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1. Introduction

The National Nuclear Regulatory (NNR) Guide RG-0027, (6.2.4) (4) requires that the licensee should monitor and record specific parameters of concern, and other parameters that were identified as affecting ageing assumptions, used in safety analyses or equipment qualification. The recorded parameters should be used to demonstrate compliance to the critical service conditions, as well as operational limits and conditions, and any other parameters that were identified as affecting ageing assumptions used in safety analyses of equipment. Furthermore RG-0027, (6.3.3) (3b) (vi), requires that the actual environmental conditions monitoring should be implemented in order to get additional information necessary for the assessment of ageing effects on the equipment in its actual operating environment.

Qualified equipment and electrical cables are exposed to environmental conditions (i.e., increased service or ambient temperature, radiation, submergence, local vibration, electromagnetic interference, radio frequency interference, toxic chemical exposure, moisture/humidity, or a combination thereof), which must be monitored to ensure that the qualified equipment remains within the bounds of its qualification conditions. The environmental condition monitoring data is also critical in order to confirm the design assumptions used during the initial qualification and subsequent requalification or re-assessments to be applied during the re-analysis of qualified equipment.

This Environmental Condition Monitoring Programme (ECMP) provides the requirements for the monitoring, recording, and trending of environmental data during normal operation to support ageing management. This will ensure that environmental conditions that could adversely impact the qualification of the equipment, re-assessment of qualified life and accelerate ageing of electrical cables are identified, monitored, and trended.

2. Supporting Clauses

2.1 Scope

The Environmental Condition Monitoring Programme (ECMP) provides requirements for the monitoring of environmental conditions external to the equipment, such as temperature, radiation, and externally induced vibration from mounting points or earthquakes. Other adverse environmental conditions such as increased service or ambient temperature, radiation, submergence, local vibration, electromagnetic interference and compatibility, radio frequency interference, toxic chemical exposure, moisture/humidity, or a combination thereof, may be monitored on an ad hoc basis as required.

The in-scope equipment and associated electrical cables for the ECMP are listed in 240-165353024, - “List of Medium and Low Voltage Cables and Associated Environmental Zones”. This list comprises of a sample selected from the entire cable population installed in the plant.

2.1.1 Purpose

This document provides the requirements to effectively implement the environmental condition monitoring programme activities at Koeberg Nuclear Power Station (KNPS) for the assessment of the qualified equipment and ageing of important to safety electrical cables.

2.1.2 Applicability

This document applies to environmental condition monitoring activities at KNPS for ageing management and on-going qualification of important to safety equipment and electrical cables.

2.1.3 Effective date

This document is effective from the authorisation date.

2.2 Normative/Informative References

Groups and departments using this document shall apply the most recent edition of the documents listed in the following paragraphs:

2.2.1 Normative

[1] 240-138996505: CAMP LV Cables Master List.

[2] 240-139089079: Programme Oversight Committee (POC).

[3] 240-149139512: Ageing Management Requirements for Koeberg Nuclear Power Station.

[4] 240-165353024: List of Medium and Low Voltage Cables and Associated Environmental Zones.

[5] 240-98789276: Cable Ageing Management Programme Manual for Low Voltage Cables and Cable Systems.

[6] 240-98789629: Cable Ageing Management for Instrumentation and Control Cables and Cable Systems.

[7] 331-023: Processing of Industry Operating Experience in Nuclear Engineering.

[8] 331-148: Programme Engineer's Guide.

[9] 331-198: Roles and Responsibilities for Cable Ageing Management Programme at Koeberg Operating Unit.

[10] 331-219: Environmental Qualification Maintenance Manual for Equipment Located in Harsh Environments.

[11] 331-289: Ageing of Electrical Cables.

[12] 331-311: Cable Ageing Management Manual for Medium Voltage Power Cables and Cable Systems.

[13] IEC/IEEE 60780-323: Nuclear facilities – Electrical equipment important to safety – Qualification

[14] IEC 62003: Nuclear power plants – Instrumentation and control important to safety – Requirements for electromagnetic compatibility testing

[15] IEC 61000-4 (all parts), Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques

[16] IAEA Specific Safety Guide No. SSG-69: Equipment Qualification for Nuclear Installations.

[17] RG-0027: Ageing Management and Long-Term Operations of Nuclear Power Plants (Interim Regulatory Guide).

2.2.2 Informative

[18] 10 CFR 50 Appendix B: Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

[19] 10 CFR 50.73: U.S.NRC Event Reporting Overview.

[20] 240-155832775: Equipment Qualification Master List (EQML).

[21] 240-89294359: Nuclear Safety, Seismic, Environmental Quality and Importance Classification.

[22] 331-127: Standard for Cable Ageing Management Programme at Koeberg Operating Unit.

[23] 331-146: Process for the Technological Document Obsolescence Management Programme (TOMP).

[24] 331-186: Equipment Qualification Programme.

[25] 331-417: Visual and Tactile Inspections for Medium Voltage, Low Voltage, and Instrument and Control Cables.

[26] EPRI EL-3501: Analysis of Field Data on HMWPE and XLPE Insulated High Voltage Distribution Cable.

[27] EPRI EL-5387: Accelerated Ageing of Extruded Dielectric XLPE-insulated Power Cables.

[28] EPRI NP-2129: Radiation Effects on Organic Materials in Nuclear Plants

[29] IAEA Specific Guide SSG No. 48: Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants.

[30] EPRI TR-100844: NPP Common Ageing Terminology.

[31] EPRI TR-102323: Guidelines for Electromagnetic Interference Testing in Power Plants.

[32] EPRI TR-107527: Ozone Electrical Components Integrated Plant Assessment and Time Limiting Ageing Analysis for Licence Renewal.

[33] EPRI Report TR-109619: Guideline for the Management of Adverse Localised Equipment Environments.

[34] IAEA Specific Guide SSG No. 82: Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL).

[35] IAEA-TECDOC-1147: Management of Ageing of I&C Equipment in Nuclear Power Plants.

[36] IEEE Standard 323: Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

[37] EPRI 1021067: Plant Support Engineering: Nuclear Power Plant Equipment Qualification Reference Manual.

[38] EPRI 1003663: Integrated Cable System Ageing Management Guidance Low-Voltage Cable.

[39] EPRI 1007933: Ageing Assessment Field Guide.

[40] EPRI 1011223: Ageing Identification and Assessment Checklist.

[41] EPRI 1016689: Medium Voltage Cable Ageing Management Guide.

[42] EPRI EL-5036: Power Plant Electrical Reference Series, Vol. 4: Wire and Cable.

[43] EPRI NMAC NP-7485: Power Plant Practices to Ensure Cable Operability.

[44] EPRI NP-5002: LWR Plant Life Extension.

[45] EPRI TR-103834-P1-2: Effects of Moisture on the Life of Power Plant Cables.

[46] EPRI TR-103841: Low-Voltage Environmentally Qualified Cable License Renewal Industry Report.

[47] IAEA-No.NP-T-3.6: Assessing and Managing Cable Ageing in Nuclear Power Plants.

[48] IAEA-TECDOC-1188: Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety in Containment Instrumentation and Control Cables Volume I.

[49] INPO AP-319: Equipment Reliability Process Description.

[50] KNPS Pericles Control and Instrument Cable Data Base.

[51] KNPS Pericles Power Cable Data Base.

[52] NEA/CSNI/R (2018) 8: Cable Ageing in Nuclear Power Plants.

[53] NRC NUREG/CR-7153, Vol. 5: Ageing of Cables and Cable Systems.

[54] NUREG/CR-3122: Potentially Damaging Failure Modes of High- and Medium Voltage Electrical Equipment.

[55] NUREG/CR-5461. SAND89-2369: Ageing of Cables Connections and Electrical Penetration Assemblies Used in Nuclear Power Plants.

[56] KAA-688: Corrective Action Process.

[57] KAA-826: Plant Health Committee Constitution.

[58] KAA-913: Integrated Equipment Reliability Process.

[59] KAD-025: Processing of Operating Experience.

[60] KGA-035: Processing of Experience Feedback Received through the EDF Co-Operation Agreement.

[61] KBA 122 E02 2008: Qualification of Safety Related Electrical Equipment (Class 1E) General Seismic Test Specification.

[62] KGU-033: Failure Investigation of Plant Equipment and Evaluation of Experience.

[63] KGU-035: Integrated Equipment Reliability Process: Scoping and Classification of Components.

[64] NUREG/CR-5941: Technical Basis for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related I&C Systems.

[65] NUREG/CR-6431: Recommended Electromagnetic Operating Envelopes for Safety-Related I&C Systems in Nuclear Power Plants.

[66] NUREG/CR-6436: Survey of Ambient Electromagnetic and Radio- Frequency Interference Levels in Nuclear Power Plants.

[67] SANS 10142-1: Part 1: Low Voltage Installations.

[68] SANS 10142-2: Part 2: Medium Voltage Installations.

[69] SAR: Safety Analysis Report.

[70] SAND96-0344: Ageing Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations.

[71] STUK Guide YVL A.8: Ageing Management of a Nuclear Facility.

[72] L1124-DE-RPT-025: Ageing Couple Definitions for Electrical and I&C Components.

[73] L1124-EL-LIS-001: List of in-scope items for SALTO EQ TLAA.

