N.V. ELEKTRICITEITS-PRODUKTIEMAATSCHAPPIJ ZUID NEDERLAND

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Methodology, approach and results of the "Long Term Operation Bewijsvoering subproject: *Qualification of Design Base Accident resistant electrical Equipment*"

Content:

See page 2

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List of revisions

Rev.	Date	Scope of revision
-	7-1-2011	First version
A		• The results of the EQDBA project are included; • Recommendations and comments of the GRS review are incorporated.

Content

Summary

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 report describes the methodology and approach of the subproject "Qualification of Design Base Accident resistant electrical Equipment".

The goal of the subproject "Qualification of Design Base Accident resistant electrical Equipment" is to ensure that electrical components with design base accident harsh environment requirements are qualified to perform their intended functions during long term operation.

Abbreviations

AUREST	AUtomated Residual life ESTimation
AUREST-DB	Aurest Database
BBNKMV	Betriebs Begleitende Nachweis Kühl Mittel Verlust (name of VGB steering group)
DBA	Design Base Accident
DMS	Document Management System
ECI	Ex Core Instrumentation
EQ	Equipment Qualification
EQDB	Equipment Qualification DataBase
EQDBA	Equipment Qualification Design Base Accident
HELB	High Energy Line Break
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronic Engineers
KCB	KernCentrale Borssele
KFD	Kernfysische Dienst
KMV	Kühl Mittel Verlust
KTA	Kerntechnischer Ausschuss
KWU	Kraft Werk Union
LOCA	Loss Of Coolant Accident
LTO	Long Term Operation
LTOB	Long Term Operation “Bewijsvoering”
MCL	Main Coolant Line
NPP	Nuclear Power Plant
NVR	Nucleaire VeiligheidsRegels (Nuclear Safety Rules)
OL3	Olkiluoto 3
PIE	Postulated Initiating Event
PLL	Primär Leck Langzeit (LOCA and post-LOCA)
PSR	Periodic Safety Review
RPV	Reactor Pressure Vessel
RPVH	Reactor Pressure Vessel Head
RPVL	Reactor Pressure Vessel Level
SKM	StörfallKlassifizierungsMatrix
SSC	Systems, Structures and Components
SSS	Safety Standard Series
TLAA	Time Limited Ageing Analysis
VGB	Technische Vereinigung der Großkraftwerksbetreiber

Glossary

The definitions in this glossary are based on [1].

Accelerated ageing	Artificial ageing in which the simulation of natural ageing approximates, in a short time, the ageing effects of longer term service conditions
Accident conditions	Deviations from operational states in which the releases of radioactive materials are kept to acceptable limits by appropriate design features. These deviations do not include severe accidents. (A deviation may be a major fuel failure, a loss of coolant accident (LOCA), etc.)
Artificial ageing	Simulation of natural ageing effects on SSC by application of stressors representing plant preservice and service conditions, but perhaps different in intensity, duration and manner of application.
Arrhenius ageing model	Mathematical model for thermal degradation of material that assumes that the degradation rate over some limited temperature range depends inversely and exponentially on the reciprocal of the absolute temperature and a constant called activation energy.
Electrical equipment	General category of equipment which includes electronic equipment (such as instrumentation transmitters), electromechanical equipment (such as solenoid operated valves) and other types of electrical equipment (such as cables, terminations and transformers).
Environmental conditions	Ambient physical states surrounding a system, structure or component (examples: temperature, radiation and humidity in containment during normal operation or accidents).
Equipment qualification	Generate and maintain evidence to ensure that the equipment will operate on demand to meet system performance requirements.
Harsh environment	Environmental conditions in an NPP location which significantly change as a result of a PIE.
N °C half-life model	Model for thermal degradation of material that assumes, over some limited temperature range, that life is reduced by half (degradation rate doubles) for every N °C increase in material temperature. N is typically in the range of 8 to 12.
Ongoing qualification	Activities performed subsequent to EQ, including condition monitoring, maintenance and analysis of operating experience, to extend qualification for an additional period of time.
Qualified life	Period of time for which satisfactory performance can be verified for a specified set of service conditions.
Qualification margin	Difference between the most severe specified service conditions of the plant and the conditions used in qualification to account for normal variations in productions of equipment and reasonable errors in defining satisfactory performance.

1 Introduction

The Borssele Nuclear Power Plant (Kerncentrale Borssele, KCB) plans to extend its 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 EPZ has started the assessment project LTO "bewijsvoering" (LTO "Justification") [2]. This project provides the justification and documentation needed for the license application for LTO in 2012. This includes recommendations and implementation of commitments that may result from the assessments.

In this report the methodology, approach and result of the LTOB subproject "Qualification of Design Base Accident resistant electrical Equipment (EQDBA)" are described. Equipment ageing may be a potential common cause failure mechanism, especially if components are exposed to harsh environment conditions. The goal of the subproject is to revalidate the qualified life of EQ-components with harsh environment requirements for the period after 2013 and to ensure the qualified life until 2034.

In chapter 2 an overview of the existing EQ program is given. This program forms the basis documentation for the EQDBA project. In chapter 3 the approach and steps of the EQDBA project are described. Chapter 4 provides that the results and procedures of this subproject shall be implemented in the existing plant programs.

In revision A of this report the results with regard to the analysis of the components in scope are included in the new chapter 5.

2 EQ program at KCB

In this chapter the existing EQ program and the historical realization of it is briefly described.

2.1 Regulation on Equipment Qualification

In the Netherlands, the nuclear regulatory requirements are contained in the Nuclear Energy Act (Kernenergie wet, Kew). Since 1989 the so called Nuclear Safety Rules (NVRs = Nucleaire VeiligheidsRegels) provide the basis for a system of more detailed safety regulations for nuclear power plants, as part of the Nuclear Energy Act. The NVRs are based on the Requirements and Safety Guides in the IAEA Safety Standard Series (SSS). IAEA safety guide 50-SG-D11 contains a chapter about Equipment Qualification (EQ). Application of the NVRs is monitored by the "Kernfysische Dienst" (KFD). KFD is the Dutch nuclear inspectorate, resorting under the Department for Nuclear Safety Security and Safeguards

2.2 Establishing EQ

The first EQ project at KCB was performed in the mid-‘80s of the twentieth century [3, 4]. After the Harrisburg accident it was realized that electrical components didn’t have a formal qualification for harsh environment conditions. The project “Ongevalsbestendige Apparatuur” (“accident resistant components”) was performed in cooperation with Siemens-Erlangen (now Areva).
Based on worst-case accident scenarios four types of accidents were worked out in such a way that all possible cases/conditions are covered:

1. Leakage of primary system inside containment (Loss Of Coolant Accident (LOCA));
2. Leakage of secondary system inside containment or in the steam relief valve room (High Energy Line Break (HELB));
3. LOCA or HELB in the annulus of the reactor building;
4. Seismic events.

With the safety functions “control of reactivity”, “core cooling” and “prevention of release of radioactive material” as goals, the electrical and I&C equipment needed to remain operational during and after the various accidents was selected.
The selected components were listed in the so called “Störfallklassifizierungsmatrix” (SKM) (“accident classification matrix”). The environmental conditions during the accidents were analyzed, e.g. the LOCA diagram for pressure and temperature [3]. To reach the qualification requirements the selected components must fulfill a qualification procedure according to an accepted standard. In practice the components used at KCB are qualified in accordance with German “Kerntechnischer Ausschuss (KTA)” or the American “Institute of Electrical and Electronic Engineers (IEEE)”, e.g. KTA3403/IEEE323/IEEE317 for containment penetrations, KTA3501/IEEE323/IEEE383 for cables, KTA3504/IEEE323/IEEE334/IEEE382 for valve actuators and other electric motors; KTA3505/IEEE323 for instrumentation. In these standards a type test of the components, which includes pre ageing programs for temperature and radiological loads, is performed. As the environmental qualification of harsh environment electrical components is component oriented (type test), it’s no problem to use both KTA and IEEE standards, as long as the accident requirements are fulfilled by the type test.

During the first periodic safety review (PSR) at KCB (1990-1993) the existing SKM was analyzed in the light of safety design. As a result the component scope was updated [5] and also some hardware updates were performed.

