Eskom	TECHNICAL REQUIREMENT SPECIFICATION	NUCLEAR ENGINEERING

Title: **Technical Requirement Specification for the RCP Pressuriser Heaters Replacement**

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Compiled by	Compiled by	Compiled by	Reviewed by	Reviewed by	Functional Responsibility	Authorised by
E Williams Pr Engineer: 20160400 DESIGN ENGINEERING			ECSA 9470012	EJ Kerr Pr Engineering Technologistr: 200870088 DESIGN ENGINEERING		
E. Williams	**K. Govender**	**R. Aschmann**	**L. Uys**	**E. Kerr**	**N. Mtoko**	**R. Goldstein**
Engineer Prof Engineering	**Engineer Prof Engineering**	**Senior Advisor Engineering**	**Chief Technologist**	**Senior Advisor Engineering**	**Manager**	**Middle Manager**
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Content

1. Introduction

This Technical Requirement Specification (TRS) describes the client (*Employer's*) requirements in respect of modification number 13028. It is intended to describe the functional and technical requirements for the design, manufacturing, examination, delivery, installation, testing and commissioning of new heaters for the reactor coolant system (RCP) pressuriser heaters.

2. Supporting Clauses

2.1 Scope

The scope of supply for modification RCP 13028 comprises the following:

a) A detailed design document according to 331-86 [23], for the plant changes, populated in the latest detailed design template available from the *Employer's* Design Engineering Department in Nuclear Engineering,

b) Replacement heater design,

c) Supply of material for manufacturing,

d) Manufacturing of replacement pressuriser heaters,

e) Delivery to Koeberg Nuclear Power Station,

f) Removal of existing pressuriser heaters,

g) Radiation shielding of the removed pressuriser heaters,

h) Delivery of the removed heaters to where they must go for decontamination and drumming under Eskom scope,

i) Installation of replacement Pressuriser heaters,

j) Testing and commissioning of all installed equipment,

k) Any engineering studies associated with providing the scope of works,

l) All documents and document updates as required by this specification,

m) All documentation required for testing and commissioning of the new heaters,

n) Provision of design basis documents. Where design basis documents are retained by the *Contractor* or others due to propriety information and/or intellectual property, the *Contractor* will state how access to this information, for audit and review purposes, will be provided to Eskom and the National Nuclear Regulator of South Africa.

o) Providing support during licensing activities with the NNR,

p) Development of an ALARA plan,

q) Development of a shielding plan which includes the design of the shielding installation as per Eskom's procedures,

r) Development of a dose estimate per task and determination of a total project dose,

s) Waste characterization - including the breakdown of each waste type generated, volume, mass and expected dose rates,

t) Supply of specialized equipment and tools,

u) List of general tools required.

The scope of supply does not include the following (*Employer* supply):

v) For all work performed in the controlled zone, Eskom will be responsible to provide generic rigging equipment, scaffolding and tools as available from the NAB tool store.

w) Decontamination of equipment and tools used for the installation,

x) The *Employer* will make available the plant (pressuriser), for heater removal and installation, in accordance with the applicable outage schedule.

y) The *Employer* will make available the plant for inspection walk downs in a suitable outage preceding the implementation outage.

z) The *Employer* will allow access to the Koeberg main documentation centre for retrieval of the archived design base documentation for the purposes of the scope as defined in this TRS.

aa) NNR licensing activities.

bb) Development of a Radiation Waste plan.

2.1.1 Purpose

Provision of technical requirements associated with the designated modification project at Koeberg Nuclear Power Station.

2.1.2 Applicability

This document shall apply throughout Nuclear Engineering and Koeberg Operating Unit.

2.1.3 Effective date

This document is effective from the date of authorisation.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs unless otherwise specified.