[74] L1124-EL-LIS-003: SALTO Cable List.

[75] L1124-EL-LIS-004: EQ Cable List.

[76] L1124-GN-LIS-016: SALTO Room Master and Environmental Zone List.

[77] L1124-GN-LIS-029: Equipment Zone List.

[78] L1124-GN-LIS-020: Comprehensive List of all SSCs Reviewed for SALTO Scoping Requirements.

[79] L1124-GN-RPT-025: AME Degradation Assessment Results (IGALL, AMM, EPRI tools, (COMPSY) Electrical.

[80] L1124-GN-RPT-040: SALTO Room Master and Environmental Zones Report.

2.3 Definitions

2.3.1. **1E:** The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal or that are otherwise essential in preventing significant release of radioactive material to the environment.

2.3.2. **Ageing**: General process in which characteristics of a Structure, System or Component (SSC) gradually change with time or use.

2.3.3. **Ageing Effect**: Ageing effect is the result of various ageing mechanisms. It is a net change in a component's characteristics (due to specific processes that gradually change the characteristics of a component with time or use) that could cause the component to lose its intended function prior to the end of its expected operational period.

2.3.4. **Ageing Management**: Ageing management is the process whereby analyses, tests and assessments are performed to determine whether the environments and service conditions can cause and/or have caused ageing of switchboards and their subcomponents.

2.3.5. **Ageing Management Programme**: A set of plant activities relating to understanding, prevention, detection, monitoring and mitigation of a specific ageing effect on a structure, component, or group of components. Plant activities include maintenance, in-service inspection, testing and surveillance, as well as operational conditions and technical support programmes.

2.3.6. **Ageing Mechanism**: A specific process that gradually changes (typically deteriorates) the characteristics of a system, structure, or component with time or use. For example: thermal degradation of an organic insulation material is a chemical process that adversely affects the insulation resistance properties of a cable due to a reduction in its dielectric strength.

2.3.7. **Condition:** Surrounding physical state or influence that can affect an SSC.

2.3.8. **Condition Monitoring:** Observation, measurement or trending of conditions or functional indicators with respect to some independent parameter (usually time or cycles) to determine and predict the current and future ability of an SSC to function within acceptance criteria.

2.3.9. **Critical (ER Classification Category):** Critical components are those that can affect nuclear safety, plant reliability or power generation and therefore every effort must be made to maximise the reliability of these components. These components will have the most aggressive PM Strategies.

2.3.10. **Degradation:** Immediate or gradual deterioration of characteristics of an SSC which could impair its ability to function within acceptance criteria.

2.3.11. **Economic (ER Classification Category):** Economic components are those that will be considered for cost effective preventive maintenance, in order to preserve their integrity and extend their useful life. A cost-effective effort should be made to maximise the reliability of these components.

2.3.12. **Environmental Conditions**: Ambient physical states surrounding an SSC (e.g., temperature, radiation, humidity).

2.3.13. **Failure:** Inability or interruption of ability of an SSC to function within acceptance criteria.

2.3.14. **Failure Mode:** The manner in which an SSC fails.

2.3.15. **Localised Adverse Environments:** A condition in a limited plant area that is significantly more severe than normal conditions. This condition would tend to increase the rate of ageing of a component or have an early adverse effect on its intended function.

2.3.16. **Maintenance:** Dealing with potential or actual SSC failures requires refurbishment or repair of ageing induced degradation and other types of degradation. Terms that describe all means for preventing and correcting SSC failures fall in this category.

2.3.17. **Operating Conditions:** Service conditions, including normal and error-induced conditions, prior to the start of a postulated design basis accident or earthquake.

2.3.18. Overhaul: Extensive repair, refurbishment, or both.

2.3.19. Preventative Maintenance: Actions that detect, preclude, or mitigate degradation of a functional SSC to sustain or extend its useful life by controlling degradation and failures to an acceptable level.

2.3.20. Refurbishment: Actions to return a failed SSC to an acceptable condition.

2.3.21. Service Conditions: All actual physical states or influences (environmental, functional, and operating conditions) that affect an item during its service life.

2.3.22. Significant (ER Classification Category): Significant components are those that can affect personnel, industrial, environmental, or radiological safety, plant reliability, power generation or may lead to regulatory or insurance consequences. Substantial effort must be made to maximise the reliability of these components.

2.3.23. Surveillance: Observation or measurement of condition or functional indicators to verify that and SSC currently can function within acceptance criteria.

2.3.24. Testing: Observation or measurement of condition indicators under controlled conditions, to verify that an SSC currently conforms to acceptance criteria.

2.4 Abbreviations

Abbreviation	Explanation
AC	Alternating Current
AMG	Ageing Management Guide
AMP	Ageing Management Programme
AMR	Ageing Management Review
AR	Availability Related
ARE	Feedwater Flow Control System
ASG	Auxiliary Feedwater System
°C	Degrees Celsius
CAMP	Cable Ageing Management Program
CANDO	Canada Deuterium Uranium Group
CAS	Security Building
CLB	Current Licensing Basis
CM	Condition Monitoring
COG	CANDO Owners Group
CRACK	Chemical Restrictions and Controls at Koeberg
CR	Condition Report
CRDM	Control Rod Drive Mechanism

Abbreviation	Explanation
CRF	Circulating Water System
CSR	Critical Safety Related
DBA	Design Base Accident
DBE	Design Basis Event
DC	Direct Current
DE	Design Engineering
DER	Design Extension Related
DSC	Differential Scanning Calorimeter
DSE	Elementary System Folder
DVC	Control Room Air Conditioning
DVE	Cable Floor Ventilation System
DVG	CRDM and ASG Ventilation System
DVH	Charging Pump Room Emergency Ventilation System
DVI	Component Cooling Room Ventilation System
DVK	Fuel Building Ventilation System
DVL	Electrical Building Main Ventilation System
DVN	NAB Ventilation System
DWL	Low Level Waste Ventilation System
DVW	Peripheral Rooms Ventilation System
DVY	N16 Detector ventilation system
E & S	Electrical and System Engineering
ECMP	Environmental Condition Monitoring Programme
ELM	Equipment Lifetime Monitor
EMC	Electromagnetic Compatibility
EMI	Electro Magnetic Interference
EMS	Electrical Maintenance Services
EPR	Ethylene Propylene Rubber
EPRI	Electric Power Research Institute
EQ	Equipment Qualification
ESE	Electrical Systems Engineering
EVC	Reactor Pit Ventilation System
EVR	Containment Continuous Ventilation System
EWR	Engineering Works Request
FB	Fuel Building
FDR	Frequency Domain Reflectometry
FROG	Framatome Reactor Owners Group
GCT	Turbine By-Pass System
Gray	Absorbed Radiation Dose
HELP	High Energy Line Break
HOBO	Honest Observer by Onset Data Logger
HMWPE	High Molecular Weight Polyethylene

Abbreviation	Explanation
HVAC	Heating, Ventilation, and Air Conditioning
Hx	Chlorination Plant
Hz	Hertz
IAEA	International Atomic Energy Agency
IER	INPO Event Report
IEEE	Institute of Electrical and Electronics Engineers
IGALL	International Generic Ageing Lessons Learned
IM	Indenter Modulus
IMS	Instrument Maintenance Services
INPO	Institute of Nuclear Power Operations
IQ	Installation Qualification
IR	Insulation Resistance
Jax	Auxiliary Transformer Building
KNPS	Koeberg Nuclear Power Station
KPI	Key Performance Indicator
kV	Kilovolt
Kx	Fuel Building
LCM	Life Cycle Management
LER	Licensee Event Report
LIRA	Line Resonance Analysis
LOCA	Loss of Coolant Accident
LOPP	Life of Plant Plan
LTO	Long Term Operation
LV	Low Voltage
LWR	Light Water Reactor
Lx	Electrical Building
MED	Maintenance Execution Department
MPFF	Maintenance Preventable Functional Failure
MRG	Materials Reliability Group
MSLP	Main Steam Line Break
MV	Medium Voltage
Mx	Turbine Hall
NAB	Nuclear Auxiliary Building
NEMA	National Electrical Manufacturers Association
NEC	Nuclear Energy Agency
NOU	Nuclear Operating Unit
NPAR	Nuclear Plant Ageing Research
NPP	Nuclear Power Plant
NPRDS	Nuclear Plant Reliability Data System
NRC	Nuclear Regulatory Commission

Abbreviation	Explanation
NSA	No Safety Association
NSF	Non-Safety Function
NSIC	Nuclear Safety Information Centre
NUREC	Nuclear Regulatory Report
OE	Operational Experience
OPS	Operating Department
PE	Programmes Engineering
PEEK	Polyether Ether Ketone
PHC	Plant Health Committee
PM	Planned Maintenance
POC	Programme Oversight Committee
PTR	Reactor Cavity and Spent Fuel Pit Cooling System
PVC	Polyvinyl Chloride
PZR	Pressuriser
R & D	Research and Development
RCV	Chemical and Volume Control System
RFI	Radio Frequency Interference
RGL	Full Length Rod Control System
RIS	Safety Injection System
RO	Reactor Outage
RP	Radiation Protection
RPN	Nuclear Instrumentation System
RRM	CRDM Cooling System
PWR	Pressurised Water Reactor
Rx	Containment Building
QL	Qualified Life
QLD	Qualified Lifetime
SALTO	Safety Aspects of Long-Term Operation
SAP	Systems Applications and Products Database
SAR	Safety Analysis Report
SCs	Systems and Components
SEC	Essential Service Water System
SEK	Monitoring and Discharge of Conventional Island Liquid Waste
SN	Level Switch
SOER	Significant Operating Experience Report
SPV	Single Point Vulnerability
SR	Safety Related
SSCs	Systems, Structures and Components
TRM	Technical Review Meeting
STUK	Finnish Radiation and Nuclear Safety Authority
US	Unit States

Abbreviation	Explanation
µSv/h	Amount of Radiation per Hour
V	Volts
VVP	Main Steam System
WANO	World Association of Nuclear Operators
XLPE	Cross Linked Polyethylene

2.5 Roles and Responsibilities

Although the responsibility for the development and implementation of the Environmental Condition Monitoring Programme (ECMP) reside with the Materials Reliability Group (MRG), other key structures and plant organisations are also responsible for certain aspects of the implementation of this programme.

