civil structures, systems and components. The recommendation and the suggestions are all connected to the same fundamental problem: cracks and corrosion in the containment building, which would, if it holds up, prevent radiation and radioactive materials leaving the plant in the case of a serious accident.[31]

However, the remedial work related to this recommendation will only be *done after authorisation for the LTO is granted.* Containment monitoring instrumentation (Linked to IAEA mission finding – Issue area E2) and Containment Integrated Leak Rate Testing are scheduled to be completed after LTO implementation.[32] Information critical to defence-in-depth will therefore not emerge until after the LTO authorisation. The requirements of regulation 4(b) and (c) are thus not met.

Integrity of containment structure

The LTO assessment identified some SSCs important to safety with ageing mechanisms that posed a risk if not treated in a timely manner, namely, containment buildings, aseismic bearings, cables, and switchboards.[33]

> Due to significant chloride loading into the containment civil structure from the atmosphere at Koeberg that was not anticipated during the design stage, the external surfaces of the containment buildings have suffered from chloride ingress that causes rebar corrosion. Since the year 2000,

[29] Eskom, Public Information Document, pg. 57
[30] Taylor page 24
[31] Id paeg 23
[32] LTO Safety Case page 211
[33] Id page 9

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> various investigations, tests, and evaluations have been dedicated to the required recovery. The first was removing loose and spalled surface areas, followed by repairs. Several repair projects have been completed to date. However, it is clear that these efforts are temporary and not a permanent solution. An investigation by a group of international experts concluded that the only permanent solution was to protect the internal rebar and tendons through impressed cathodic protection. [34]

The two sentences that follow this quote are now unredacted in the LTO Safety Case and refer to the documentation of the investigation analysis. However, since the report referred has not been made publicly available this does not give any assurance that the matter will be dealt with timeously. [35] The removal of redactions merely confirms the concerns that structural integrity that is the third basis for defence-in-depth will not be assured before the LTO licence is application is considered by the NNR. For this reason, as well as the delay in ensuring monitoring of the containment buildings, SAFCEI submits that it would be premature for the NNR to authorise the LTO of the Koeberg NPP. These issues need to be resolved and the effectiveness of the solution verified independently before the plant is authorised to continue beyond its current license.

The basis for the above concerns is set out in the unredacted Safety Report:

<u>Delays in effecting repairs</u>

The first major concern is that Eskom's general delay in dealing with the issue of chloride ingress compromises defence-in-depth. Although these problems were evident in 2000 they have not been adequately addressed to date. Cracking containment vessel concrete - which may have initially occurred because of the weather - has been exacerbated because of Eskom delayed maintenance.[36] In 2017, Eskom has admitted that:

> It is noted that in the past, there have been significant delays to repair concrete degradation with the net result that large patches amounting to approximately 10% of the containment building surface area have delaminated and chloride ingress extends past the rebar cover depth.[37]

Eskom states in the the LTO Safety Case that the cracks will only be repaired in 2025.[38]

<u>Lack of up to date information</u>

The second major concern is that the NNR is being asked to a licence the extension of the operating life of Koeberg by 20 years without access to highly relevant safety information

[34] Safety Report, p85.

[35] The following words were unredacted: "The investigation analysis is documented in JN465-NSE-ESKB-R-5704 (*Long-Term Repair Strategies for the Containment Buildings – Expert Panel Report*) [132]"

[36] Taylor page 24

[37] Eskom, Plant Engineering: Life Of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 23, https://koebergalert.org/2020/11/10/eskom-releases-koeberg-decommissioning-strategy/

[38] LTO Safety Case page 211

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concerning the leak tightness of the containment building. The last time an integrated leak rate test was done on the containment building was in 2015. This test checks the leak-tightness and the structural integrity of the building in relation to the degradation of reinforced concrete. What Eskom does is increase the pressure inside the containment building to replicate the loss of coolant around the reactor.[39] An integrated leak test happens every ten years. The current plan seems to be that Eskom will do an integrated leak test on Unit 1 during a 200 day outage starting on 24 July 2024, three days after the licence expires, and make repairs if necessary. Eskom wants the NNR to grant a 20-year licence before a critical test on a vital structure, and last barrier in defence-in-depth.