2.2.1 Normative

Regulatory

[1] NNR RD-0034: Quality and Safety Management Requirements for Nuclear Installations

[2] OHS Act: Occupational Health and Safety Act No. 85 of 1993

[3] PER: Pressure Equipment Regulations of the Occupational Health and Safety Act No. 85 of 1993

[4] SANS 347: Categorization and Conformity Assessment Criteria for All Pressure Equipment

Quality

[5] 238-101: Quality and Safety Management Requirements for Nuclear Suppliers Level

[6] ASME NQA-1: Quality Assurance Requirements for Nuclear Facility Applications

[7] ISO 9001: Quality Management Systems 1

[8] SANS 3834: Quality requirements for fusion welding of metallic materials

Mechanical

[9] ASME III: ASME Boiler and Pressure Vessel Code, Section III Division 1 – Subsection NB, Class 1 Components, Edition/ Addenda as permitted by reference [21]

[10] ASME XI: ASME Boiler and Pressure Vessel Code Section XI: Rules For In-service Inspection Of Nuclear Power Plant Components 2007 edition including addenda up to 2008

Electrical

[11] IEEE 323-2016: IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

[12] IEEE Std 344: Recommended Practice for Seismic Qualification of Class 1E Equipment Nuclear Power Generating Stations

[13] IEEE 383-2015: IEEE Standard for Qualifying Electric Cables and Splices for Nuclear Facilities

[14] KBA0915K09016: 1000V Cables for Design Base Accident Conditions

[15] KBA0915K09031: Electrical Qualification ADR MV, LV and Control Cables

[16] SANS 10142-1: Wiring of Premises. Part 1: Low voltage installations

2.2.2 Informative

Koeberg – General

[17] 240-127002040: Procurement Quality Engineering Requirements (KSA-089)

[18] 240-86973501: Engineering Drawing Standard – Common Requirements

[19] 240-89294359: Nuclear Safety, Seismic, Environmental, Quality, Importance and Management System Level Classification Standard (KSA-010)

[20] 331-170: Requirements for Protective Coatings for use at KNPS (KSA-106)

[21] 331-172: Standard for Repair / Replacement of Installed Mechanical Components (KSA- 031)

[22] 331-186: Environmental Qualification at Koeberg Operating Unit

[23] 331-86: Design Changes to Plant, Plant Structures or Operating Parameters (KAA-815)

[24] 331-93: Guide for Classification of Plant Components, Structures and Parts (KGA-003)

[25] 331-94: Importance Category Classification Listing (KLA-001)

[26] 36-943: Drawing Standard

[27] K10000663N: National Nuclear Regulator Letter dated 30 July 2012. Title: Eskom Modification Process – Updated Regulatory Requirements

[28] KAA-501: Project Management Process for KNPS Modifications

[29] KAA-648: Administration and Responsibilities for Requalification Testing

[30] KAA-709: Process for Performing Safety Evaluations, Screenings, and Safety Justifications

[31] KAM-038: Process for Repair / Replacement of Installed Mechanical Components

[32] KBA0000G001000: Koeberg Nuclear Power Station Graphic Symbols

[33] KBA0901G00256: Nuclear Island Room Identification

[34] KBA1222F00001: Equipment marking

[35] KFA-006: Testing Procedure For Plant Modifications

[36] KGA-025: Screening And Safety Evaluation Guide

[37] KGH-007: Radiation Protection Use and Control of Temporary Lead Shielding

[38] KLA-023: Outage Preparation Milestone Checklist

[39] KNM-001: Maintenance Welding Programme

[40] KSA-011: Requirements for Controlled Documents

[41] KSA-037: Qualification and Certification Requirements for Personnel Performing NDT at the Nuclear Portfolio

[42] KSA-132: Lifting and Rigging Program

Koeberg – Project Specific

[43] 240-83539994, rev. 2: Standard for Non-Destructive Testing (NDT) on Eskom Plant

[44] 240-86973501, rev. 3: Engineering Drawing Standard – Common Requirements

[45] 32-226: Requirements and Rules for Radiation Protection and the Safety of Radiation Sources

[46] 32-227: Radiation Protection and the Safety of Radiation Sources

[47] 331-433, rev. 2: Detailed Design review report (KFU-026)