2.5.1 Programmes Engineering Manager

The responsibilities of the Programmes Engineering Manager include the following:

- Specify high level objectives and responsibilities.
- Approve major ageing management actions.
- Assess the effectiveness of plant programmes.

2.5.2 Material Reliability Manager

The responsibilities of the Material Reliability Group Manager include the following:

- Ensure that programmes are established in accordance with appropriate regulatory, procedural and plant requirements.
- Ensure that Programme Engineers are identified, qualified, and formally appointed in writing for a specific programme or programmes.
- Ensure that Programme Engineers are properly trained in accordance with Programme Training and Authorisation Programme (EA-13-027).
- Ensure that programme health is effectively monitored and improved.
- Ensure that the programme activities are not deferred without necessary approvals, adequate technical justification, and consideration of necessary contingencies.
- Facilitate the review and implementation of actions associated with industry best practice, OE, WANO SOERs and INPO Event Reports (IERs) related to engineering programmes.
- Support Programme Engineers participation in industry organisations such as International Atomic Energy Agency (IAEA), Pressurised Water Reactor (PWR) owners' group, Framatome Reactor Owners Group (FROG), Electric Power Research Institute (EPRI) committees and users' groups.
- Provide effective communication on programmes to the senior management and oversight committees, as required.

2.5.3 Programme Engineer

The Programme Engineer:

- Has the primary responsibility of developing, implementing, managing, and providing oversight for the identified engineering programme(s) in accordance with applicable industry codes and standards, regulatory requirements, and OE.
- Is the primary advocate for the overall health of their assigned programmes and ensures issues are raised and understood by the appropriate level of management.
- Reviews operating experience, scientific or subject literature from industry, academia, laboratories, and professional research bodies, which have performed similar work or developed related programmes.
- Participates in meetings, industry working groups or conferences to plan co-operative activities and to devise concerted approaches to problems.
- Shares the responsibility of reporting equipment failures and lessons learnt from events or conditions that are important to nuclear, public and personnel safety and plant reliability.
- Reviews inputs provided by the various line groups (who provide a service to the Programme Engineer in the form of written recommendations, reports, test data and research data) for their validity.
- Interact with the regulatory authorities on programme related issues.
- Performed programme related activities as stipulated in this guide.
- Review changes to the EDF, WANO, INPO, EPRI and IGALL AMPs and the IGALL Master Table provided in the latest IAEA Safety Reports Series No. 82, “Ageing Management for Nuclear Power Plants - International Generic Ageing Lessons Learned (IGALL)”.
- Provide technical guidance to the plant design modification group for changes that will impact the equipment under the programme scope.
- Ensure that all changes to a programme undergo a proper review by relevant responsible groups to assess the impact on these groups.
- Compile waivers, deferments, and justifications when a deviation to the specific programme is unavoidable.

2.5.4 Electrical Systems Engineering (ESE)

- Perform System Monitoring and Trending in accordance with KGU-002, to identify changes in trend, failures in their incipient stages and determines corrective actions required to ensure reliable performance.

2.5.5 Maintenance Execution Departments

- Develop the maintenance procedures and work instructions for the condition monitoring activities for electrical cables and qualified equipment in accordance with relevant plant processes.
- Schedule the maintenance activities according to the information prescribed in this manual.

- Install and retrieve the remote monitoring devices on selected locations identified by Engineering.

2.6 Process for Monitoring

The development, implementation and the effectiveness of this programme are continuously monitored by the programme engineer in accordance with 331-148, "Programmes Engineers' Guide".

2.7 Related/Supporting Documents

- 240-165353024 - List of Medium and Low Voltage Cables and Associated Environmental Zones

3. Requirements

The regulatory guide RG-0027, (6.3.3) (3b) (vi), (iv) require that the monitoring of actual environmental conditions be implemented in order to get additional information necessary for the assessment of ageing effects on the equipment in its actual operating environment. The implementation of this ECMP will satisfy the RG-0027 requirements.

International standards recommend that an analysis should be carried out to determine where measurements of environmental conditions should be made based on the zones, rooms, and equipment at the nuclear installation. This analysis should consider the stressors acting upon the equipment (e.g., service temperature, radiation, submergence, local vibration, electromagnetic interference, radio frequency interference, toxic chemical exposure), to determine whether the actual environmental conditions are more severe than assumed during the initial qualification.

Trends in the service conditions should be assessed to determine the impact on the condition of qualified equipment, to assess ageing of cables and to identify corrective actions, if necessary.

The monitoring of environmental conditions in the nuclear installation during operation should verify the following:

- The assumptions in the equipment qualification are consistent with the ambient conditions in the part of the installation in which the equipment is installed.
- The design limits of the equipment are not exceeded.
- The status of qualified equipment remains valid.
- The assumptions in the ageing assessment of cables are respected.

Monitoring of environmental conditions may also be used to support the evaluation of remaining qualified life by determining if an item of equipment is suitable for continued service.

The requirements provided in the ECMP, if effectively implemented, will provide reasonable assurance that the intended functions of cables, their associated components and qualified equipment, exposed to adverse localised environments or hotspots caused by increased service temperature, radiation, submergence, local vibration, electromagnetic interference, radio frequency interference, toxic chemical exposure, moisture, or a combination thereof, are fulfilled.

3.1 Programme Scope

3.1.1 In-scope Electrical Equipment and Cables

The equipment and cables within the scope of the ECMP represent a sample selected from the cable population of installed cables categorised as important to safety. The selection was based on equipment and cables located in areas/zones with known or potential adverse environmental conditions. Following a measurement campaign, to identify environmental condition “hot spots”, additional equipment and cables may be added or removed from the list based on the results of the various measurement campaigns that will be conducted.

The in-scope electrical and I&C equipment were extracted from the SALTO scoping list 1124-GN-LIS-020 “Comprehensive List of all SSCs reviewed for SALTO Scoping Requirements”. All the electrical and I&C equipment verified for comprehensiveness using the following sources to determine the final list for the cables and equipment.

- Pericles Data Base.
- 240-138996505: CAMP LV Cables Master List.
- 240-142894140: CAMP MV Cables Master List.
- 240-155832775: Equipment Qualification Master List (EQML).
- L1124-EL-LIS-001: List of in-scope items for SALTO EQ TLAA.
- L1124-EL-LIS-003: SALTO Cable List.
- L1124-EL-LIS-004: EQ Cable List.

A list of all the cables, equipment and associated Environmental Zones within the scope of this AMP is provided in a separate Excel Spreadsheet 240-165353024, “List of Electrical Cables, Qualified Items and Associated Environmental Zones”.

3.1.2 Environmental Zones and Room Numbers

The associated environmental zones and plant locations where the in-scope components are located were assigned based on the Environmental Zones listed in L1124-GN-LIS-016 “SALTO Room Master and Environmental Zone List” and L1124-GN-LIS-029: “Equipment Zone List” as an initial starting point.

The Room Master and Environmental Zone List, provided in Table 1 below, was developed as part of the SALTO A project. The key inputs and values were obtained from the Plant Data System, plant walk downs, radiation surveys during containment entries, monthly routine radiation surveys, DSE operating and design values, SAR documents, SAP list and the IQ Review database. Any additional “hot spots” and zones identified during measurement campaigns will be added to the Environmental Zone List as required.

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3.2 Preventative Action to Minimise Ageing Effects

3.2.1 Evaluating Ageing Effects

The effects of ageing on the functionality of systems, structures and components must be managed to maintain the current licensing basis so that there is an acceptable level of safety during the period of extended operation. The operator must demonstrate that the effects of ageing on the functionality of cables and associated equipment must be managed to maintain the current licensing basis and in LTO.

The specific methods to be used by the plant operator in meeting these requirements are not mandated, but the most appropriate method(s) or technique(s) can be selected by the operator for evaluating the ageing effects.

3.2.2 Equipment Qualification

The existing equipment qualification programme, 331-186, defines and maintains a list of equipment required to perform their safety function(s) before, during and after a design basis event (DBE), such as a loss of coolant accident (LOCA), high energy line break (HELB), main steam line break (MSLB), design extension conditions (DEC) as appropriate, seismic events, airplane crash, station blackout, and other environments such as intense electromagnetic fields.