2.3 Quality assurance

The plant document management system (DMS) includes descriptions regarding the processes of EQ. Top level document is a strategic document about qualification of components [6]. The principle of EQ and the applied procedures at KCB are stated in this document.
Next level documents give the specific requirements on component level, the “Basis E&I specificaties". Reference [7] is an example of these specifications, in this case for class 1E cables. Also for other relevant EQDBA components, like containment penetrations, electric motors and instrumentation the specifications are laid down in “Basis E&I specificatie” documents.

A classification document of all safety and safety related electrical components is available, the “E&I-klasseringshandboek” [8]. Qualification requirements regarding harsh environment are stated in this document. The SKM is part of this document.
For specific component types there are maintenance instructions in the DMS. If necessary also information about spare parts forms part of these documents. Also instructions for procurement, storage and record keeping are part of the DMS.

2.4 EQ-component list

The EQ-component list exists in the equipment qualification database (EQ-DB). The EQ-DB was developed mainly to improve the traceability of the documented qualification evidence. In this database all the components with harsh environment requirements are listed. The component list in the SKM is limited to the so-called end components like electric motors, temperature sensors, etc. Other relevant components of the functional component chains, like cables and connectors, are also part of the EQ-DB.
Figure 1 gives an example of a component chain in the EQ-DB. Box “Störfallmatrix” shows the accident requirement (PL = leakage of primary system; SL = leakage of secondary system; LRi = leakage in ring room area).
In the column “Keten” all the subcomponents of the functional chain are listed up. The columns “AKS” (= tagging code), “Ruimte” (= room of installation) and “Merk en type” (= Manufacturer and component type) gives specific information of the subcomponents. Column “TypeSleutel” indicates a link to the archive of qualification documents. Columns “Max P” en Max T” indicates the maximum qualified pressure and temperature during accident conditions. The total qualified radiological dose is indicated in column “Max Dosis”.

AKS: **YA000P151** | *StorfallMatrix: PL:* L *SL:* x *LRI:* x | *INDEX:* 496

Keten	*AKS*	*Ruimte*	*Merk en type*	*Opmerking*	*TypeSleutel*	*Max P:*	*Max T:*	*Max Dosis:*
21020 Messumformer, St. anzeige	**YA000P151** PV 01	01.102	ROSEMOUNT 1154-SH9-RB	Serienummer 0533482	T12A	5 bar	215 grC	1100 kGy
21029 Adapter	**YA000P151**	01.102	ROSEMOUNT Adapter 1/2"NPT M22 x 1,5		Loc-Nuc	3,3 bar	215 grC	1100kGy
21030 Stecker an Arm. / Komp.	**YA000P151**	01.102	S&F AX Anschluß	42/15-900Z S&F Montageanweisung 42/15-900Z	An-S1	4,3 barA	155 grC	250 kGy
21070 Kabel zu UV / DU	**1KX8419**	01	HEW JE-Li 2G(St)2G FRNC-X	2x2x0,5	Ka-Hew	5,4 bar	155 grC	250kGy
21080 UV	**1KX001A101**	01.332	BBC EJB 35 R	Maxi Termi point 0,8X2,4	UV-B	Ademend	nvt	nvt
21081 Klemmen	**1KX001A101**	01.332	Weidmüller KMVF/SAKH10	Epoxidharz NU475/NU514 SAKH10 siehe Kl-W3	Kl-W2 Z 0014601 001 01	5,4 bar Eignungsprufung, certificaat van Weidmuller klemmen type KMVF en KMVT	155 grC KSY50/312/83	250kGy
21090 Kabel UV - DU	**1KX18262**	01	HEW JE-Li 2G(St)2G FRNC-X	40x2x0,5	Ka-Hew	5,4 bar	155 grC	250kGy
21100 SHB-Durchführung (DU) Geb01	**XG013G210**	01.332	Schott SL14.370.008-061D	960122-6 DU-Sc1	DU-Sc1	5,4 bar	155 grC	250kGy
22065 SHB-Durchführung (DU) Geb02	**XG013G210**	02.401	Schott SL14.370.008-061D	960122-6 DU-Sc1	DU-Sc1	5,4 bar	155 grC	250kGy
22090 Kabel von DU / UV	**1HV8001**	02	HEW JE-Li 2G(St)2G FRNC-X	32x2x0,5	Ka-Hew	5,4 bar	155 grC	250kGy
22100 Elektronikschrank / RV	**1JG001**	33.302				nvt	nvt	nvt

Figure 1: Example of a component chain in the EQ-database

The EQ-DB contains all the relevant information of the type test and the qualification of the components with harsh environment requirements, with exception of the qualified life.

3 LTOB subproject EQDBA

Main goal of project EQDBA is to revalidate the qualified operating life for all the components with harsh environment requirements for the period of LTO. If revalidation until 2034 is unsuccessful, timely measures will be taken to ensure the qualified life for the entire period of LTO.

3.1 General information on EQDBA

Temperature and radiation are the main stressors causing ageing degradation of component materials during normal operation of the plant, with regard to the functional requirements and the harsh environmental conditions during design base accidents (DBAs). Type test of components with harsh environment requirements includes an accelerated ageing program for thermal and radiological loads. Before testing under accident conditions the component is pre-aged to simulate the operational environmental conditions (temperature, radiological load). A component may have a requirement to perform a certain period after an accident. Then an accelerated ageing program for post accident conditions and a performance test must be part of the EQ-program as well. Based on the data of the qualification program and the actual environmental conditions in the plant the qualified life can be determined for each component and location. If necessary the qualified life determination for the very long term needs to be supported by on-going qualification programs, e.g. applying the deposit method for cable insulation.

Other qualification steps in the type test programs, such as load-cycles (e.g. KTA 3504), are not relevant for DBA qualification, but for normal operation. Experience showed that the margin between the test specifications and the operational loads is sufficient for the period of LTO. Maintenance- and surveillance programs guarantee detection of unexpected ageing degradation due to load cycles.

For thermal ageing calculations Arrhenius and n-°C half-life are widely accepted models [1]. Equal dose - equal damage assumption with special attention to dose rate effects for specific elastomeric materials is a commonly used model to calculate the qualified life with respect to radiological ageing [1].

Experience showed that synergetic effects of thermal and radiological loads are not present in KWU-build NPPs. Always one of the stressors is dominant. The fulfilled monitoring program [10] at NPP Borssele confirms this, see attachment 1.

Preconditions for successful qualified life calculations are the availability of qualification data out of the type test program, specific material parameters activating energy and dose rate factor, and local environmental conditions during normal operation.

3.2 Principles for the EQDBA project at KCB

Arrhenius equation, including on-going qualification if necessary, is the preferred method to determine the qualified life with respect to thermal ageing. If there is insufficient data to use the Arrhenius equation then n-°C half life can be used as alternative. Use of conservative qualification data is a possibility if precise qualification data of components isn’t available. This is only permitted if the conservatism is based on reliable literature and if there is a significant qualified life margin in the result of the calculation. The decision to use conservative qualification data will be taken on an engineering judgement base and substantiated in the AUREST analysis report [15].

Equal dose – equal damage, taking dose rate factors into account, is the preferred method to determine the qualified life with respect to radiological ageing.

A well-substantiated evidence of the manufacturer, e.g. a qualification document, to prove the qualified life can serve as an alternative method. This evidence should state clearly the qualified life in relation with the environmental conditions during normal operation. Also the harsh environment conditions (including post-LOCA if necessary) of the qualification must be clear. The decision to use manufacturer evidence be taken on an engineering judgement base and substantiated in the AUREST analysis report [15].

Requalification or replacement programs will be developed if a qualified life calculation is not possible or unsuccessful. That may be caused by a lack of qualification data or by an insufficient qualified life.

3.3 Activities in the project

3.3.1 Component and program scope

The component scope consists of the electrical components with harsh environment accident and post-accident requirements. Therefore the scope is based on the EQ-database, which is described in chapter 2.
The program scope is limited to the determination of the thermal and radiological qualified life of each component. The year in which the qualified life ends will be regarded as the period of revalidation. If these revalidated periods don't reach year 2034 measures will be taken.