Not only will the decision by the NNR to grant such extension therefore lack highly relevant safety information and analysis, but it will not be able to assure the public that the requirements for defence-in-depth for the next 20 years are in place regarding structural integrity. And there is there is no guarantee that an accident will not occur between now and July 2024.[40]

The result is the LTO Safety Case does not meet the requirements for analysis and assurances of safety required by Regulation 4(a) and (b) regarding the issue of leak tightness.

Eskom's view in the LTO Safety Case, based on the 2015 integrated leak test and a temporary solution, is that "the current condition of the buildings is deemed to have sufficient integrity, and the design of the buildings remains fit for purpose and suitable for long-term operation."[41]

Apart from the leak test information being eight years out of date, there is no reference in the unredacted report to support this assertion. In fact the opposite is true. Consider the fact that the IAEA pointed out that some remedial measures regarding identified safety measures needing immediate attention during the last outages, including Unit 2's containment structure in 2018 and 2020, were still marked as pending on Koeberg's SAP database. Either the database has not been updated, which is concerning or the pressing remedial measures weren't done, which is an even more concerning.[42]

Thirdly the problem of chloride ingress and the resulting cracks will not be remedied until 2025, after the LTO licence is granted.

Given that the integrity of the containment building is critical to defence-in-depth, SAFCEI reiterates that it would be premature for the NNR to authorise the LTO of the Koeberg NPP before the problem of chloride ingress, and the monitoring of containment structures has

[39] Eskom, Safety Case, pg. 121

[40] Taylor page 25

[41] Eskom, Safety Case, pg. 122

[42] International Atomic Energy Agency, SALTO, pg. 64 . Taylor page 25

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been resolved, and the effectiveness of the solution verified independently. The LTO Safety Case is presently without the information necessary for compliance with regulations 4(a) and (b) in this aspect of the reactor and an authorisation based on this report would stand to be challenged as unlawful. The NNR should not grant an extension of the licence to Koeberg until the requisite up to date analysis of leak tightness of the containment building has been undertaken and the effects of chloride ingress repaired.

C. INTERNAL PRESSURE MONITORING

Eskom cannot currently reliably monitor what is happening inside the containment building. This is clear from the IAEA SALTO report and the LTO Safety Case. The consequence of this is that defence-in-depth is undermined and consequences for safety could be severe, including a catastrophic release of radiation.[43] Furthermore the LTO Safety Case fails to comply with regulations 4(b) and (c) and the LTO authorisation cannot be lawfully granted.[44]

The monitoring and control of pressure inside the reactor vessel is clearly critical to preventing such an unintended release of radiation:

> The central safety objective in reactor plant design and operation is limiting the release of radioactive fission products. To ensure that this objective is met, the containment must be designed and maintained so that the fission products are retained after operational and accidental releases inside the containment. The containment temperature, pressure, and combustible gas control systems are those systems which are necessary for reducing the release of airborne radioactivity and for ensuring continued containment integrity. These containment systems function as necessary during normal operation and during the period following a postulated accident.[45]

The monitoring system for the containment building involves four parts: strain gauges, thermocouples, pendulums and invar wires. The thermocouples, monitor the temperature inside the containment building. The SALTO report observed the fundamental overall problem that the "containment structure monitoring system is not fully functional"[46] and paints a concerning picture:[47]

> 2.1 - FACTS:
>
> F1) Temperature monitoring is a precondition for accurate evaluation of results of strain gauges, pendulums and invar wires. However, some thermocouples linked to the strain gauges of

[43] Taylor article page 26

[44] (b) be prepared using the results of safety analyses, with due consideration of the ageing of structures, systems and components and the periodic safety review;
(c) provide an overall assessment of the safety of the nuclear installation and justification for continued safe operation for the intended period of Long Term

[45] https://www.nrc.gov/docs/ML1122/ML11223A222.pdf - Westinghouse Technology Systems Manual Section 5.4 Containment Temperature, Pressure, and Combustible Gas Control Systems

[46] SALTO report page 61

[47] International Atomic Energy Agency, SALTO, pg. 61;

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> containment monitoring system of unit - 1 are not functional. The temperatures were calculated from coil resistances. This method does not provide accurate temperature values.
> F2) Some strain gauges of containment dome of unit 1 are partially out of service and the strain gauges of unit 2 are out of service or are providing erratic values.
> F3) The modification of the containment monitoring system is in the initial stage
> F4) Four pendulums in unit 1 named P2-A, P4-A, P1-B and P3-B show non-realistic behaviour compared to strain gauge evaluations in the same area. According to TLAA 301 (containment reanalysis report), one possible cause of the non-realistic behaviour is concrete repairs in this area with the consequence of corrosion effects. According to TLAA301, these pendulums need to be intrusively examined, refurbished and re-set, which is not completed.