The EQ Programme requires the preparation and maintenance of a qualification file containing the qualified equipment's performance specifications including their safety function(s), the environmental conditions to which the equipment could be subjected to during normal operation, extreme events, postulated DBE(s) and/or DEC(s). The equipment qualification programme contains provisions for ageing that require, in part, consideration of all significant types of ageing degradation (e.g., thermal, radiation, pressure, humidity, chemical effect, submergence, vibration, cyclical ageing, or their synergistic effects) that can affect equipment functional capability.

A critical element of equipment qualification is the determination of how the environmental and operational stressors, discussed in Section 3, affect equipment during normal operation. Ageing assessment is the evaluation of appropriate information for determining the effects of ageing on the current and future ability of equipment to function as designed under all service conditions.

When “life-limiting” ageing mechanisms (termed significant ageing mechanisms) are identified, they must be incorporated into the qualification program and an equipment qualified life determined. Significant ageing mechanisms can be addressed by performing analyses, simulating them during type testing, inspecting, and maintaining installed equipment to minimize their significance, and periodically replacing installed parts or equipment.

The data received through the implementation of the ECMP will be used to systematically address the following:

- Assess whether normal environmental and operational stressors cause significant ageing degradation.
- Apply methods (analysis, ageing tests, or in-service activities) to address ageing degradation.
- Establish or re-assess a qualified life.

3.2.3 Cable Ageing Management

Electrical cables are one of the major components of the Koeberg Nuclear Power Plant (KNPS) and provide multiple functions including transmission of instrumentation and control signals and supply of electrical power to components that require it. The integrity of cable insulation is crucial for the safe and reliable operation of cables beyond their initial operating life. An important factor in the safety and reliability of cables is the integrity of their polymeric insulation and jacket materials. These materials suffer from degradation due to environmental conditions like exposure to heat, radiation and other environmental factors over extended periods of time.

Electrical cables are adequately addressed in the existing Cable Ageing Management Programme CAMP) manuals 240-98789629 (Cable Ageing Management for Instrumentation and Control Cables and Cable Systems), 240-98789276 (Cable Ageing Management Programme Manual for Low Voltage Cables and Cable Systems) and 331-311 (Cable Ageing Management Manual for Medium Voltage Power Cables and Cable Systems).

The environmental condition monitoring results gathered and trended through the implementation of the ECMP will provide additional information to assess the rate of cable or connection degradation within the scope of CAMP. The identification of environmental “hot-spots” will assist in determining any additional scope that may be required to be added to the CAMP.

The Cable Ageing Management Programme (CAMP) identifies localised adverse environments and adverse service conditions that could lead to the early failure Medium Voltage (MV), Low Voltage (LV) cables and related cable systems. It also manages significant ageing effects as mentioned in the previous sections of this manual to preclude in-service failures as defined in 331-127, “Standard for Cable Ageing Management Programme at Koeberg Operating Unit”.

3.2.3.1 Electrical Cables and Associated Equipment Age-Related Degradation

The ageing of cables has long been recognized as a potential threat to safe operation of NPP, especially towards the end of life, and a large body of research exists into ageing mechanisms. Operating experience has shown that the problems arising from the ageing of cables are relatively small in comparison with those associated with other electrical and instrumentation components.

Under normal ambient conditions, cables can be expected to out-live the rest of the plant. However, the potential threat posed by common mode failure of cables has been considered serious enough to justify a large amount of work in many countries. The most severe scenario is the requirement for cables to continue to function normally until at the end of plant life.

Research and development (R&D) work has been conducted to characterize the ageing mechanisms and to develop testing and monitoring techniques for use in nuclear power plants.

New, additional cabling becomes necessary when modifications to existing plant and systems are added and special attention has to be drawn on the proper cable installation and grounding.

The ageing degradations and ageing effects associated with electrical cables are adequately covered in the existing Cable Ageing Management Programme manuals 240-98789629 (Cable Ageing Management for Instrumentation and Control Cables and Cable Systems), 240-98789276 (Cable Ageing Management Programme Manual for Low Voltage Cables and Cable Systems) and 331-311 (Cable Ageing Management Manual for Medium Voltage Power Cables and Cable Systems).

3.2.4 Cables and Associated Equipment Service Conditions, Environment Effects and Stressors

There are various conditions that affect electrical cables and associated equipment, like the surrounding environment or external influences. Degradation is caused by various conditions and service/operating conditions are defined and exist when the cables and associated equipment is in service and can be divided as follows:

- While the plant is at power which includes start-ups, shutdowns, and certain design basis events. Extreme design base events like design basis accidents also becomes service conditions when they happen.
- At any time during life which includes environmental conditions and influences resulting from performance of design conditions. The above conditions produce stressors, and stressors produce cable degradation. Included in these service condition stressors are error-induced ‘conditions, which also induce degradation. The control of both normal ageing degradation and error-induced degradation is part of the ageing management that is discussed in this document.

During operation, cables and associated components are exposed to several stressors that can lead to deterioration. These stressors may act individually or in combination with one another to produce an ageing mechanism. Service conditions are the actual surrounding physical states or influences that can affect a cable, connector, and wire during its service life. Service conditions include both environmental conditions and self-heating. Knowing both service conditions and materials gives the basis for identifying applicable ageing effects.

The main potential stressors are discussed below.

3.2.4.1 Heat

This refers to:

- Ambient room temperature
- High temperature or radiant heat (hot spots)
- Ohmic heating

Thermal ageing results from the exposure of cable materials to normal and abnormal thermal environments. The normal ambient room temperature in most plant areas results in very slow degradation of cable insulation and jacket materials. However, localised elevated temperature or radiant heat from sources such as process lines that are too close, or inadequate ventilation, can produce severe damage normally limited to one portion of the cable.

The plant areas at Koeberg that is controlled by ventilation systems remains between -20°C and 55°C, which is the normal design temperature limits for cables and equipment. The ambient temperatures for other areas that is not controlled by ventilation systems are usually within the design limits. Data from the Koeberg weather station shows that the lowest, highest, and average temperatures over the last two years were as follows:

- Lowest Temperature: 3°C - August 2020
- Highest Temperature: 36,5°C - April 2021
- Highest Average Temperature: 25,3°C - February 2021

Elevated temperatures resulting from thermal stratification in the ambient air volume can age large sections of cable that are located at higher elevations within an enclosed space.

Ageing of insulation can also result from ohmic current heating of cable conductors and hot spots as described in Reference [37] EPRI Report TR-109619, “Guideline for the Management of Adverse Localised Equipment Environments”. The rate of degradation is dependent on the nature of the cable materials, the intensity of the heat source, the cables proximity to it, and the existence of any mitigating factors such as shielding or ventilation.

Ohmic heating, resulting from electrical current in power cables, generally affect the entire length of a cable run, with the most adverse effect in locations that have ambient environment hot spots or poor heat transfer. As current flows through a conductor, heat is generated by the resistance of the conductor.

Thermal ageing that results from conductor ohmic heating is significant in power cable applications where the connected load is operated for a significant percentage of its installed lifetime, and the current during such operation is a substantial percentage of the ampacity of the cable. Intermittently operated, low-duty factor loads (even at high current) will not result in substantial ageing of the connected cable. Similarly, loads that are run continuously, but whose operating currents are low in relation to the ampacity of the cable, will result in limited cable ageing.

Refer to Section 3.3.3.2 “Temperature” for more detail.

3.2.4.2 Radiation

This refers to:

- Gamma during normal operations
- Gamma plus beta during an accident

The radiation tolerance of an individual material will vary based on the general type of material and its chemical structure and formulation. Organic materials commonly used in nuclear plant cable applications vary widely in their radiation resistance. Changes in the material’s overall mechanical properties such as elongation-at-break, tensile strength, and hardness and electrical properties such as dielectric strength and conductivity can result from exposure to radiation.

Cable materials exposed to a total gamma dose of less than approximately 1×10^3 Gray will experience little, or no ageing effect caused by radiation exposure. PVC is known to exhibit some degradation when subjected to a total dose of 2×10^4 Gray, but most other commonly used materials such as crossed linked polyethylene (XLPE), and ethylene propylene rubber (EPR) can withstand a significantly higher total dose.

Detailed radiation resistance data for many materials can be obtained from EPRI report NP-2129 “The most commonly used cable materials tend to harden with irradiation except for butyl rubber, which softens”.

Refer to Section 3.3.3.3 “Radiation” for more detail.

3.2.4.3 Wetting

Wetting is primarily a concern for crimped terminal connections or terminal blocks in wet and salt air spaces and not an insulation concern.

In some cable applications, the combination of voltage and moisture can affect insulation that is dirty or deteriorated, thus resulting in surface tracking paths at terminations between conductor and ground, or conductor and conductor. For such conditions to occur, the physical arrangement of the termination must be such that the electrical distance between the conductor and ground or another conductor is not large, and the surface is wet and retains the moisture, or the surface is contaminated with a conductive material, or a material that supports moisture paths.