3.3.2 Selecting method and calculation tool

3.3.2.1 Co-operation with KWU-built NPPs

After studying possibilities to reach the goal of the project it was decided to co-operate with other KWU-built nuclear power plants (NPP). Several German and one Swiss NPP joined in the „Verband der Großkraftwerks-Betreiber“ (VGB) steering group “Betriebsbegleitende Nachweise der KMV-Störfallfestigkeit” (BBNKMV) (“proof of accident resistance”). Beside the steering group there are 6 working groups active which are responsible for specific component groups (cables, actuators, containment penetrations, connectors, motors and sensors/transmitters). In this committee programs to demonstrate the qualified life of components are developed in confirmation with the German standard KTA3706. For example an ongoing qualification program for cables is in use, using cable deposits near the main coolant line in NPPs and performing periodical testing of elongation-at-break and LOCA behavior on representative cable samples.
Requalification projects are performed in cooperation with EQ-experts of external companies like Areva NP.

Advantages for NPP-Borssele are the large amount of qualification data available, the possibility of joining in co-operated requalification programs and the available knowledge built up so far. A quick investigation learned that about 70% of the components with harsh environment requirements at KCB will be covered by components in the VGB-program.

3.3.2.2 Calculation tool

As calculation and presentation tool for the qualified life of components a computer-assisted tool called AUREST (AUtomated Residual Lifetime ESTimation) is developed commissioned by the VGB- steering group “Betriebsbegleitende Nachweise der KMV-Störfallfestigkeit”. Areva NP developed and maintains the AUREST tool.
Calculation of qualified life in AUREST is based on Arrhenius equation and equal dose – equal damage models; see the descriptions in section 3.3.2.3 for more detailed information.
KCB uses AUREST as a tool in the EQDBA project. AUREST consist of three basic parts: component libraries [13], component chain data [14] and a calculating tool [9], see the overview in figure 2.
Two component libraries are used: the “General Component Library” and the “KCB Specific Component Library”. The components in the General Component Library are (re)qualified within the VGB-program. Content of this library is formed by the qualification data of type test programs of the components. This qualification data are used as basic data to calculate the operating life of the components in the plant. Qualification documents

can be found in the VGB-Information system and on the VGB website (in an area with restricted access for members of the steering and working groups). The KCB Specific Component Library consists of the components installed at KCB, which are not covered by a component in the General Component Library. Qualification data are recorded in this library as far as it is available. Qualifications documents used to prove the qualified life for these components are listed up in the AUREST analysis report [15].

The component chain data consist of all the KCB specific components with harsh environment requirements. The specific requirements and the environmental conditions are recorded in this part of AUREST.
Based on the qualification data, the operating life and the environmental conditions, the remaining qualified life of each component is calculated. Then the year in which the qualified life ends is calculated. However, performing these calculations is only possible if the plant component is covered by a component with sufficient qualification data in one of the libraries.

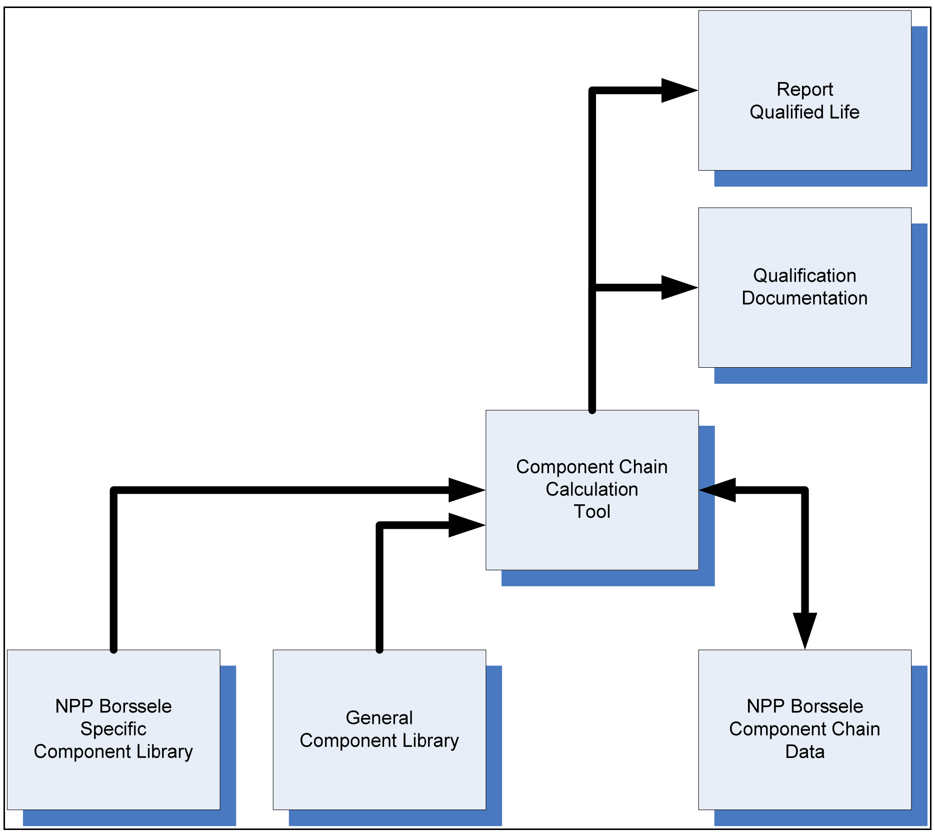

Figure 2: Overview of the AUREST Database

3.3.2.3 Calculation of remaining qualified life

Remaining qualified life calculations are made with respect to thermal and radiological ageing [9].

Calculation of qualified life as a function of the thermal load is based on Arrhenius law.

$$t_E = t_Q * e^{\frac{\phi(T_Q - T_E)}{k * T_Q * T_E}}$$

$t_E = qualified\ life$
$t_Q = qualification\ time$
$T_Q = 273K + qualification\ temperature\ (°C)$
$T_E = 273K + environmental\ temperature\ (°C)$
$\phi = activation\ energy$
$k = Boltzmann\ constant:\ 8{,}617.10^{-5}\ eV/K$

Calculation of qualified life as a function of the radiological load is based on the equal dose – equal damage model, with respect to the dose rate effect [9].

$$t_E = \frac{D_Q}{\dot{D}_E} * \left(\frac{\dot{D}_Q}{\dot{D}_E}\right)^{-n}$$

$t_E = qualified\ life$
$D_Q = qualification\ dose$
$\dot{D}_Q = qualification\ dose\ rate$
$\dot{D}_E = environmental\ dose\ rate$
$n = dose\ rate\ effect$

The difference between the qualified life and the operating life is the remaining qualified life for a specific component. If the location of a component changes during the operating life, then the received environmental loads of the old location are transferred to the new location.

3.3.3 Measurement program environmental conditions

The use of accurate measured local temperatures and dose rates leads to a refined and more accurate calculated qualified life of the components with harsh environment requirements. Therefore a comprehensive measurement program was performed to establish the environmental temperature and radiological dose rate for each single component [11].
The program consists of two parts. In the first part a measurement program is performed on a number of selected components in the plant. Not every single component is measured in this program. If environmental circumstances in areas are stable and there aren't significant sources of temperature and/or radiological loads in that area, then the environmental conditions can be transferred to all the components in that area. Based on a limited number of well chosen measured positions the environmental conditions were

determined for every single component in the scope [10, 12]. This evaluation was the second part of the monitoring program.
Using 138 alkaline dosimeters the radiological loads inside the reactor building under normal operation conditions of the plant were measured during the fuel cycles 2007/2008 and 2008/2009 on a set of carefully selected components.
During the same fuel cycles the temperature on 50 locations in the containment (building 01) were measured. During fuel cycle 2008/2009 17 locations in the annulus of the reactor building (building 02) and eight in the steam relieve valve rooms (building 03) were measured.
The results of the monitoring program and the account for it are documented in [11].
The second part of the program was determining the environmental conditions for the not directly measured components. Based on the rules in [10] and the results of the monitoring program [11] the environmental conditions for every single component were established. The results are entered in the component chain data of the AUREST-database.. Because of their expertise with similar programs in KWU-build NPPs, Areva was selected to perform this measurement program.