In summary - as thermocouples are not functioning on Unit 1 accurate temperature values are not accurately discernible. Without such, the evaluation of results of strain gauges, pendulums and invar wires cannot be accurately evaluated and instead, temperatures are being calculated resulting in temperature values that are not accurate. [48] Basically, these instruments measure the strain on and the lateral & horizontal displacement of the containment walls, all of which are vital to know what will happen during an accident.[49]

The question arises whether the containment building handle a rise in pressure, and if not the consequences could be serious. At Fukushima, the pressure rose higher than the buildings could handle in Units 1, 3 and 4. The pressure led to the release of radioactive gases and hydrogen explosions. At Three Mile Island, the operators had to vent radioactive gases to prevent over-pressurising the containment structure. [50]

The observations contained in F2 to F4 of the SALTO report above show a concerning lack of attention by Eskom to safety. In the Safety Case Eskom indicates its intention to attend to rectification of cables and connectors for Unit 1's thermocouples after 24 July 2024 ie after the current licence expires, and during Outage 127 and that a "Purchase request is initiated."[51]

The SALTO report makes the following recommendation:[52]

> The plant should ensure full functionality of the containment structure monitoring system."

One can assume that this means currently, not at some time in the future.

The IAEA also states: [53]

[48] id

[49] Eskom, Plant Engineering: Life of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 9
[50] Taylor page 26
[51] LTO Safety Case page 3
[52] SALTO report page 62

[53] International Atomic Energy Agency, SALTO, pg. 61

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> The operating organization shall establish surveillance programmes for ensuring compliance with established operational limits and conditions and for detecting and correcting any abnormal condition before it can give rise to significant consequences for safety.

The SALTO report provides a table of 15 recommendations and suggestions regarding a list of "fundamental overall problems."[54] An IAEA recommendation is very serious matter and points to inadequate conformance to IAEA Safety Requirements. It is defined as:

> Advice on what improvements in operational safety should be made in the activity or programme that has been evaluated. It is based on inadequate conformance with the IAEA Safety Requirements and addresses the general concern rather than the symptoms of the identified concern. Recommendations are specific, realistic and designed to result in tangible improvements.[55]

A suggestion is a statement of how to improve safety:

> A suggestion is advice on an opportunity for safety improvement not directly related to inadequate conformance with the IAEA Safety Requirements. It is primarily intended to make performance more effective, to indicate useful expansions to existing programmes and to point out possible superior alternatives to ongoing work.[56]

Until that process is completed Koeberg does not have a fully functional containment structure monitoring system. Once again the NNR is being asked to authorise the continued operation of the Koeberg power station for a further 20 years without having access to critical safety information, and in violation of the requirements of regulation 4(b). Moreover a false impression is being created as to safety of Koeberg far into the future. Eskom has incorrectly stated that:

> "The SALTO assessment confirmed that the continued safe operation of Koeberg was supported, including LTO."[57]

This is clearly not the case as Eskom only intends addressing the lack of a fully functional containment structure monitoring system after the authorisation for Koeberg's LTO is granted. The SALTO report as to the consequences of the current state of the containment monitoring system are clear:

> 2.2 – SAFETY CONSEQUENCE: Without a fully functional containment monitoring system, not all necessary data for the containment structure will be available to demonstrate the intended safety function during LTO. [58]

In light of the above SAFCEI submits that the authorisation should not be granted until the recommendations of the IAEA regarding fully functional containment structure monitoring system have been implemented. Eskom cannot present an analysis of containment safety to

[54] SALTO report page 12
[55] SALTO report page 14, definitions
[56] id

[57] Eskom, Public Information Document, pg. 3

[58] Salto report page 61

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the NNR without this system and hence the LTO Safety Case is not yet compliant with regulation 4(b) and (c) as is abundantly clear from the SALTO statement on safety consequences of