This condition can result in localised burning of the insulation and carbonization at the ends of the tracking paths and ultimately the insulation will fail. A condition called dry banding can be a problem for circuits in moist areas that cycle. In dry banding, the moisture that bridges the conductors begins to evaporate as the leakage current heats the liquid. The current flows through a smaller and smaller band of moisture until, just as the last of the moisture evaporates fully, a very high current density is flowing through a very narrow band of moisture. The heating in the narrow band is intense, which causes significant damage with each energization. The sealing of junction boxes and inspection of circuits in moist areas will eliminate such problems. Refer to Sections 3.3.3.5 “Humidity, Moisture and Water Spray” and 3.3.3.6 “Steam” for more detail.

Other stressors like humidity, vibrations and EMI/RFI are not mentioned here but are discussed in more detail under section 3.3.3.

3.2.5 Preventive Actions

It is essential to ensure that the ventilation systems are regulated and that factors such as radiation, temperature, mechanical interference, moisture, and vibration are kept within their control design parameters to prevent the cables and their associated equipment from ageing. Most medium and low voltage cables and associated equipment at Koeberg are in harsh, mild, and temperature-controlled environments that experience no significant change in environment during both normal and accident conditions.

Most cables and associated equipment are located in harsh and mild environmental areas where they are not exposed to significant increases in temperatures and radiation during both normal and accident conditions. There are a few exceptions where cables are located in high radiation, temperature, and humidity areas like the Reactor Building, Fuel Building, NAB, Steam Bunkers and the SEC Plant as indicated in Table 2.

Table 2: Plant areas and adverse localised conditions and environments

PAIA section 38(b). Redacted as it contains sensitive information

Plant Area	Adverse Localised Conditions	Adverse Localised Environments

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3.3 Detection of Ageing Effects

3.3.1 Ageing Factors, Mechanisms and Effects

Evaluation of cables and their associated passive components, the stressors acting upon the components and the operational history indicate that nearly all components have significant ageing mechanisms that can affect their function. Evaluation of both Koeberg and international failure history, coupled with a review of the existing maintenance programme shows that these ageing mechanisms can be managed throughout the plant life.

The ageing mechanisms coupled with the maintenance and surveillance technique that manages the ageing mechanism are documented in the CAMP Manuals.

3.3.2 Diagnostic Technologies (Detection of Ageing Effects)

Additional Data Loggers, such as the Westinghouse Equipment Lifetime Monitors™(ELM's) and Honest Observer by Onset Data Logger's (HOBO's) must be installed in the room numbers for Unit 1 and Unit 2 for continuous monitoring as indicated in List 240-165353024 (Medium and Low Voltage Cables and Associated Environmental Zone) for high radiation, temperature, and humidity areas only. The permanently installed radiation and temperature devices, as indicated in the above list, are continuously monitored via InSQL. All other areas should be walked down and inspected according to the frequencies as indicated in Table 4 "Walkdown and Inspection".

The results of the walkdowns and inspections must be recorded in the Equipment History Records or Inspection Data Input Sheets and an engineering work request (EWR) shall be raised and then forwarded to Engineering Programmes for further evaluation and trending in order to identify the ageing factors, influences, and effects. If any corrective actions are required, then the normal corrective action process shall follow as per Corrective Action Process, KAA-688. The component failure (CF) process as described in KGU-033 and the non-conformance (NC) process as defined in KAA-840.

3.3.3 Environmental Conditions and their Effects on Equipment

Environmental conditions can be viewed in terms of their potential effects on materials and equipment. The following subsections briefly describe the effects of service conditions on equipment and materials during both plant operation and DBEs. When the effects are produced while the plant is operating (including temporary shutdown periods), they are called ageing effects.

3.3.3.1 Temperature

The temperature at various points within a piece of equipment is a function of the ambient temperature in the vicinity of the item, the heat generated within the item, and any heat transferred to the item from associated components or process fluids. The ambient temperature can vary with outdoor temperature as well as the plant's power level. It is also affected by the plant's operating state (for example, refuelling, start-up, or power operation), off-normal equipment conditions such as valve packing steam leaks, operational events such as loss of an HVAC system, and accidents such as LOCAs and other types of pipe breaks. Self-heating varies with the operational mode of the equipment. For example, energized coils are hotter than coils in a deenergized state.

Temperature can alter device and material characteristics immediately or gradually. Performance changes and equipment damage can result from both steady-state and transient effects. Temperature can alter characteristics indirectly through gradual chemical and physical processes called thermal ageing.

Examples of functional degradation due to temperature and to thermal ageing include reduction of sealing capability in O-rings and gaskets; excessive electrical leakage caused by changes in electrical properties of cable insulation; and changes in circuit performance resulting from changes in the characteristics of electronic components. Electrical property changes include changes in dielectric strength, conductor resistivity, insulator volume resistivity, dielectric constant, and dissipation factor.

The specific temperature areas where the equipment is located, and the installation of additional temperature data loggers are covered in Table 3 and Table 4.

3.3.3.2 Radiation

There are four types of nuclear radiation in a nuclear power plant: alpha, beta, gamma, and neutron. The principal source of nuclear radiation is the fission products contained in the reactor fuel. Gamma is the principal type of radiation addressed in equipment qualification, although beta radiation is also considered. Alpha radiation, due to its extremely low penetrating power, plays no role in qualification. Neutron flux can affect electrical equipment in the vicinity of the reactor during power operation. Radiative stressors and the increment in thermal stressors caused by radiation are usually low under conditions of normal service, so changes in properties occur slowly; however, the cumulative effect over long periods can be significant. Radiation affects materials by two principal processes: physical displacement of atoms/electrons and ionization/excitation of atoms and molecules. Both processes occur for all materials, but the damage to metals and inorganics is principally through displacement effects.

The specific radiation areas where the equipment is located, and the installation of additional radiation data loggers are covered in Table 3 and Table 4.

3.3.3.3 Pressure

Pressure and rapid pressure changes can affect equipment by causing additional forces on parts and components. Excessive differential pressure, generally from high external pressure, can cause structural failure of sealed devices. Rapid pressurization can also cause structural failure of devices not fully sealed (for example, National Electrical Manufacturers Association [NEMA] enclosures). The current-interrupting characteristics of electrical contacts can also be affected by varying pressure.

The main area that could be affected by pressure is the EQ in-scope equipment and cables in the Reactor Building. The ILRT containment pressure test is performed every 10 years. The previous test was performed in 2015 and no incidents or malfunctioning of any EQ in-scope equipment and cables were detected or reported from 2105 to date. Continuous remote monitoring is available on InSQL from the Reactor Protection Containment Pressure Transmitters ETY 101, 102, 102 and 104 MP.

3.3.3.4 Humidity, Moisture, and Water Spray

Relative humidity will vary depending on the plant's geographic location, the temperature in the vicinity of the equipment, and the effects of air conditioning. In addition, water or steam leakage in certain plant areas may significantly increase the relative humidity. Water or chemical spray conditions may result either from piping or component leaks or from maintenance or equipment operational alignments. Deliberate or inadvertent fire suppression system actuation (for example, sprinkler systems) can also produce spray conditions. Sprinkler systems, inadvertently activated due to local steam leaks, have been known to cause water intrusion into electrical conduits. Humidity can directly cause degradation and can aggravate the effects of other stressors. Humidity causes corrosion and, at interfaces between dissimilar metals, galvanic effects. Corrosion can directly affect performance of metallic components. Electrical terminations and contact surfaces can be degraded by corrosive effects. The transfer of highly conductive corrosion products to other components can affect their electrical characteristics.

Humidity can directly degrade organic materials, weakening their physical, mechanical, and electrical properties and distorting their shapes. Hygroscopic materials, such as polyimides, are particularly vulnerable. The absorption of water in many organic materials is both a physical and a chemical process. Absorbed water can chemically combine with existing molecules and change the chemical formulation. Other absorbed water molecules not chemically reacting can cause swelling of material. The presence of surface moisture significantly alters the resistivity and dielectric-withstand potential of insulating surfaces. Humidity can aggravate thermal and radiation effects in electrical insulating materials. For example, moisture entering the crevices and pores produced by hardening and embrittlement lowers the material's insulation resistance and electrical breakdown strength.

The Humidity, Moisture, and Water Spray areas and the installation of additional humidity data loggers are covered in Table 3 and Table 4.

3.3.3.5 Steam

Exposure to high-temperature saturated steam combines temperature and humidity effects. The condensation of steam on colder surfaces results in rapid heating of the cooler surface (condensing heat transfer). This heat transfer is much more rapid than exposure to hot air. The condensed moisture can further degrade equipment by collecting on the equipment surface or accumulating in undrained areas. Qualification to steam conditions can also include exposure to superheated steam or a combination of saturated and superheated conditions. For example, a main steam line break (MSLB) inside containment for a PWR can start off as saturated steam conditions until the level in the affected steam generator drops below the tube bundle. Once the tube bundle becomes uncovered, the discharge from the MSLB will be superheated steam. Steam pressure plays an important role in determining if the environment is superheated or saturated. When device temperatures equal or exceed saturation temperature, surface moisture will begin to dry off.

The only in-scope equipment and cables that could be exposed to steam in containment is the level, flow, and pressure transmitters, and in the steam bunkers the steam pressure transmitters and steam dump instruments. These transmitters and instruments are all 1E equipment and designed for accident and steam conditions. The above components are inspected and tested every 1RO.

These areas where the above equipment is located are covered in Table 3 "The Temperature, Radiation and Humidity Data Gathering" and Table 4 "The Walkdown, and Inspection Requirements".

