LTO LICENSE APPLICATION PROJECT NPP BORSSELE*

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Abstract. Borssele NPP plans to extend its operating life with 20 years until 2034. Borssele has started the project LTO “bewijsvoering” (LTO “Justification”) in order to meet the requirements of the Dutch regulator. The outline of the project is based on IAEA safety guide 57 “Safe Long Term Operation of Nuclear Power Plants”. This paper describes the contents and coherence of the different parts in the project and how these respond to the IAEA guidelines on LTO.

The goal of the project LTO “bewijsvoering” is to ensure that safety and safety relevant systems, structures and components continue to perform their intended functions during long term operation.

The outcome of the project LTO “bewijsvoering” will be used for a license change application and this will be submitted to the Dutch regulator KFD for approval of prolonged operation of Borssele NPP after 2013.

1. Introduction

The Borssele Nuclear Power Plant (in Dutch: “KernCentrale Borssele”, KCB) plans to extend it’s operating life to 60 years, until 2034. Government agreement for this life extension was obtained on June 16th, 2006, when the Borssele covenant between the owners and the government was made. This agreement will make it possible for KCB to realize Long-Term Operation (LTO) for an additional period of 20 years.

For LTO the following conditions have to be complied with:

- Safe operation has to be demonstrated;
- A license change will have to be issued for operation after 2013.

In order to meet these requirements N.V. Elektriciteits-Productiemaatschappij Zuid-Nederland (EPZ) is performing the assessment project LTO “bewijsvoering” (LTO “Justification”). This project provides the justification and documentation needed for the license application for LTO scheduled june 2012.

2. Regulatory Framework

In the Netherlands, the nuclear regulatory requirements are contained in the Nuclear Energy Act. Within the Nuclear Energy Act the so called Nuclear Safety Rules (NVRs = Nucleaire VeiligheidsRegels) provide the basis for a system of more detailed safety regulations for nuclear power plants. The NVRs are based on the Requirements and Safety Guides in the

* A Dutch Version of US License Renewal

IAEA Safety Standard Series (SSS). Application of the NVRs is monitored by the "Kernfysische Dienst" (KFD). KFD is the Dutch nuclear inspectorate.

2.1. IAEA Guidelines

The existing set of NVRs does not provide guidance on Long Term Operation (LTO). Therefore, in consultation with the KFD, it was decided that IAEA guidelines on LTO will be used as the basis for the LTO "bewijsvoering". The regulatory framework for the LTO "bewijsvoering" of KCB is accordingly defined by:

- IAEA Safety Report No. 57 [1];
- IAEA Safety Guide No. NS-G-2.12 [2].

Particularly IAEA Safety Report No. 57 gives specific guidelines for the LTO assessment, see figure 1. These guidelines can be seen as a high level version of US NRC License Renewal guidelines.

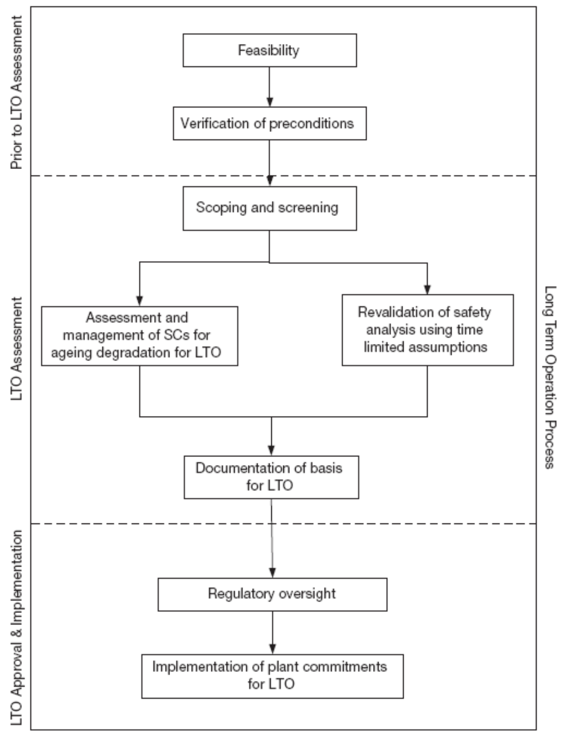

Figure 1, Overview of activities for LTO assessment; figure taken from SR57 [1]

2.2. Additional Requirements

The preparatory work for the LTO assessment at KCB was reviewed in 2009 by an IAEA SALTO peer review team, on request of the KFD. The peer review mission had a limited scope restricted to the LTO assessment part of Safety Report 57. Based on the comments of this SALTO peer review team, the project LTO "bewijsvoering" was extended by the inclusion of the assessment of active safety and safety relevant components.