3.3.4 Preparing AUREST for use at KCB

The main activity to put AUREST into service is to build-up the plant specific component chain data module. Areva transformed the data of the EQ-database into the correct format for use in AUREST. To do this transformation an intermediate form to couple the data of the EQ-database and AUREST is developed. Future hardware changes of harsh environment components will be documented in the EQ-database by EPZ, and transformed by use of the intermediate data form into AUREST by Areva. In this procedure qualification documentation and data will be checked by EPZ as well as Areva. This guarantees quality assurance for future changes of components with harsh environment requirements. The environmental conditions of the components, determined in the measurement program described in section 3.3.3, are transferred into the component chain data.

3.3.5 Analysis of the harsh environment components

First analysis in AUREST is to check if the KCB specific components are covered by a component in the standard component library. KCB components which are not covered in the standard component library are listed in the plant specific component library. To handle these components in the light of justification of qualified life there are four different manners foreseen:

- Sufficient qualification data available for AUREST calculation models
  If sufficient qualification data are available, life calculations can be performed using the AUREST calculation tool.
- Requalification
  If the available qualification data are insufficient to perform calculations using the AUREST calculation tool, a requalification program can be performed to obtain the missing data. Requalification can exist of analytical and/or experimental proofs. An experimental proof may include a pre-aging program and LOCA/post LOCA or HELB performance tests.
- Providing evidence without AUREST
  If the qualified life of a component is clearly stated in the qualification documents, but the available data are insufficient to make use of the calculating tool of AUREST, then justification of the qualified life based on the qualification documents is permitted.
  N °C – half life calculation is another possibility to use as an alternative method without calculating in AUREST.
- Replacement
  Components with a lack of qualification justification can be replaced for certificated qualified components. In that case qualified components from the general component library in AUREST are preferred. Other sufficiently qualified and documented components may be used as well.

In case of insufficient data to perform a qualified life calculation with AUREST, the choice of performing a requalification or replacement program depends on the available information and the amount of similar components. In the AUREST analysis report [15] the choices made are described.

3.3.6 Qualified life calculations

If all the qualification data needed are available, the calculations to determine the remaining qualified life can be performed. The first time calculations will be carried out in the LTOB-project. Future calculations will be performed yearly after every planned outage of the plant. Then the data of the operating life of every component in AUREST will be updated and new qualified life calculations can be performed. The minimal remaining qualified life must be sufficient to reach the next outage.
Advantage of the yearly calculation is that the amounts of effective full power days regarding the radiological load are updated after every outage. Updated qualification data from on-going qualification programs, e.g. for cables, will be added into the new calculations. Besides that the data of new installed components can be added in the AUREST database. The AUREST database is developed in such a way that lifetime calculations are performed for the complete database.

3.3.7 Summary of the project activities

The EQDBA process, described in chapter 3, uses a number of steps, which are schematically shown in figure 3. The steps in the EQDBA process are briefly described below:

1. Environmental condition monitoring program, for each component in scope the environmental temperature and radiological load is determined.
2. Developing the KCB component chains in AUREST;
3. Comparing the KCB components with the standard component library;
4. Performing the qualified life calculations;
5. Checking the qualified life with regard to a period of 5 years[1]. The period of 5 years gives sufficient time to take measures to guarantee the qualified life for the period of LTO.
6. Developing a replacement or a requalification program to reach qualified life for the period of LTO, if the residual qualified life ≤ 5 years;
7. Developing a program to reach qualified life for the period of LTO, if the component is part of the “KCB Specific Component Library”.

[1] As given in the conceptual document [2] qualified life calculations are performed for the complete period of LTO (2034) as well. The period of 5 years is established as a practical period.

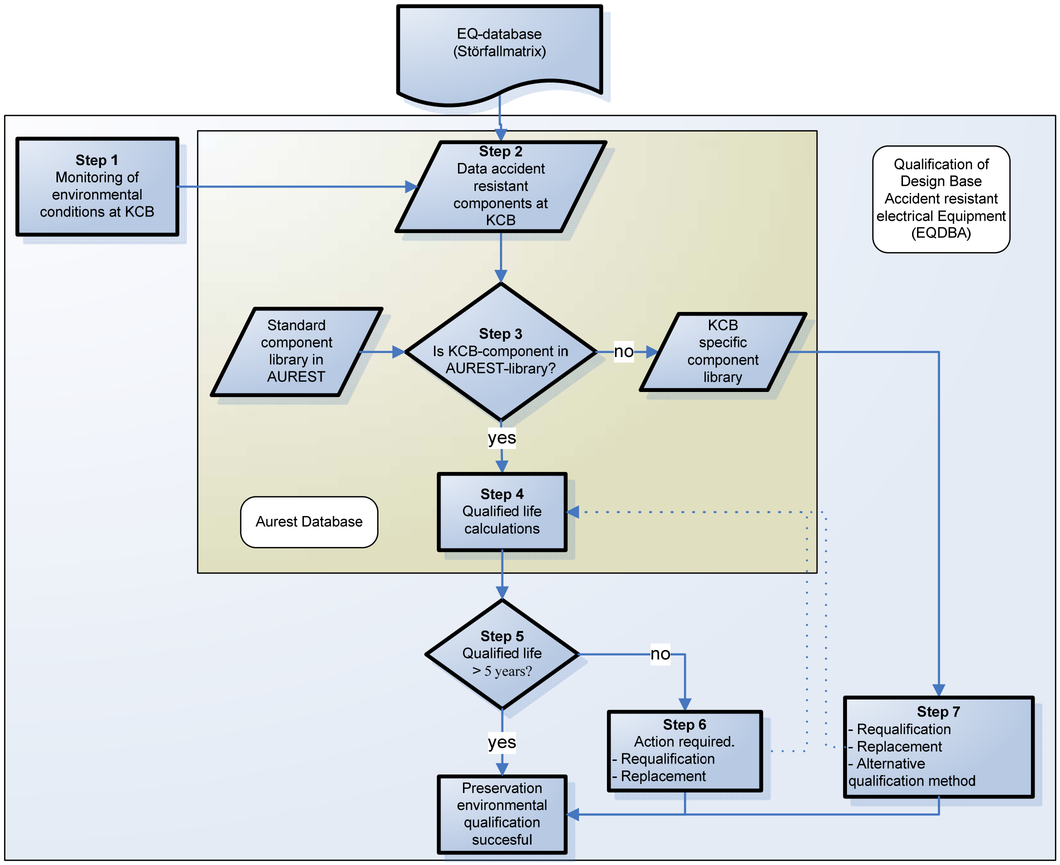

Figure 3: Overview of the activities in the EQDBA project

4 Integrating AUREST in the plant programs

After completion of LTOB subproject EQDBA the AUREST tool and the relevant procedures will be integrated in the existing plant programs on EQ. This will ensure the preservation of the qualified life of components with harsh environment requirements during the operating life of KCB. Inspection of electrical components with harsh environment requirements by KFD is part of the regular inspection program. The results of the qualified life calculations in AUREST can be part of this inspection program.

5 Results of the EQDBA project

The AUREST-DB contains 364 functional component chains, with a varying number of subcomponents. Within the AUREST-DB assessments were performed as described below. In this chapter the results of the assessments [15] are summarized.

First an assessment was made to investigate if the in-scope components have a covering component in the general component library (step 3 of figure 3). Components without a covering component in the general library are placed in the NPP Borssele specific component library. These components are described in section 5.1, as well as the actions performed to demonstrate the qualified life of the components (step 7 of figure 3).

In section 5.2 the results of the qualified life calculations as carried out in the AUREST-DB, step 4 of figure 2, are described. The activation energies of the thermal qualified life calculations for each component are based on report [20]. This report is written by Areva in order of the VGB and contains the activation energies used in the AUREST database. The acceptation process regarding the activation energy for each component by the German regulator is in progress and is expected to be finished before the end of Q3-2012. If activation energies will be changed due to the regulation process the qualified life calculations will be repeated taking the new values into account.

An automated function of the AUREST-DB is a check of the qualification of the components vs. the qualification requirements. Two components are assessed to be insufficient qualified. These components and the prepared actions are described in section 5.3.

5.1 Components in the NPP Borssele specific component library

In [15] the components in the NPP Borssele specific component library are listed up in two categories; components with and components without sufficient qualification data available to demonstrate the qualified life. For components in the first category qualified life calculations are performed in the AUREST database. For the last category of components sufficient qualification data will be gathered or components will be replaced.