3.3.3.6 Submergence

Submergence in water during accident conditions can result in some effects that differ from exposure to 100% relative humidity or saturated steam conditions. Theoretically, moisture absorption in polymers should be the same for 100% relative humidity and exposure to water. However, water immersion may promote the leaching of certain materials. Immersion in water also provides an immediate electrical ground plane that can affect electrical performance, particularly for partially damaged (for example, cracked) cables and splices. In addition, immersion in water may promote moisture intrusion into equipment, particularly if additional pressurization is caused by a significant hydrostatic pressure. Submerged equipment within containment will be exposed to different accident conditions, such as temperature profile, total integrated dose, and chemical effects, compared to equipment located above the flood level.

The in-scope equipment and cables that are exposed to submergence conditions are the SEC Cable Galleries, SVA Cable Galleries, Cable Trenches between Unit 2 Turbine Hall and the Oil and Grease storage and the cable trenches behind the (Jx) galleries. These areas are covered in Table 4 “The Walkdown, and Inspection Requirements.

3.3.3.7 Flooding

Flooding has the potential to cause common mode failure of cables and equipment in multiple areas in NPP’s. Immersion of cables and equipment in water promotes moisture intrusion into damaged and cracket cable insulation and equipment. Cable routes and equipment areas susceptible to submergence during flooding conditions should be identified and corrective actions should be taken.

KNPS implemented modification S88109-1/2 “Raise Level Sensors RIS 042 and 045 SN Above New Flood Level” to provide the operator with a means to detect the entry of surplus water in containment which may lead to the immersion of equipment such as the electrical and pneumatic actuators of certain RCV and RRA valves, and other long term cooling components.

The in-scope equipment and cables that are exposed to flooding areas are covered in Table 4 “The Walkdown, and Inspection Requirements”.

3.3.3.8 Chemical Contamination

Chemicals principally affect equipment by their presence in process fluid systems and their use in containment spray systems. Polymer degradation could release chemicals, such as chlorine issued by neoprene and polyvinyl chloride (PVC), that attack surrounding components in elevated normal and accident temperatures and radiation environments; however, this is likely to be far more localised. Moreover, chemicals can react with materials, causing corrosion, the release of flammable or toxic gases, and other chemical reactions. Ionic chemicals dissolved in water or condensate can significantly increase the water’s conductivity and affect surface tracking of insulators.

No specific zones are affected at the KNPS. The caustic soda injection system for the containment spray system has been removed and Koeberg follow the chemical CRACK program “Chemical Restrictions and Controls at Koeberg” which is well established and for many years in service.

3.3.3.9 Localised Vibration

Vibration can cause fatigue and failure in both passive and active components. Vibration results in wear whenever it causes surface rubbing. It also promotes the loosening of parts, particularly fasteners, and rattling of loosely retained components (for example, cabinet doors). Another possible failure mechanism during vibration is cyclic fatigue damage. This may occur under high-level hydrodynamic or operating basis earthquake loads but would generally not be expected for most other lower-level vibrations. When the equipment experiences significant displacement due to the vibration, it may collide with structures or adjacent items; subcomponents may also collide with each other.

Vibration stresses may be self-induced during equipment operation or transmitted to the equipment from external sources such as earthquakes. In normal service, vibration is generated by the operation of rotating and reciprocating machinery. The severity of rotating machinery vibration is often related to unbalance and misalignment between drivers and the driven equipment.

The main zones affected by vibration is the areas of the primary pumps in containment and the turbine and generator in the turbine hall. The vibration of this equipment is monitored continuously with high vibration thresholds and no electronic equipment as indicated in 240-165353024 “List of Medium and Low Voltage Cables and Associated Environmental Zones” is in the near vicinity of the turbine or primary pumps.

The in-scope equipment and cables that could be affected by vibration, is the primary hot and cold leg resistance temperature detectors in the close vicinity of the primary pumps and the feed water flow transmitters in the turbine hall. This equipment is inspected and tested every 1RO and no additional monitoring is required.

3.3.3.10 Earthquakes

Earthquakes produce random ground motion that is transmitted through buildings to all internal equipment and systems. The frequency range of this motion is typically between 1 and 33 Hz. For evaluating or analysing the effect of ground motion on structures and components, it is useful to convert the time history to a response spectrum, as indicated in document KBA 1222 E02 008. A response spectrum is a plot of the maximum response of each of a series of single-degree-of-freedom bodies with different natural frequencies when their mounting points are subjected to a time history with a given duration and frequency content. The response is plotted versus the frequency of those bodies for a selected value of damping. Note that the value of damping selected for the purpose of displaying a response spectrum is not necessarily related to the actual damping value for the component being evaluated or analysed.

The BNI seismic instrumentation system continuously monitored any seismic event at KNPS. Micro-seismic waves are continuously monitored at the Koeberg Duynefontein site for the prediction of maximum ground acceleration as per Section 5.2-1, Table T-5.2.1 of the Site Safety Report for Duynefontein.

3.3.3.11 Electromagnetic and Radio Frequency interference (EMI/RFI)

Electromagnetic interference, including radiofrequency interference, can be caused by electrical equipment, electrical surges (e.g., voltage spikes resulting from switching transients or lightning) and electrostatic discharges.

Electromagnetic interference can affect electrical equipment including instrumentation and control systems and components. Equipment qualification for electromagnetic interference should address the combination of the system design and the component design to minimize the coupling of electromagnetic interference between the source and other electrical components.

The standard IEC 62003 (Nuclear power plants – Instrumentation and control important to safety – Requirements for electromagnetic compatibility testing) establishes requirements for electromagnetic compatibility testing of instrumentation, control, and electrical equipment supplied for use in systems important to safety at nuclear power plants and other nuclear facilities. The document describes general test methods, and necessary application-specific parameters and criteria to ensure that nuclear safety requirements are met.

To meet this criterion, I&C systems in nuclear power plants must withstand EMI/RFI and power surges from external and internal devices such as transformers, solenoid coils, relays, radio-frequency disturbances, and power switching transients. It is not expected that any significant ageing mechanisms on I&C equipment from long term EMI/RFI exposure exist in the nuclear plant area.

Other typical emission sources that can be controlled to protect EMI/RFI sensitive equipment are:

- Portable Transceivers (Walkie-Talkies)

  Proper administrative control of portable transceivers is necessary to protect EMI/RFI sensitive equipment and should provide at least a margin between the transceiver emissions limit of 4 volts per meter and the recommended equipment susceptibility limit of 10 volts per meter. At the KNPS Walkie-Talkies is not allowed in the plant.

- Arc Welding

  Arc welding should be avoided and prohibited, if possible, in rooms containing in-service EMI/RFI sensitive safety equipment. Arc welding that is necessary in areas with potentially EMI/RFI sensitive equipment in service should be controlled using shielded enclosures around the welding equipment and power line filters on power cables.

Koeberg have experienced EMI interference in the past with EQ Barton transmitters in the containment. This issue was resolved by installing end inductors on the input and output cable of these transmitters.

Actions:

A site survey of sources of electromagnetic interference should be performed during normal operation and should include monitoring for the effects of operating and maintenance activities to establish and verify the basis for equipment qualification.

It is recommended that KNPS must carry out EMI radiation mapping of plant zones where sensitive equipment that is susceptible to EMI are located. The recommended zones/areas are as follows:

Zone	Description

Detailed equipment qualification specifications and acceptance criteria for electromagnetic interference should be determined in accordance with international industry standards or, alternatively, on the basis of individual system requirements.

Electromagnetic fields within a specified location within a nuclear installation may change with time as a result of the operation of equipment or replacement of equipment in the area (zone). Therefore, when changes to electrical inputs or electrical equipment occur within an area (zone), additional site survey measurements of electromagnetic fields should be performed to identify and quantify sources of electromagnetic interference in order to ensure that the status of qualified equipment will be preserved.

3.3.4 Inspection Requirements and Frequencies for Cables and Cable Systems

The inspection, walkdowns, frequencies, and responsible group requirements for all LV, MV cables and cable systems are based on the SSCs classification and environmental conditions and are indicated in List 240-165353024 “List of Medium and Low Voltage Cables and Associated Environmental Zones” and Table 4.

Results of the inspection and the as found conditions must be recorded in the Equipment History Records or Inspection Data Input Sheets, including pictures, and then forwarded to Engineering Programmes for further evaluation and trending in order to identify the ageing factors, influences, and effects.

Corrective actions and defects shall be raised to correct the anomalies identified. An engineering work request (EWR) shall be raised if there any need for an engineering evaluation.

3.4 Monitoring and Trending of Ageing Effects

3.4.1 Adverse Localised Equipment Environment

An adverse localised equipment environment is a condition in a limited plant area containing a piece or pieces of equipment, that is significantly more severe than the specified service condition for the equipment, the room in which the equipment is located, or the surrounding plant area. The service conditions of interest include normal, abnormal, and error-induced conditions, prior to the start of a design-basis accident or earthquake. EPRI Report TR-109619 “Guideline for the Management of Adverse Localised Equipment Environments” states that adverse localised equipment environments should be systematically identified and documented so their effects can be evaluated and controlled.