Furthermore, non-technical requirements from the KFD, i.e. the safety factors 10 (organisation and administration) and 12 (human factor) from the IAEA PSR Safety Guide 426 [3] will be taken into account in the next Periodic Safety Review.

Based on the regulatory framework KCB conducts the project LTO "bewijsvoering" to demonstrate that sufficient assurance is provided that safety and safety relevant systems, structures and components will continue to perform their intended functions during long term operation.

2.3. Overall Structure of LTO "Bewijsvoering" at KCB

The overall structure of the LTO "Bewijsvoering" is given in Figure 2. The figure gives a general overview of the elements in LTO "Bewijsvoering". The same three phases as identified in SR57 [1] are used in project LTO "bewijsvoering". The numbers used in Figure 2 refer to the chapter numbers in SR57.

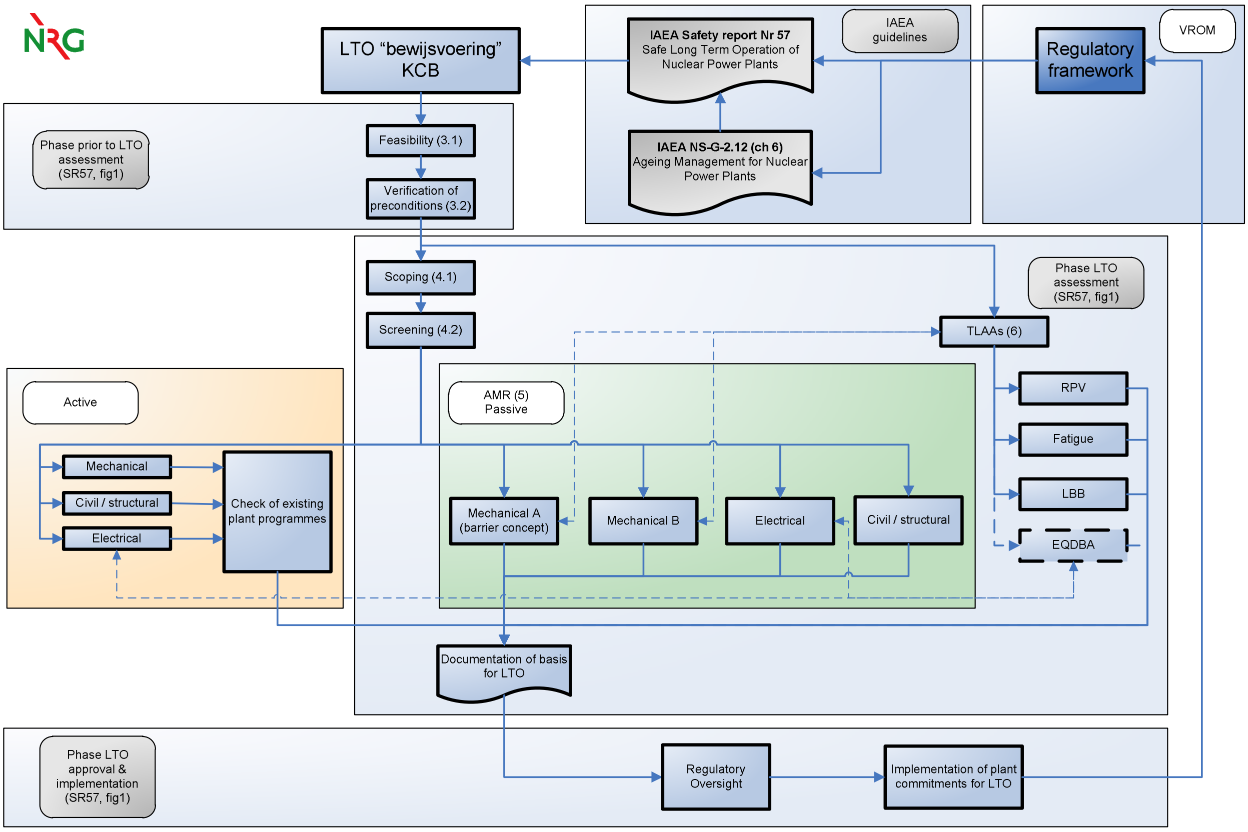

Figure 2 Overview of LTO "bewijsvoering" project (numbers as in SR57 [1])