5.1.1 Components with sufficient qualification data to demonstrate the qualified life.

The table below summarizes the analysis in report [15] regarding components in the NPP Borssele specific component library for which the qualified life can be demonstrated. In the column on the left the kind of component is described, as well as the manufacturer and component type. In the right column information about the qualification documents is given, as well as the justification for the demonstration of qualified life.

Rosemount pressure transmitters series 1153 series 1154	In NPP Borssele 31 state of the art pressure transmitters, series 1153 and 1154, of manufacturer Rosemount are in use. Qualification data is available in TÜV test reports FRW116596Q and FRW116696Q. The transmitters are qualified in conformity with IEEE standards 323 en 344. The product data sheets of the transmitters contain information about the thermal qualified life and qualified radiological dose. While the values of the activation energy in the above mentioned documents can not be verified by Areva, the method described in [16] is used to state the thermal qualified life. This method regarding electronics is the regular manner which is used for similar components in the general component library. Based on this method and regarding the environmental conditions at the plant locations the thermal qualified lifetime is determined to 40 years. The operational life of the transmitters is calculated with the AUREST-DB. If the operational life of a transmitter reach 40 years before 2034, than the transmitter will be timely replaced. The total radiological qualified dose is 550 kGy and the residual radiological qualified life is calculated with the AUREST-DB. The sealings (O-rings) of the electronics covers are replaced periodically, at least every 4 years on occasion of the periodical calibration of the transmitters. This guarantees the pressure tightness of the electronics compartments.
Souriau junction box 8NA 02B 008A and connectors 8 NA 66G 1212SN 03A 30CA; 8NA 66G 1212SN 04B 200A	The primary pressure relieve valves of manufacturer Sebim are equipped with valve position sensors. The Souriau junction box type 8NA 02B 008A, with build-in connector, and connectors 8 NA 66G 1212SN 03A 30CA and 8NA 66G 1212Sn 04B 200A are part of the position measurement electrical circuit. Manufacturer documentation is available, the equipment is class 1E-LOCA qualified. The radiological qualification dose is 850 kGy and the residual radiological qualified life is calculated with the AUREST-DB. As qualification temperature a conservative value of 70°C is chosen, which is the maximum temperature for the given radiological dose. While exact data of the pre-ageing program is not given in the manufacturer documentation, the qualified thermal life is limited to 40 years. This will be sufficient conservative regarding the

	environmental condition of 46 °C and the given environmental performance of -40 to +85 °C. The operational life is calculated with the AUREST-DB. If the operational life reach 40 years before 2034, than the components will be timely replaced.
Baily/Sebim valve position sensor BUD	The primary pressure relieve valves of manufacturer Sebim are equipped with valve position sensors. A qualification document of the BUD sensor is available, RSQ 316.00. The sensor is class 1E-LOCA qualified. Thermal qualification data: 120 °C/ 1920 h; activation energy 0,85 eV. Radiological pre-ageing: 145 kGy / 1 kGy/h. The thermal and radiological residual lifetime are calculated with the AUREST-DB.
Hartmann & Braun pressure transmitter AED280	In NPP Borssele 2 transmitters of H&B type AED280 are in use, which are installed in the annulus area and have an LRi accident requirement. A manufacturer product sheet is available. The transmitter has a type test according to IEEE323 and KTA3505. The radiological pre-ageing data (1000 Gy; 5 Gy/h) is taken form the product sheet. The residual radiological qualified life is calculated with the AUREST-DB. Although exact data of the thermal pre-ageing program is not stated clearly in the datasheet a long term temperature of 70 °C is stated. This value is given as maximum of the allowed ambient temperature range as well as the allowed process temperature range. Taken into account the environmental temperature (23 °C) of the transmitters the qualified thermal life is determined to 40 years. The operational life is calculated with the AUREST-DB. If the operational life reach 40 years before 2034, than the components will be timely replaced.
Veam/Litton connectors CIR00WN05-18-10ST10-22-G1; CIR00WN05-18-19ST10-12-G; CIR065WN05-18-10PT10-22; CIR065WN05-18-19PT10-12.	For the in NPP Borssele used Veam/Litton connectors a qualification document of the manufacturer is available. The connectors are LOCA, HELB and seismic qualified in conformity with IEEE323, IEEE344 and IEEE383. The connectors are thermally pre aged with 160 °C / 360 h. The activation energy of 0,89 eV is based on reference [16]. Radiological the connectors are pre aged with 70 kGy / 5,8 kGy/h. The thermal and radiological residual lifetime are calculated with the AUREST-DB.

Degussa connector ET-NW-653	Several temperature and level transmitters are equipped with Degussa connector type ET-NW-653. The qualification and pre ageing data (67,5 °C / 2000 h; 0,89 eV ; 620 Gy/h / 46,2 kGy) is based on the qualification of Degussa temperature sensors with the same connector type in the general component library (Prüfspezifikation TT-403/TT-406). The thermal and radiological residual lifetime are calculated with the AUREST-DB
ASCO/Joumatic solenoid MB301 ADR	A qualification document of the MB301 ADR is available, in which the type test is described. The solenoids are class 1E LOCA qualified. Pre ageing and qualification data: 100 °C / 2730 h; 0,81 eV; 210,28 kGy / 5 kGy/h. The thermal and radiological residual lifetime are calculated with the AUREST-DB.
AUMA actuators serie SAI serie SAN	For the AUMA actuators qualification report TB-N 83/225 of the manufacturer is available. The actuators are class 1E-LOCA and seismic qualified in accordance to standards IEEE323 and -382. Data of the pre-ageing program: 130 °C / 744 h; 500 Gy/h / 750 kGy. The activation energy (0,89 eV) is based on reference [16]. The thermal and radiological residual lifetime are calculated with the AUREST-DB.
Draka cables YMvK	For cables of type YMvK of manufacturer Draka, applied in the annulus area of the reactor building, sufficient qualification data was gathered by the execution of a requalification program in conformity with standard KTA3706. One cable in the plant was replaced to serve as a specimen for the requalification program. The program and the results are described in references [17, 18]. The gathered qualification data ensures the qualified life demonstration for the period of LTO. Thermal qualification data: 75 °C / 1494 h; 1,12 eV. Radiological qualification data; 11,6 kGy / 44,6 Gy/h. The thermal and radiological residual lifetime are calculated with the AUREST-DB.

5.1.2 Components without sufficient qualification data to demonstrate the qualified life with the AUREST calculation tool.

It is important to realize that all components used for harsh environment (accident) conditions are initially type tested to demonstrate the capability for the accident requirements. Generally the type test is performed to demonstrate the qualification for the NPPs initial operational life, i.e. 40 years. Nevertheless for the components described in this chapter the plant has no sufficient documentation available that describes the qualification program in a comprehensive way. That makes it difficult or even impossible to demonstrate a formal qualified life.
The table below summarizes the analysis [15] regarding concerned components. The deficiency in formal qualification data is described, as well as the measures taken to solve this deficiency.

ABB pressure transmitter 265GSV….	Pressure measurement YA002P001 is equipped with an ABB 265GSV transmitter. The transmitter is placed in the annulus of the reactor building. YA002P061 is a backup measurement for YA001P051, YA001P061 and YA002P051, which forms a 2-out-of-3 reactor protection signal. In 2011 it was decided to state the LRi-I requirement for the YA002P061 [21], before that time this measurement has no accident requirement. Now the requirement is in line with YA001P051, YA001P061 and YA002P051. Although the environmental accident conditions in the annulus are relatively mild, the ABB 265GSV transmitter does not formally fulfill these conditions. The transmitter will be replaced by a qualified type in the outage of 2013.
Siemens sensor FSK88	The sensor is qualified in conformity with KTA 3505 as stated in TÜV document KSY 70/PB 108/88. Specific qualification data is not noted in this document and is not available either. Regarding the thermal qualified life the method described in [16] is used. This method regarding electronics is the regular manner which is used for similar components in the general component library. Based on this method and regarding the environmental conditions at the plant locations the thermal qualified lifetime is determined to be 40 years. The operational life is calculated with the AUREST-DB. If the operational life reach 40 years before 2034, than the components will be timely replaced. The radiological qualification for LOCA and post LOCA is not clearly fixed in the qualification document. In the VGB working group on component qualification a solution for this obscurity is in progress. If this action is not successful the sensor will be replaced.
Schoppe & Faeser connector 42/15-900Z	The S&F 42/15-900Z is used for the cable connection of pressure transmitters (14 pieces). The connectors are LOCA qualified in combination with the original S&F transmitters and installed in 1988. Sufficient qualification data to calculate a residual qualified life are not available. While a requalification program for this small amount of connectors is not feasible, the connectors will be replaced during the