An adverse environment is only of interest when it could affect the ageing or operability of equipment. Therefore, the scope of most identification and management efforts is limited to adverse environments that could affect equipment and environments in areas not containing susceptible equipment are not of interest.

An adverse environment would also only be significant if it were in excess of the conditions considered in the design basis for systems and components. Variations in environmental conditions are common within power plants. For example, temperatures are higher in the vicinity of hot process lines and cooler a short distance away. However, the environment in the vicinity of the process line would not necessarily be considered an adverse localised equipment environment if the temperature remained within the design temperature or if no equipment were located within the adverse environment. If, on the other hand, the design-basis temperatures were exceeded in the vicinity of the process line and susceptible equipment were located there, the area would have an adverse localised equipment environment and would be of concern.

Utilities do not necessarily need to implement new programs or processes to identify and manage adverse localised equipment environments. To some extent, all utilities already perform or have performed activities that provide assurance that their plants are not susceptible to common mode failures due to adverse localised equipment environments. However, utilities could benefit by implementing a systematic approach of capturing, crediting, and refining the tools and processes that are in place to identify and manage adverse localised equipment environments.

The main concern related to adverse localized equipment environments is that they cause a faster than expected rate of ageing of equipment and as a result, the equipment could fail in service or, in the case of environmentally qualified equipment, could be rendered more susceptible to failure under design basis accident conditions. Undetected or unevaluated adverse localized equipment environments in the vicinity of environmentally qualified equipment is not acceptable. Environmentally qualified components must have defined replacement schedules or qualified lives that are based on the severity of environmental conditions. If an environmental condition at the location of a qualified component is more severe than the analysed condition, the accumulated deterioration of the component during service may cause failure during a design basis event, should one occur. Therefore, either adverse localized equipment environments associated with environmentally qualified components must be corrected, or the qualified life must be adjusted to account for the severity of the condition and assure operability under accident conditions

One method that is particularly useful for identifying and managing adverse localised equipment environments is walkdowns. Use of ongoing walkdown programs would give plants a method by which they frequently assess the condition of equipment in the plant and the environments that surround the equipment. If used effectively, walkdowns can be a tool for both identifying adverse localised equipment environments and providing feedback on the actual condition of equipment in the plant.

3.4.2 Environmental Conditions and Vulnerable Plant Areas

List 240-165353024 includes all the in-scope cables for LV and MV power cables, and all the LV cables for control and measurement and qualified components as well as their associated environmental zones.

The Room Master and Environmental Zone List in Table 1 defines the environmental zones and specifies the prevailing environmental conditions to which the in-scope equipment is exposed in each zone. The cable inherits the same importance classification as the in-scope equipment it supplies.

Temperature and radiation parameters for zones inside the reactor buildings were based on long term maximum, minimum and average values obtained from the Plant Data System (InSQL) ventilation systems parameters and the Radiation Protection (RP) group. The temperatures for outside the containment were also obtained from ventilation system measured parameters.

The Westinghouse Equipment Lifetime Monitor (ELM) addresses a long-standing need in the nuclear industry to continuously and passively monitor the temperature and radiation environment of components located throughout the plant. This monitor is capable of performing up to six different functions which includes temperature, low and high range gamma, beta particle and neutron radiation. The data acquired from the monitor can be used in many ways including the following:

- Extending the qualified life of safety-related equipment by improving on initial assumptions regarding service environment.
- Conducting long term temperature and radiation surveys to ensure operation within qualified limits.
- Assessing potential age-related degradation of cables and equipment for plant life extension.
- Justifying continued use of cables and equipment following an accidental excursion in environmental radiation or temperature.

Additional data loggers such as the ELM's and HOBO's, as indicated in List 240-165353024 "Additional Temperature, Radiation and Humidity Data Monitoring" column and Table 3, must be installed where temperature, radiation, and humidity readings are difficult to obtain and could be used for future trending. Koeberg has purchased 40 of the ELM monitors and the locations on the plant to install these can be found in 240-165353024. Westinghouse will be responsible for reading the data loggers and to provide Eskom with a report of the results of the measurements performed using the ELM's.

Table 3: Temperature, radiation and humidity data gathering

Env. Zone	Zone Description	Temperature and Humidity Measurement Device	Room Number	Radiation Measurement Device	Room Number	InSQL / Remote	ELM Devices and Freq.

PAIA section 38(b).Redacted as it contains sensitive information

PAIA section 38(b). Redacted as it contains sensitive information

Env. Zone	Zone Description	Temperature and Humidity Measurement Device	Room Number	Radiation Measurement Device	Room Number	InSQL / Remote & Freq.	ELM Devices and Freq.

PAIA section 38(b).Redacted as it contains sensitive information

Env. Zone	Zone Description	Temperature and Humidity Measurement Device	Room Number	Radiation Measurement Device	Room Number	InSQL / Remote & Freq.	ELM Devices and Freq.

PAIA section 38(b).Redacted as it contains sensitive information

Env. Zone	Zone Description	Temperature and Humidity Measurement Device	Room Number	Radiation Measurement Device	Room Number	InSQL / Remote	ELM Devices and Freq.

PAIA section 38(b).Redacted as it contains sensitive information

Env. Zone	Zone Description	Temperature and Humidity Measurement Device	Room Number	Radiation Measurement Device	Room Number	InSQL / Remote	ELM Devices and Freq.

PAIA section 38(b).Redacted as it contains sensitive information

3.4.3 Walkdown and Inspection Requirements

The walkdown and inspection requirements indicated in Table 4 are plant areas to ageing mechanisms due to localised adverse conditions and environments that will minimise, and control ageing affects when inspected.

Table 4: Walkdown and inspection

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b).Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b).Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b).Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b). Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group
[redacted]				[redacted]		[redacted]

PAIA section 38(b).Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b).Redacted as it contains sensitive information

Plant Areas	Zones	Adverse Conditions	Adverse Environments	Inspection Requirements	Frequency	Group

PAIA section 38(b).Redacted as it contains sensitive information

3.4.4 Interface with the Ageing Management Database (COMSY)

When a new ageing degradation is identified, the Ageing Management Matrix will be updated in accordance with 331-275, "Process for the Development and Control of Ageing Management at Koeberg Operating".

The process for updating the AMM/COMSY is to use the CAP process (CR/CA) to inform the AMM/COMSY custodian to review the new mechanism against the existing information for that SSC/commodity group and update the matrix where necessary.

When a new "hot-spot" or adverse localised environment has been identified by the implementation of the ECMP, the programme will initiate a review of the impact of the hot-spot on other plant programmes using the CAP process. Figure 1 below shows the interaction of the ECMP and other ageing management programmes at KNPS. The data received through the implementation of the ECMP will be used to systematically assess whether normal environmental and operational stressors cause significant ageing degradation, apply methods (analysis, ageing tests, or in-service activities) to address ageing degradation and establish or re-assess a qualified life. The environmental condition monitoring results gathered and trended through the implementation of the ECMP will provide additional information to assess the rate of cable or connection degradation within the scope of CAMP.

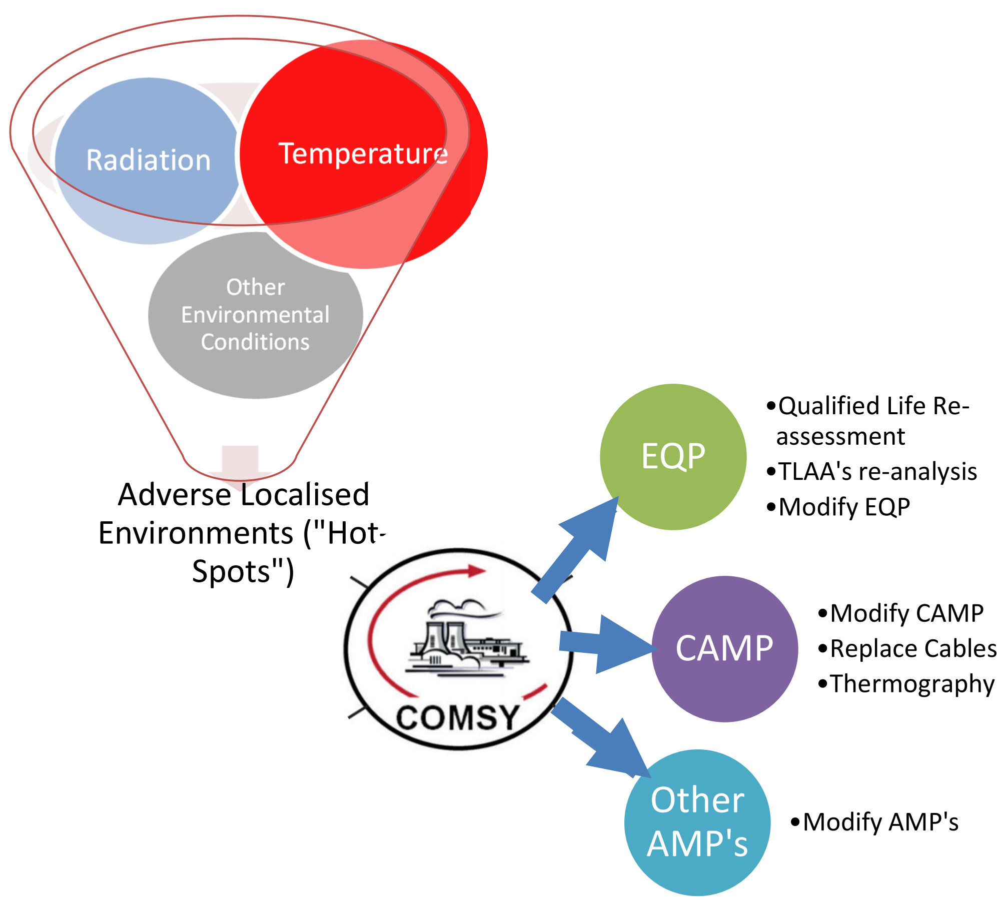

Figure 1: Interaction of the ECMP and other AMP

3.5 Mitigating Ageing Effects

3.5.1 Condition Monitoring

This programme is a condition monitoring programme. Ageing effects could be mitigated when plant areas affected by localised adverse conditions and localised adverse environments are identified, condition is assessed, and the corrective actions are taken to mitigate the ageing effects. This programme has no specific operations, maintenance, or repair, regarding mitigation of ageing. When higher degradation than expected is detected, additional actions to mitigate ageing effects could be applied like additional shielding between the cables and the heat or radiation sources, rerouting away from the heat, radiation sources or hot spots and improved ventilation in problem areas or in electrical cabinets and junction boxes.