3. Scoping, screening and Ageing Management Review

As a starting process for the assessment in LTO "Bewijsvoering" the scoping was performed. Within this step, all SSCs in Scope of LTO were identified on a system level based on the following criteria from IAEA Safety Report No. 57 [1]:

1. All SSCs important to safety:

   a. that ensure the integrity of the reactor coolant pressure boundary

   b. that ensure the capability to shut down the reactor and maintain it in a safe shutdown condition

c. that ensure the capability to prevent accidents that could result in potential off-site exposure or that mitigate the consequences of such accidents

2. Other SSCs whose failure may impact upon the safety functions specified above.

In the subsequent Screening process further detailing of the scope on component or commodity group level was performed.

The Ageing Management Review (AMR) involved detailed technical evaluation of in-scope passive long-lived components (e.g. Main Coolant piping) as well as passive subcomponents of active long-lived SCs (e.g. Main Coolant Pump casing) to demonstrate that the effects of ageing are adequately managed such that the intended function(s) will remain consistent with the KCB licensing basis during Long-Term Operation.

The AMR process for passive long-lived SCs generally consisted of two stages. The ageing effects that require management were first identified and evaluated for in-scope SCs. The environmental and operational conditions could cause long-term degradation of each in-scope SC during the service life of the plant. Therefore, each report considered the environmental and operational conditions to which each SC is subjected, including e.g. system pressure, temperature and water chemistry, but also loads or humidity if applicable. These conditions were then evaluated with respect to their effect on potential ageing mechanisms affecting each in-scope component.

Once the identification of SC related relevant Ageing Mechanisms had been completed, the necessity for relevant Ageing Management Activities (AMAs) was then investigated. Effective ageing management may be accomplished by coordinating and/or adapting existing ageing management including maintenance activities as well as In-Service Inspection (ISI) and surveillance, as well as operations, technical support programs and external activities, such as research and development.

Ageing Management Activities serve to manage the effects of ageing during operation, such that the intended SC function can be maintained consistent with the current licensing basis. Existing plant activities and documents were reviewed during this step to determine where existing AMAs are adequate without modification, as well as whether existing AMAs should be augmented for LTO. The existing activities may be adequate to manage ageing effects for particular structures or components during LTO. However, if an identified measure did not exist at KCB, recommendations were made regarding the specific areas in which KCB plant practices and policies should be augmented to substantiate LTO.

During the KCB Ageing Management Review (AMR) process, different methodologies were used to evaluate different SCs and commodity groups. Mechanical A SCs form part of the fission product barrier, i.e. the barrier for radioactive release. Mechanical B SCs consist of the remaining safety related in-scope mechanical systems.

Mechanical SCs and Electrical and Structural/Civil commodity groups are differentiated from one another as follows:

- Mechanical A SCs,
- Mechanical B SCs,
- Structural commodity groups, and

- Electrical commodity groups.

Interfaces between the three disciplines were identified within the individual AMR reports. Such interfaces between the Mechanical and the Structural AMR reports are e.g. supports and hangers, interfaces between the Electrical and the Structural AMR reports are e.g. cable trays.

A total of 17 Ageing Management Review reports were prepared for NPP Borssele in the framework of Long-Term Operation in the three disciplines. A catalog of relevant aging mechanisms was also prepared for each of the 3 disciplines, to guide the performance of each AMR. As applicable, recommendations were made to improve KCB programs and/or practices to align the NPP with current nuclear industry practices and recommendations from equipment manufacturers

With the fulfillment of the AMR recommendations the effects of ageing on in-scope SCs is adequately managed (i.e. the intended function(s) will be maintained consistent with the KCB licensing basis during LTO). All reports are currently being reviewed by the Dutch nuclear regulatory authority.