	outages of 2013, 2014 and 2015 [19] for a qualified type, e.g. Degussa/Sensycon ET-NW653. The maximum operational lifetime will be 27 years. The environmental conditions at the locations in the plant are mild, a temperature of 24 °C, and no radiological load [11]. By that only very slight ageing degradation effects will be present. Although not strictly demonstrated with a residual qualified life calculation, there is no reason to doubt about the momentary functionality. A maximum operational life of 27 years is in view of the qualification and the environmental conditions acceptable.
Rosemount adapter ½" NPT M22x1,5	To connect the cables with an S&F 42/15-900Z or a Degussa ET-NW-653 connector to the Rosemount pressure transmitters an adapter is used. Although the metallic material of the connectors is insufficient for ageing degradation, there is a lack of availability of qualification data of the sealing material. EPZ has decided to replace the adaptors and connectors during the outages of 2013, 2014 and 2015 [19] for a qualified type.
Hartmann & Braun pressure transmitter serie AVD serie AVK	17 pressure transmitters of the AVD and AVK series are used in the annulus of the reactor building and have a requirement for annulus accident conditions. Clear documentation regarding the qualified life for accident conditions in the annulus is not available. These transmitter types are subject in the program of the VGB working group "BBNKMV", with the aim to gather information to demonstrate the qualified life. EPZ has decided to replace the transmitters during the outages of 2013, 2014 and 2015 [19] for a qualified type, e.g. Rosemount. Besides the qualified life this decision is also based on the maintenance program (operational reason).
Hermetic pump CKPX80V-2H	Two nuclear fuel storage pool cooling pumps, located in the annulus of the reactor building, are required to be functional during a DBA in the annulus. An analytical qualification to demonstrate the qualified life, based on the available documentation, is in progress by Areva. It is expected that this analytical qualification will be successful and will be finished in Q3 of 2012. In case the analytical qualification is not successful the pumps will be replaced for a qualified type. An eventually replacement of the pumps is prepared in reference [19].
Hermetic pump CKPKX85Z including winding temperature sensors	Two pumps of the back-up residual heat removal system, located in the annulus of the reactor building, are required to be functional during flooding or a DBA in the annulus. The pumps are equipped with LOCA resistance cable penetrations, Schott for the power cables and Barlian for the instrumentation (winding temperature measurement) cables. An analytical qualification to demonstrate the qualified life, based on the available documentation, is in progress by Areva. It is expected that this analytical qualification will be successful and will be finished in Q3 of 2012.

	In case the analytical qualification is not successful the pumps will be replaced for a qualified type. An eventually replacement of the pumps is prepared in reference [19].
Fischers connectors DE/SE 107-A042-20 KE/DES 107-A042-20	This type of connectors is used in the circuits of the incore temperature instrumentation. An analytical qualification to gather data for qualified life calculations is performed by Areva and was successful. The report of this analytical qualification is expected in Q3 of 2012.
BBC junction box EJB 35 R	There are no qualification data available for this type of metal junction boxes. Due to the material there is no ageing degradation effect which limits the operational life of this equipment. Important is that the junction boxes are equipped with a pressure regulation valve which prevent for a pressure difference in- and outside the box in case of a LOCA. Every junction box is equipped with such a pressure regulation valve.
Rose junction box 01.233318	There are no qualification data available for this type of metal junction boxes. Due to the material there is no ageing degradation effect which limits the operational life of this equipment. Important is that the junction boxes are equipped with a pressure regulation valve which prevent for a pressure difference in- and outside the box in case of a LOCA. Every junction box is equipped with such a pressure regulation valve.
Rose junction box 01.316018	There are no qualification data available for this type of metal junction boxes. Due to the material there is no ageing degradation effect which limits the operational life of this equipment. Important is that the junction boxes are equipped with a pressure regulation valve which prevent for a pressure difference in- and outside the box in case of a LOCA. Every junction box is equipped with such a pressure regulation valve.
Eaton-Holec junction box K463 GS	The polymer K463 GS junction boxes, applied in the annulus of the reactor building, will be equipped with a pressure regulation valve in the outage of 2013 [19], ensuring that there will be no pressure difference in- and outside the box during a DBA in the annulus. A product sheet is available; the maximum allowable environmental temperature (105 °C) exceeds the DBA temperature. The box has no significant ageing degradation effects regarding to its function or which limits the operational life.
Hazemeyer junction box K463 UP	The polymer K463 UP junction boxes, applied in the annulus of the reactor building, will be equipped with a pressure regulation valve in the outage of 2013 [19], ensuring that there will be no pressure difference in- and outside the box during a DBA in the annulus. A product sheet is available; the maximum allowable environmental temperature (105 °C) exceeds the DBA temperature. The box has no significant ageing degradation effects regarding to its function or which limits the operational life.

Twenkatherm thermocouple cable KX PV/Vmb-2AF	This single thermocouple cable, applied in the annulus of the reactor building, is part of the electrical circuit of the RPVH temperature measurements. There is no qualification data with regard to the required DBA in the annulus available. The cable will be replaced during the outage of 2014 for a qualified type [19].
Cable of unknown manufacturer	Of the power cable of pump TG020D001 the manufacturer is unknown, due to incomplete registration of component data. The cable is installed in the annulus of the reactor building and has a DBA requirement for the annulus. To be sure about the qualification status the cable will be replaced during the outage of 2013.
Siemens terminal 8WA2150 Löt/Löt	This type of cable terminal is only used in the annulus of the reactor building and has a DBA requirement for the annulus. While no qualification documents are available the terminals will be replaced for a qualified type during the outages of 2013 and 2014 [19].
Amphenol terminal Air LB	This type of terminal is used in the valve position electrical circuits of the primary pressure relieve valves (Sebim). Although a datasheet (EDF SEPTEN) confirms that the terminal is qualified for LOCA- and post LOCA requirements, the reference document of the type test (EDF/DER NO HM 63-7195/5) is not available. By that the relevant qualification data of the type test to calculate the qualified life is not available. The terminals will be replaced during the outage of 2014 for a qualified type [19].
SEBIM cable EPR-SH ...	This type of cable is used in the valve position electrical circuits of the primary pressure relieve valves. Although the valve position measurement equipment is qualified as a component chain, the qualification data of the EPR-SH cable are not available. Even if ethylene propylene rubber is a commonly used material for LOCA qualified cables, the cables will be replaced during the outage of 2014 for a qualified type.
Phoenix terminal MK-TP/TP	This type of terminal is only used in the annulus of the reactor building and has a requirement to be functional during a DBA in the annulus. While no sufficient qualification documents are available the terminals will be replaced in the outages of 2013 till 2015 [19] for a qualified type.
Phoenix terminal UK16	This type of terminal is used in two electrical circuits. While no qualification documents are available the connectors will be replaced in the outages of 2013 and 2014 [19] for a qualified type.

Phoenix terminal UK4-FSR	This type of terminal is used in the annulus of the reactor building and has a requirement to be functional during a DBA in the annulus. While no sufficient qualification documents are available the terminals will be replaced in the outages of 2013 and 2014 [19] for a qualified type.
Phoenix terminal UK4-FSR/UK10-N	This type of terminal is used in the annulus of the reactor building and has a requirement to be functional during a DBA in the annulus. While no sufficient qualification documents are available the terminals will be replaced in the outages of 2013 and 2014 [19] for a qualified type.
Phoenix terminal UK4-TP/TP	This type of terminal is only used in the annulus of the reactor building and has a requirement to be functional during a DBA in the annulus. While no sufficient qualification documents are available the terminals will be replaced in the outages of 2013 till 2015 [19] for a qualified type.
“Unkwown” terminals	In 11 electrical circuits terminals are used of which the manufacturer is unknown, due to incomplete registration of component data. These terminals will be replaced in the outage of 2013 [19] for a qualified type.
DRAKA cable VMvK-G ...	5 pieces of this type of cable are used in the annulus of the reactor building and have a requirement to be functional during a DBA in the annulus. This type of cable is initially not qualified for a DBA in the annulus. Allthough it is expected that the cables withstand the relatively mild accident conditions in the annulus, a requalification program for this amount of cables is not feasable. Therefore the cables will be replaced in the outages of 2013 and 2014 [19] by a qualified type.
Screw fitting Rosemount transmitter	At two pressure transmitters used in the annulus of the reactor building, having a DBA requirement for the annulus, there is no qualification data available of the cable screw fitting. To be sure the connection compartment of the transmitter is leak proof, the screw fittings will be replaced by a qualified type during the outage of 2013 [19].