The qualified life (QL) of each qualified component cable is managed under the EQ programme as stipulated in the EQ Maintenance Manual 331-219.

3.6 Acceptance Criteria

3.6.1 EQ Cables and Related Equipment

The acceptance criteria for determining the end of QL of installed EQ cables and related equipment are plant specific and directly connected with the condition monitoring techniques selected in this AMP. The acceptance criteria ensure that cables are able to successfully perform their safety related function during accident conditions at the ageing level determined by the selected condition monitoring techniques. If cables are subject to EQ requirements, tests are performed prior to test the cable in accident conditions and post-accident conditions (for example LOCA and post-LOCA conditions). programme is a condition monitoring programme. Ageing effects could be mitigated when plant areas affected by localised adverse conditions and localised adverse environments are identified,

Condition indicators are measured on aged cable samples (naturally ageing, accelerated ageing or a combination of both) until the expected lifetime, and prior to subjecting the samples to accident and post-accident conditions.

The acceptance criteria for in-service EQ cables are that the EQ cables are maintained within the bounds of its qualification basis, including its established QL and continued qualification for the projected accident conditions. The EQ programme, as defined in 331-219, requires replacement or requalification prior to exceeding the qualified life of each installed qualified cable.

3.7 Corrective Actions

The the qualified lifetime (QLD) of the cable is exhausted, or very close to be exhausted or the cable does not meet specified acceptance criterion, a report about qualified lifetime is issued with specification of corrective actions which may include, but are not limited to, replacement or requalification of the installed cable.

An engineering evaluation or assessment is performed, and corrective actions are taken when unacceptable conditions or defects are found. The corrections actions are in line with the Corrective Action Process, KAA-688. The component failure (CF) process as described in KGU-033 and the non-conformance (NC) process as defined in KAA-840 and are followed for engineering assessments. The assessment must consider the age and operating environment of the cables and cable systems as well as the severity of the anomaly and whether such an anomaly has previously been correlated to degradation of cables or connections

Corrective actions may include but are not limited to, cable testing, shielding, or otherwise changing the environment, relocation, rerouting, installing permanent drainage systems, installation of sump pumps and alarms, more frequent inspections of manholes, or replacement of the affected cables and cable systems. When an unacceptable condition or situation is identified, a determination is made as to whether the same condition or situation is applicable to inaccessible cables or connections, or the

3.8 Operating Experience and Feedback of Research and Development Results

Relevant plant-specific operating experience is considered in the development of this manual to ensure that the manual is adequate for the Koeberg NOU. This manual includes provisions for the continuous review of plant-specific and industry operating experience, including research and development results such that, the impact on the programme is evaluated and any necessary actions or modifications to the programme are performed in line with the relevant station processes such as KAD-025, " Processing of Operating Experience", 331-023, "Processing of Industry Operating Experience in Nuclear Engineering", and KGA-035, "Processing of Experience Feedback Received through the EDF Co-Operation Agreement".

This operational experience is summarised as follows:

3.8.1 Institute of Nuclear Operations (INPO)

PAIA section 36(b). Redacted as it contains 3rd party references and information

3.8.2 Conclusions from the Report

3.8.2.1 LV Systems

3.8.2.2 MV Systems

PAIA section 36(b). Redacted as it contains 3rd party references and information

3.8.2.3 Neutron Monitoring Systems

3.8.3 United States Nuclear Regulatory Commission (NRC)

3.8.3.1 Evaluation of Licensee Event Reports (LER)

3.8.3.2 Low Voltage Connectors

3.8.3.3 Low Voltage Cables

3.8.3.4 Hook up and Panel Wire

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.3.5 Low Voltage Compression and Fusion Fittings

3.8.3.6 Low Voltage Terminal Blocks

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.3.8 Medium Voltage Cables

3.8.3.9 Medium Voltage Connectors

3.8.3.10 Medium Voltage Compression and Fusion Fittings

3.8.3.11 Medium Voltage Splices

3.8.3.12 Neutron Monitoring Systems

3.8.4 Conclusions from the Review

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.4.1 Low Voltage Systems

3.8.4.2 Medium Voltage Systems

3.8.4.3 Neutron Monitoring

3.8.5 Studies Providing Industry Wide Operating Experience for Low and Medium Voltage Electrical Cable and Terminations

3.8.5.1 EPRI TR-103834-P1-2. "Effects of Moisture on the Life of Power Plant Cables"

3.8.5.2 Medium Voltage Cable

PAIA section 36(b). Redacted as it contains 3rd party references and information

3.8.5.3 Low-Voltage Cable

3.8.5.4 EPRI NP-5002. "LWR Plant Life Extension"

PAIA section 36(b). Redacted as it contains 3rd party references and information

3.8.5.5 NUREG/CR-3122. "Potentially Damaging Failure Modes of High- and Medium Voltage Electrical Equipment"

3.8.5.6 EPRI TR-103841. "Low-Voltage Environmentally-Qualified Cable License Renewal Industry Report"

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.5.7 NUREG/CR-5461. SAND89-2369. " Ageing of Cables. Connections. and Electrical Penetration Assemblies Used in Nuclear Power Plants"

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.5.8 EPRI EL-3501 and EPRI EL-5387. "Characterization of Failed Solid-Dielectric Cables: Phase I and II"

PAIA section 36(b).Redacted as it contains 3rd party references and information

3.8.5.9 EPRI NMAC NP-7485. "Power Plant Practices to Ensure Cable Operability"

PAIA section 36(b).Redacted as it contains 3rd party references and information the overall failure rate of medium voltage cable has been low as well.

3.9 Quality Management

3.9.1 Quality Assurance Criteria

The quality requirements, as laid out in 10 CFR 50 Appendix B - Quality Assurance Criteria for Nuclear Power Plants, informs the processes at KNPS. The following governing and operational documents are applicable:

- 240-101650256: Ageing Management Matrix,
- 240-149139512: Ageing Management Requirements for Koeberg Nuclear Power Station, Standard,
- IQ Review – KNPS Preventive Maintenance Strategy
- KAA-913 Integrated Equipment Reliability Process

3.10 Summarised List of the Environmental AMP Requirements

This section provides a summary of the actions required for KNPS to adequately meet the requirements of the ECMP and to manage ageing of the in-scope SSC's:

- Walkdowns, periodic inspections and monitoring tasks should be performed by MRG and associated line groups according to Table 3 and Table 4. Results of the inspection and walkdowns must be recorded in the Equipment History Records or Inspection Data Input Sheets, including pictures, and then forwarded to programme engineer for further evaluation and trending in order to identify the ageing factors, influences, and effects.
- Corrective actions and defects shall be raised to correct any anomalies identified.
- An engineering work request (EWR) shall be raised if there is any need for an engineering evaluation.
- The responsible departments and sections with the applicable frequencies for walkdowns and inspections as indicated in Tables 3 and 4 must be adhered to.
- The plant should identify adverse localised environments such as hot-spots and perform thermography scanning to identify the impact to important to safety electrical SSC's including cables.
- Other adverse localised environments or zones, such as EMI zones, should be assessed by the plant to determine the EMC of important to safety electrical SSC's and cables located in these zones. Some proposed locations are documented in section 3.3.3.11. Detailed equipment qualification specifications and acceptance criteria for electromagnetic interference should be determined in accordance with international industry standards or, alternatively, on the basis of individual system requirements.

- Specific trends from remote monitoring temperature, radiation, and pressure transmitters, available on InSQL, should be trended by MRG and the data utilised in applicable engineering programmes.
- The data from Installed local monitoring equipment, as per Table 3, should be trended by MRG and the data utilised in applicable engineering programmes. Appendix 1 for a detailed top view of the exact locations where additional data loggers must be installed.

4. Acceptance

This document has been seen and accepted by:

Date	Rev.	Compiler	Remarks
April 2022	1.	Danie JS Giliomee	The document is compiled to comply with the Koeberg Power Station Ageing Management Programme Requirements

6. Development Team

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

7. Acknowledgements

Not Applicable.

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