4. Active components

Safety Report 57 [1] is largely based on US-NRC rules, which assume that any plant implementing LTO also applies the Maintenance Rule (10 CFR 50.65) [4]. The Maintenance Rule ensures proper ageing management of active components, however, this aspect is not addressed in SR57. The Maintenance Rule is not mandatory in NPPs that do not fall under the regulations of the US-NRC. Therefore, evaluation of active components is included in the project LTO “bewijsvoering” in line with with the methodology of the Maintenance Rule [4].

KCB does have a comprehensive programme for life-cycle management of the KCB plant in place. The purpose of this life-cycle management programme is to ensure that all activities have been established and applied, necessary to maintain the KCB plant compliant with design and applicable regulatory requirements. The active components are identified in the screening process. The active components are classified into three groups: Mechanical, Civil/structural and Electrical. The assessment of the active components is currently in progress and to be completed before going into LTO.

5. Revalidation of TLAAs

The TLAAs identified at KCB are: Reactor Pressure Vessel, Fatigue, Leak Before Break and Qualification of Design Base Accident resistant electrical Equipment (EQDBA). These topics are discussed in the current section.

5.1. Reactor Pressure Vessel

The time limited ageing mechanism for the KCB Reactor Pressure Vessel is irradiation embrittlement. The TLAA for the RPV formally ends at the end of the design lifetime in 2013, therefore it needs to be revalidated in the project LTO “bewijsvoering”. The revalidation of the RPV TLAA is performed by a new analysis.

A safety assessment of the Reactor Pressure Vessel (RPV), including the assessment of irradiation induced ageing of the KCB RPV, has been carried out. In the 70s one irradiation surveillance program (SOP, in Dutch “Staal Onderzoeks Programma”) was performed on the KCB RPV with an unirradiated reference set SOP 0 and two irradiation sets SOP 1 and SOP

2. The evaluation of the fluence detectors was done in Petten/Arnhem. A second irradiation surveillance program with one unirradiated set SOP 0a and two irradiation sets SOP 3 and SOP 4 was started in 2007. The structural integrity of the RPV with respect to operation, irradiation surveillance and Pressurized Thermal Shock (PTS) analysis is assessed. Moreover an analysis schedule for the in the RPV inserted irradiation sets SOP 3 and SOP 4 is provided. Finally, the RPV safety of KCB is evaluated in terms of the up-to-dateness of the assessment methods used and by a general benchmark of the KCB results with RPV safety assessment data worldwide. It could be proven that the safe operation of the KCB RPV is guaranteed for all load cases with large safety margins.

5.2. Fatigue

In the design phase of NPP Borssele and during modifications of the plant, fatigue analyses with time limited assumptions were made for certain safety important components. For these components it was proven that the fatigue cumulative usage factor (CUF) is below 1.0 for operation until the end of 2013, based on conservative assumptions on the number of load cycles and stress ranges of transients. For the number of transients a load catalogue was specified. By monitoring the number of transients and comparing the actual number with the assumed number of transients in the load catalogue, the validity of the assumptions on the number of transients is checked on a yearly basis.

Revalidation of the existing analyses for LTO can in principle be done by showing that the assumed number of load cycles and stress ranges of transients in the original analyses will not be exceeded during the LTO period. However, during the last decade worldwide discussions emerged on the conservatism of the existing fatigue design curves and particularly the influence of the coolant environment on the fatigue life (environmental fatigue). Although this issue is still disputed by experts in the world and only based on laboratory tests, procedures were developed in the USA and Japan to address environmental fatigue. New design curves were developed together and correction factors to account for environmental fatigue. Depending on several parameters the influence of a water environment can be substantial in theory.

To be able to revalidate the fatigue analyses for LTO including the incorporation of possible environmental influence, best estimate calculations of the fatigue life are needed including realistic assumptions on the (thermal) loads. For this reason during the yearly outage in 2010 the FAMOS system was implemented which is able to precisely monitor thermal loads including stratification. The monitoring locations are based on an assessment of the thermal loads (the FAMOS manual). Based on the experience with FAMOS and similar systems in German NPPs it is expected that new representative load specifications can be produced with FAMOS after 5 cycles.