5.2 Results of qualified life calculations

With use of the AUREST-DB residual qualified life calculations for each relevant component are performed for the entire period of LTO, i.e. until 2034. A more practical threshold value for the residual qualified life of the components is provided to be 5 years. This period is sufficient to take actions according to step 6 of figure 3.

In the table below the components of which the qualified thermal or radiological residual life ≤ 5 years are described, as well as the foreseen actions.

Philips temperature sensor 2 AB I 15	This type of temperature sensors is used as incore temperature measurement. Relevant for ageing degradation is the outcore part of the circuit on which a Fischer connector is mounted. The thermal residual qualified life is < 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature of 47 °C the formal thermal qualified life is limited. There are three activities in progress to gather information to extend the qualified life: 1. In order of the VGB working group “BBNKMV” a new type of cable for the incore temperature measurement circuits is qualified, which includes the Fischer connector. Qualification data of this qualification program can be used for the existing equipment. The results of the qualification program are expected for the end of 2012 2. In the VGB program a test of artificial aged equipment in NPP Isar is in progress. Data of the results of this program may be used for the existing equipment. 3. Areva performs an analytical requalification program using data of qualification programs for ECI and RPVL measurements for OL3. The momentary results of this program are positive, the definitive results will be reported before the end of 2012. Parallel to the qualification programs the replacement of the sensors, including the connectors, for qualified types will be prepared [19].
Degussa (Sensycon) ABB temperature sensor 53-1563	From 5 of this type of temperature sensors the thermal residual qualified life is shorter than 5 years. This sensor is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature of 38 °C the formal thermal qualified life is limited. From 3 of this type of temperature sensors the radiological residual qualified life is shorter as 5 years. In the radiological pre-aging program the equipment was loaded with

	46,2 kGy; 620 Gy/h. With an environmental radiological dose of 0,6 Gy/h the formal radiological qualified life is limited. In order of the VGB a requalification program is in progress to extend the qualified life of the sensors. The results of this program are expected before the end of 2012. Parallel to this requalification program the replacement of the connectors for qualified types will be prepared [19]. If the requalification does not deliver sufficient data the sensors will be replaced.
Degussa (Sensycon) ABB temperature sensor 53-1564	From 2 of this type of temperature sensors the thermal qualified life is shorter than 5 years. This sensor is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature of 25 °C the formal thermal qualified life is limited. In order of the VGB a requalification program is in progress to extend the qualified life of the sensors. The results are expected before the end of 2012. Parallel to this requalification program the replacement of the connectors for qualified types will be prepared [19]. If the requalification does not deliver sufficient data the sensors will be replaced.
Degussa (Sensycon) ABB temperature sensor 53-1584	From 12 of this type of temperature sensors the thermal residual qualified life is shorter than 5 years. This sensor is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature of 38 °C the formal thermal qualified life is limited. From 9 of this type of temperature sensors the radiological residual qualified life is shorter than 5 years. In the radiological pre-aging program the equipment was loaded with 46,2 kGy; 620 Gy/h. With an environmental radiological dose between 0,35 and 0,6 Gy/h the formal radiological qualified life is limited. In order of the VGB a requalification program is in progress to extend the qualified life of the sensors. The results are expected before the end of 2012. Parallel to this requalification program the replacement of the connectors for qualified types will be prepared [19]. If the requalification does not deliver sufficient data the sensors will be replaced.

Fischer connector DE / SE 107A042 - 11 /-10	This type of connector is used in the electrical circuits of the incore RPVL and the RPVH temperature measurement. The thermal residual qualified life is < 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 1.14 eV. With an environmental temperature between 36 and 72 °C the formal thermal qualified life is limited. There are three activities in progress to gather information to extend the qualified life: 1. In order of the VGB a new type of cable for the incore temperature measurement circuits is qualified, which includes the Fischer connector. Qualification data of this qualification program can be used for the existing equipment. The results of the qualification program are expected for the end of 2012 2. In the VGB program a test of artificial aged equipment in NPP Isar is in progress. Data of the results of this program may be used for an analytical requalification of the existing equipment. 3. Areva performs an analytical requalification program using data of qualification programs for ECI and RPVL measurements for OL3. The definitive results will be reported before the end of 2012. Parallel to these qualification programs the replacement of the connectors, as part of the measurement circuits, for qualified types will be prepared [19].
Fischer connector KE / DSE 107A042 -10	This type of connector is used in the electrical circuits of the RPVH temperature measurement. The thermal residual qualified life is < 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 1.14 eV. With an environmental temperature between 48 °C the formal thermal qualified life is limited. There are three activities in progress to gather information to extend the qualified life: 1. In order of the VGB a new type of cable for the incore temperature measurement circuits is qualified, which includes the Fischer connector. Qualification data of this qualification program can be used for the existing equipment. The results of the qualification program are expected for the end of 2012 2. In the VGB program a test of artificial aged equipment in NPP Isar is in progress. Data of the results of this program may be used for an analytical requalification of the existing equipment. 3. Areva performs an analytical requalification program using data of qualification programs for ECI and RPVL measurements for

	OL3. The definitive results will be reported before the end of 2012. Parallel to these qualification programs the replacement of the connectors, as part of the measurement circuits, for qualified types will be prepared [19].
Fischer connector KE / DSE 107A083 -10	This type of connector is used in the electrical circuits of the incore temperature measurement. The thermal residual qualified life is < 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 1.14 eV. With an environmental temperature between 48 °C the formal thermal qualified life is limited. There are three activities in progress to gather information to extend the qualified life: 1. In order of the VGB a new type of cable for the incore temperature measurement circuits is qualified, which includes the Fischer connector. Qualification data of this qualification program can be used for the existing equipment. The results of the qualification program are expected for the end of 2012 2. In the VGB program a test of artificial aged equipment in NPP Isar is in progress. Data of the results of this program may be used for an analytical requalification of the existing equipment. 3. Areva performs an analytical requalification program using data of qualification programs for ECI and RPVL measurements for OL3. The definitive results will be reported before the end of 2012. Parallel to these qualification programs the replacement of the connectors, as part of the measurement circuits, for qualified types will be prepared [19].
DEGUSSA connector ET-NW-653	From 34 of this type of connectors, used for temperature sensors and pressure transmitters, the thermal residual qualified life is shorter as 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature between 24 and 38 °C the formal thermal qualified life is limited. Of 16 of this type of connector the radiological residual qualified life is shorter as 5 years. In the radiological pre-aging program the equipment was loaded with 46,2 kGy; 620 Gy/h. With an environmental radiological dose between 0,5 and 0,6 Gy/h the formal radiological qualified life is limited.