D. BEST PRACTICE

The underlined words in the following quote were initially redacted in the LTO Safety case:

> "EDF (Electricite de France) is often referred to as the "technical safety reference for Koeberg" due to the similarity in design to Koeberg, its rigorous safety improvement programme, and the close cooperation between the South African and French nuclear regulators and, as such is used to form the basis for many of the technical decisions and the general operating rules (GORs) employed at Koeberg.[59]

And

> Although the reanalyses are in progress, it is envisaged that sufficient margins will be available for these components to continue operation for an additional 20 years based on operating experience from EDF.[60]

What this reveals is that Eskom did not want to disclose the role of international best practice, particularly French practice (the EDF) in the development and implementation of safety standards for Koeberg LTO. There are other redactions relating to French standards in the earlier version of the report. See for example the following: (Initially redacted text is underlined)

> "9.4.3 Koeberg is a Framatome-designed plant with nuclear safety design criteria based on the ANSI N18.2-1973 code. The design basis of Koeberg considers the general principal design criteria for nuclear power plants, 10 CFR 50 Appendix A, to ensure that the operation of the plant is inherently safe throughout its operating life. The SAR I-4.3.2.3 (*Principles Applicable to the NSSS"*

The NNR expects Koeberg to meet international "best practices" and refers to the safety levels of the WENRA[61] in addition to other standards. French safety standards for long term operation were adopted by WENRA in 2009. One can therefore consider French practice to be international best practice.

According to the NNR website:

> The NNR's Regulatory Framework consists of legally binding requirements by International Safety Conventions, laws passed by Parliament that govern the regulation of South Africa's nuclear industry, regulations, authorisations, conditions of authorisations, requirements and guidance documents that the NNR uses to regulate the industry….. The NNR establishes additional requirements based on international best practices. …The NNR Safety Standards are premised on international standards such as the IAEA Safety Standards, the UK NII Safety Principles and the WENRA Reference levels. [62]

[59] Safety report page paragraph
[60] Id page 105
[61] Western European Nuclear Regulatory Association
[62] https://nnr.co.za/about/acts-and-regulations/

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However the use of French practice as the technical safety reference for the Koeberg LTO would involve installing a core catcher and possibly other safety features at significant extra expense than Eskom is prepared to pay for the LTO.

According to French law the standards of safety of an LTO must meet the standards of a new reactor. As far back as 2009 the ASN required Reactors to meet current safety standards, ie standards applicable to *new reactors* for the process of extension of life.[63] The evaluation and addressing of aging of the reactors had to be considered against this new baseline. This change was then adopted by an international group, the Westerm Europe Nuclear Regulators Association (WENRA) association of heads of European nuclear safety authorities.[64]

The French are currently extending the life of many of their entire fleet of 56 reactors, including ones of the exact same design as Koeberg at massive cost, an estimated cost €1.7bn per reactor (2016 euros). Applying that figure to the upgrade of Koeberg's two reactors[65] would suggests that a figure of approximately R70bn might be a reasonable figure for the upgrade. However in 2010 Eskom indicated that it intends only spending R20 billion on the Koeberg LTO. Taking into account inflation that would currently approximate R43 billion, almost half of what the French would spend on the extension of life of a comparable reactor.[66]

In line with the requirements of new nuclear reactors, French are installing significant upgrades on plants with the same design as Koeberg's.[67] Upgrades to cooling systems, backup generators and electrical systems that Eskom seems not to be making. The aim of the French is to bring the safety features of the reactors as close to its new design, the European Pressurised Reactor, as possible. Eskom and the NNR appear not to be following this approach.[68]

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[63] ASN - Programme générique proposé par EDF pour la poursuite du fonctionnement des réacteurs en exploitation au-delà de leur quatrième réexamen de sûreté – 28 June 2013. (https://gazettenucleaire.org/2013/269p12.html). Available in English supplied by S Thomas.

[64] https://www.wenra.eu/; In its letter in reference [5], the NSA considered that the reassessment studies should be conducted with regard to the safety objectives applicable to new reactors. This position is consistent with that expressed in November 2010 by the WENRA association of heads of European nuclear safety authorities in a statement on safety goals for new nuclear power plants. Indeed, WENRA states that these targets should be used as a reference to identify reasonably practicable safety improvements for existing nuclear power plants during the ten-year safety reviews.