Although NPP Borssele has a set of existing Fatigue TLAAs it was decided for LTO to perform an independent scoping survey to determine for which component locations fatigue assessments should be necessary. This survey was based on international practice and engineering judgement. The scope for which revalidation is foreseen consists of the newly determined component locations complemented with the component locations for which fatigue TLAAs were available.

For all component locations in the scope, a systematic review is performed on the available fatigue assessments. Based on a comparison of the number of transients in the analysis with the expected number of transients in 2034 an expected CUF_{2034} is calculated for every in-scope component location. It is recommended to perform further assessment for the locations where CUF_{2034}<1 can not be demonstrated before going into LTO to prove that adequate safety margins against crack initiation by fatigue are in place also during LTO. Environmental fatigue is addressed by following the newly proposed KTA rules on environmental fatigue in which awareness threshold values for ferritic and austenitic steel are given. For component locations in contact with water and usage factors above the awareness threshold values further measures are specified.

With the assessment and the follow-up of the recommendations a sound basis is given for the prevention of crack initiation by fatigue for the period of LTO.

5.3. *Leak Before Break*

Leak Before Break (LBB) is part of the break preclusion concept at KCB. The TLAAs for leak before break are assessed first on their time dependent factors since this aspect is most important for LTO assessment.

The scope for Break Preclusion for LBB is:

- Primary Piping
- Main steam and Feedwater Lines within the secondary containment

In particular, the Leak Before Break argumentation contains time dependent assumptions regarding the growth of defects.

The goal of the review is the answer to the question: Is the concept Break Preclusion (Bruchausschluß) as entered in 1997 still valid in case of plant life extension to 2034?

Two steps of LBB include time dependency:

- Time for growth of surface defect to through wall defect, the number of Reactor Lives
  from this step has to allow for 60 years of operation.
- Time for growth of through wall defect to critical through wall defect – only when through wall defect occurs. Since no through wall defect has been detected, this time dependency always occurs after the step mentioned above and is therefore not relevant for plant life extension to 2034.

The relevance of time dependency in Break Preclusion for KCB 2034 is concentrated in the first step mentioned above of the LBB assessment. The number of Reactor Lives from this step has to be larger than 1.5 (60 years/40 years). The review of this time dependency is the subject of the revalidation of the LBB TLAAs.

From the assessment it is concluded that the time dependent assumptions in LBB TLAAs are not restricting operation for 60 years.

5.4. *Qualification of Design Base Accident resistant electrical Equipment (EQDBA)*

The first equipment qualification project at NPP Borssele was performed in the mid-‘80s of the twentieth century. Due to the Harrisburg accident it was realized that the electrical components didn’t have a qualification for harsh environment conditions. The project “Ongevalsbestendige Apparatuur” (in English: accident resistant components) was worked out in cooperation with Siemens-Erlangen. In this project the approach of the German NPPs was adopted. Based on design base accident scenarios and required safety functions a list of electrical equipment needed to manage the various accidents was developed. The selected components, the requirements and the criteria were listed in the so called “Störfallmatrix” (in English: accident matrix).

The selected hardware was qualified in conformity with the German KTA standards. As follow-up of the first PSR (1992) an update of the “Störfallmatrix” was made in 1994. Also some hardware updates were performed as a result of this PSR.

Goal of the EQDBA project is the implementation of a method to establish the qualified life of each component with a harsh environment qualification for LTO. The project LTO “bewijsvoering” deals with this issue as a TLAA-like issue.

The AUREST-Database is used as a tool to calculate and present the qualified life of the components. Areva developed this database in close cooperation with the German NPPs, within the a working group which handles proof of qualified life. EPZ participates in this working group to ensure information about developments with respect to the concerned equipment.

The EQDBA project has led to the qualification of design base accident resistant electrical equipment, where for components with insufficient data requalification and replacement programmes are carried out.

6. Conclusions

KCB plans to extend its operating life with 20 years until 2034. EPZ has started the project LTO “bewijsvoering” in order to meet the requirements of the Dutch regulator. The outline of the project is based on IAEA safety guide 57 “Safe Long Term Operation of Nuclear Power Plants”. This paper describes the contents and coherence of the different parts in the project and how these respond to the IAEA guidelines on LTO.

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