	In order of the VGB working group "BBNKMV" a requalification program is in progress to extend the qualified life of the connectors. The results are expected before the end of 2012. Parallel to this requalification program the replacement of the connectors for qualified types will be prepared [19]. If the requalification does not deliver sufficient data the connectors will be replaced in the outages of 2013 till 2015..
Siemens cable JE-LiHCH … FRNCX / JE-H(St)H … FRNCX	The thermal residual qualified life of a cable of the RPVL measurement circuit is shorter than 5 years. The local hotspot temperature is 71,9 °C. The cable will be replaced during the outage of 2013 or 2014 [19].
Weidmüller terminal KMV-T hohe Form	The thermal residual qualified life of the terminals in one electrical circuit is shorter than 5 years, the environmental temperature is 46 °C . The terminals will be replaced in the outage of 2013 or 2014.[19].
Philips temperature sensor MT-08-1 CAV32	This type of sensor is used for the temperature measurement of the RPVH. The thermal residual qualified life is shorter as 5 years. The sensors will be replaced during the outage of 2014 [19].
Siemens temperature sensor R542-G-11-190120	This type of temperature sensor is used as level indicator inside the RPV. Relevant for ageing degradation is the outcore part of the circuit on which the Fischer connector is mounted. The thermal residual qualified life is < 5 years. The equipment is initially qualified in conformity with standard KTA3505. In the thermal pre-aging program the equipment was loaded with 67,5 °C for 2000 hours. The activation energy is 0,89 eV. With an environmental temperature between 50 and 72 °C the formal thermal qualified life is limited. There are three activities in progress to gather information to extend the qualified life: 1. In order of the VGB a new type of cable for the incore temperature measurement circuits is qualified, which includes the Fischer connector. Qualification data of this qualification program can be used for the existing equipment. The results of the qualification program are expected for the end of 2012 2. In the VGB program a test of artificial aged equipment in NPP Isar is in progress. Data of the results of this program may be used for the existing equipment. 3. Areva performs an analytical requalification program using data of qualification programs for ECI and RPVL measurements for OL3. The definitive results will be reported before the end of 2012. Parallel to these qualification programs the replacement of the sensors, including the connectors, for qualified types will be prepared [19].

HEW cable JE-Li2GC2G ..FRNCX(s) / JE-2G(St)2G …FRNCX(s)	From 12 cables, used for MCL temperature measurements, the radiological residual qualified life is shorter than 5 years. The environmental radiological dose is 0,6 Gy/h. The cables will be replaced during the outages of 2013, 2014 and 2015 [19].

5.3 Components which are insufficient qualified

As a result of the analysis with AUREST it was found that the DBA qualification of 2 components was not sufficient in light of their DBA requirement. The reason may be a fault in the component selection in the past or a change in the DBA requirement. The components and the foreseen measures are described in the table below.

Harting connector HAN xE Leittechnik	1 connector of type HAN 24E is applied for an actuator with PLL requirements, i.e. LOCA and post-LOCA. The connector is qualified for PLM, i.e. LOCA/24 hours. The connector will be replaced for a sufficient qualified type during the outage of 2013 [19].
cable JE-LiY(C)Y…	1 PVC insulated cable used in the electrical circuit of the level measurement of the fuel element pool is assessed as insufficient qualified. The requirement is PLL, i.e. LOCA and post-LOCA. The cable will be replaced for a sufficient qualified type during the outage of 2013 [19].

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[12] Areva NLTQ-G/2009/de/0164 rev. A “Beschreibung der Erhebung von KMV-störfallfestten Komponenten der E- und Leittechnik und deren Umsetzung auf das Format 2009a der AUREST-Datenbank des kernkraftwerk Borssele (KCB)“.

[13] Areva NLEC-G/2008/de/0084 rev. B “Spezifikation der AUREST-Gerätebibliothek”.

[14] Areva NGLE/2004/de/00025 rev. E “Spezifikation zur Erstellung der Funktionskettendatei”.

[15] Areva PTCQ-G/2012/de/0133 rev. A “Darstellung der mit der AUREST-DB erzielten Ergebnisse, Identifikation von Handlungsbedarf und Festlegung der weiteren Vorgehensweise“; 27-7-12.

[16] Areva NLTQ-G/2009/de/0065 Rev. C: „Anwendung von Aktivierungsenergien von Kunststoffen KMV-störfallfester Komponenten elektrotechnischer und leittechnischer Systeme in deutschen Kernkraftwerken –Teil 1: Thermische Alterung und Prozeduren“.

[17] Areva PLTQ-G/2011/de/0211 Rev. A " Erbringung des experimentellen Nachweises der KMV- Sttörfallfestigkeit LRi I von YmvK Kabeln des Herstellers DRAKA"; 02-11-2011.

[18] Areva PLTQ-G/2011/de/0218 Rev. B "Ergebnisbericht zum experimentellen Nachweis der KMV-Festigkeit Lri I von YmvK-Kabeln des Herstellers Draka", 20-2-2012.

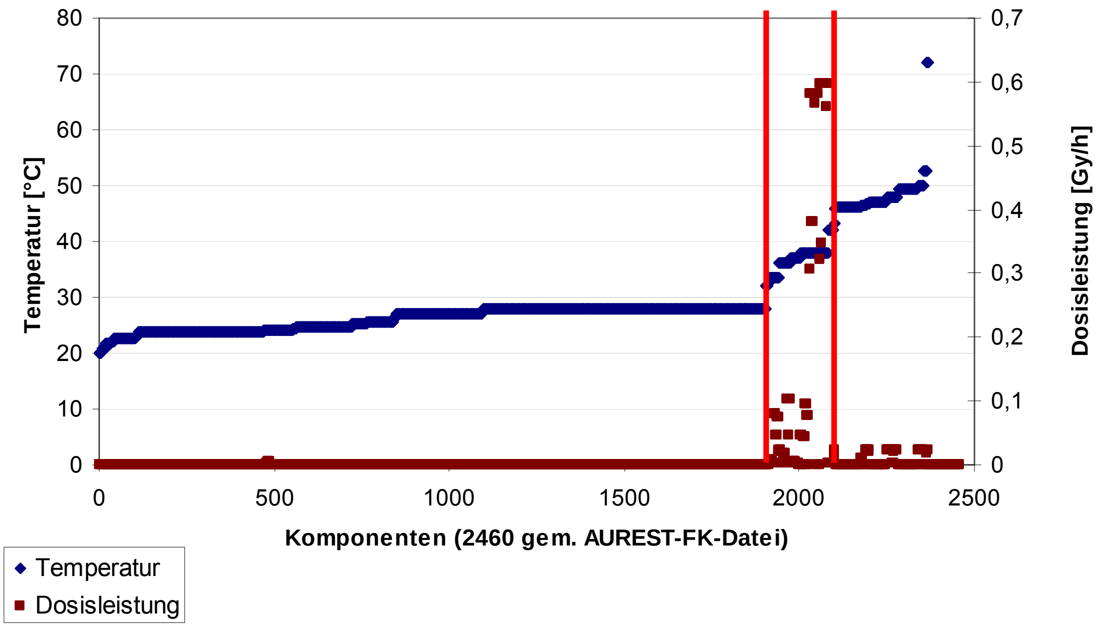
[19] EPZ KTC/MCr/FN/R116317 "Wijzigingsvoorstel Vervanging ongevalsbestendige E&I componenten", 17-04-2012.

[20] Areva NLTQ-G/2009/de/0068 „Anwendung von Aktivierungsenergien von Kunststoffen KMV-störfallfester Komponenten elektrotechnischer und leittechnischer Systeme in deutschen Kernkraftwerken – Teil 2: Werte der Aktivierungsenergien"

[21] EPZ KTE/SAL/SAL/I116165 "Wijziging ongevalsbestendigheidseis YA002P061"; 23 september 2011.

Attachment 1

Die folgende Grafik basiert auf die Funktionskettendatei der AUREST-Datenbank für KCB. Zu jeder Komponente sind die betriebliche Temperatur und die betriebliche Dosisleistung dargestellt, wobei nach aufsteigender Temperatur sortiert wurde.



Bewertung:

Es zeigt sich, dass in dem Bereich, in welchem die betriebliche Dosisleistung hohe bzw. höhere Werte annimmt, s. rote Bereichsgrenzen, die betriebliche Temperatur bei einem Maximum von 46 °C liegt, wobei der größte Teil der Komponenten in dem Bereich eine Temperatur von kleiner als 40 °C annehmen.

Weiterhin zeigt sich, dass im Bereich rechts neben der rechten Bereichsgrenze zu den höheren Temperaturen, hier bis 70 °C, nur Dosisleistungen bis zu einer Größe von 0,022 Gy/h vorliegen.

Fazit: Im Falle KCB ist zulässig, im Rahmen von Qualifizierungsprüfungen die thermische und radiologische Alterung sequentiell aufzubringen, da nachweislich unter reellen Einsatzbedingungen die relevanten Komponenten entweder einer hohen Temperatur oder einer hohen Dosisleistung ausgesetzt sind.