[65] Cour des comptes, 2016 Annual Public Report, pg.24, https://www.ccomptes.fr/sites/default/files/EzPublish/20160210-Annual-Public- Report-English-summaries-Observations.pdf

[66] Taylor, page 13

[67] Autorité de sûreté nucléaire, Generic Phase of the Fourth Periodic Review EDF's 900 MWe Reactors, March 2021, pg. 75-77, https://www.asn.fr/content/download/177423/file/Rapport%20d%27instruction%20de%20l%27ASN%20pour%20les%20RP4%20-%20 r%C3%A9acteurs%20900%20MWe.pdf

[68] Tristen Taylor, page 13

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France draws on the recommendations of international bodies such as the Western Europe Nuclear Regulators Association (WENRA)[69] for standard setting in regard to safety and extension of life. The Koeberg Nuclear Power Station (KNPS, Koeberg) was built by the French company Framatome between 1978 and 1984. In line with international practice, the plant was granted a 40-year operational licence which will expire in July 2024. Its design is similar to reactors in France that have sought extension of life (Bugey in particular). Hence the French approach to extension of life is highly relevant to the application for Koeberg's extension of life.

France does not grant long term extension of life permits. Permits to operate nuclear facilities are issued by the Government after consulting ASN[70](English=NSA), and have unlimited duration. The facility undergoes an in-depth "periodic safety review" every ten years to assess the conditions for continued operation of the facility for the following ten years.[71]

The Koeberg application for an extension of the permit beyond the next 10 years would therefore not be in compliance with French regulatory practice, and is in itself a best practice issue and concern.

Eskom needs to disclose to the public and the NNR exactly how far its safety program will go to meet international best practice, and in particular where it differs from the French regarding the LTO for a comparable French reactor to Koeberg, so that the public can evaluate and comment on the safety risk posed by adopting a standard that is less than international best practice. On the other hand if best practice is applied to the Koeberg LTO the cost needs to be indicated to determine whether safe LTO for Koeberg is financially viable. It may well be unaffordable.

Until this is done the application for LTO should not be granted as it fails to place relevant considerations before the NNR, the decision maker contrary to the requirements of section 6 of the Promotion of Administrative Justice Act.

CONCLUSION

SAFCEI reiterates its concern that the application for LTO is premature as the requisite information and analysis required to comply with the regulations for the content of the safety case for long term operation are not yet available. Some of these analyses require significant expenditure and improvements to the reactor in order to generate the required data. Many of these features were identified in the 2022 SALTO report as requiring attention before long term nuclear safety could be assured but remain outstanding. Suggestions and

[69] https://www.wenra.eu/

[70] The Autorité de sûreté nucléaire (English: Nuclear Safety Authority, ASN) is an independent French administrative authority set up by law 2006-686 of 13 June 2006 concerning nuclear transparency and security. It has replaced the General Direction for Nuclear Safety and Radioprotection. - Wikipaedia

[71] "ASN issues a position statement on the conditions for continued operation of the 900 MWe reactors beyond 40 years"

https://www.french-nuclear-safety.fr/asn-informs/news-releases/900-mwe-reactors-beyond-40-years

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recommendations of the SALTO report have in many instances been deferred to be attended to after the LTO is granted.

Without the requisite analysis, repairs and upgrades the safety of the reactor cannot be assured for a further period of time let alone 20 further years. This applies at the very least to safety critical issues identified in the SALTO report, and in particular the recommendation that the plant should ensure full functionality of the containment structure monitoring system. [72]

The NNR needs to ensure that the regulations are strictly complied with as regards the safety report and should refuse to authorise the extension of the licence until these requirements are met and independently verified.

Nothing in this submission should be construed to invalidate submissions made at any stage of the process by SAFCEI or its attorneys that asserts that their rights to procedural fairness, public participation and access to information in regard to the application for the long term operation of the Koeberg NPS have been violated.

SAFCEI reiterates that until there is full disclosure of all documents supporting the LTO application it will not be possible for it to participate meaningfully in the comment process.

Francesca de Gasparis

SAFCEI Executive Director

[72] SALTO report page 62

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