[48] DSG-318 087, Rev. 1: *Contractor* Quality Requirements For The Procurement Of Assets Goods And Services

[49] GGS 1302: Optimisation of Radiation Protection

[50] GGS 1315: Requirements for Radiation Workers

[51] GGS1303: Dose Limits

[52] GGS1304: Operational Radiation Protection

[53] KAA 637: Access Control to Radiological Controlled Zones

[54] KAA-632: ALARA Programme

[55] KAA-913: Integrated Equipment Reliability Process

[56] KAE-012: Hazardous and Non-Hazardous Waste and Scrap Disposal

[57] KAH-002: Radiation Surveillance Programme

[58] KBA0000G001000 Z2: Koeberg Nuclear Power Station Graphic Symbol

[59] KBA0022CHEMSPEC00: Koeberg Chemistry Specifications rev. 1

[60] KBA-0028 NES MA ISI 02 : ISI Programme Requirements

[61] KBA1207E00002: RCP Pressuriser Equipment Specification

[62] KBA1207E00061: Modal 40 Pressurizer Equipment Maintenance and Operating Manual

[63] KBA1217RCP003: DSE Reactor Coolant System Chapter 3 General Design

[64] KBA1222D0004, rev. 2: Thermal Insulation Technical Specification

[65] KFA-006, rev. 5: Testing Procedure For Plant Modifications

[66] KGU-013: Guide for the Use of Lead Blankets for Temporary Radiation Shielding

[67] KSA 048: Management of the Solid Radioactive Waste Programme

[68] KWH S-037: Classification of solid radioactive materials and the acceptable on and off site packaging requirements for such materials

[69] KWH-AL-004: Radiation Protection Formal ALARA Programme Criteria, Actions and Documentation

[70] QFR-026, rev. 0: Maintenance Strategy Input Sheet

[70] SAR Koeberg SAR Part II Chapter 1.11: Environmental Qualification of Electrical Equipment for Accident Conditions in the Containment

[71] SAR Koeberg SAR Part II Chapter 3.2: General Precautions Taken To Ensure Integrity Of The Main Reactor Coolant System (RCP)

[72] SOW: Scope of Works for Modification 13028

2.3 Definitions

2.3.1 Confidential: the classification given to information that may be used by malicious/opposing/hostile elements to harm the objectives and functions of Eskom Holdings Limited.

2.3.2 ***Contractor***: service provider, consultant or supplier that has been deemed successful (via a tender process) to provide the required service.

2.3.3 Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.3.4 Public domain: published in any public forum without constraints (either enforced by law, or discretionary).

2.3.5 Requirement: A condition or capability needed by a user to solve a problem or achieve an objective.

2.3.6 Scope of Supply: The sum of the products, services, and results to be provided as a project.

2.3.7 Secret: the classification given to information that may be used by malicious/opposing/hostile elements to disrupt the objectives and functions of Eskom Holdings Limited.

2.3.8 Shall, should, may: “Shall” is used to denote a requirement, “should” a recommendation and “may” to denote permission.

2.3.9 Top Secret: the classification given to information that may be used by malicious/opposing/hostile elements to neutralize the objectives and functions of Eskom Holdings Limited.

2.3.10 Trigramme: Koeberg labelling system that consists of a unit number followed by three alphabetic characters identifying a system, followed by a three-digit number, followed by two letters (bigramme) indicating a component.

2.3.11 Acceptance: The *Employer’s* use of this word on the *Contractor’s* documentation (including drawings, procedures, schedules, and so on) means that the *Employer* has observed no deviation from the requirements of this specification. The *Employer’s* acceptance does not relieve the *Contractor* of its obligation to adhere to all the requirements of this specification and all applicable laws and regulations. The *Employer’s* acceptance shall not relieve the *Contractor* of any responsibility for sufficiency, accuracy, or quality of workmanship.

2.3.12 Accepted with Comments: Indicates that changes or clarifications are required to the document in order to satisfy the requirements of this specification or the quality expectations of the *Employer*. The *Contractor* is expected to incorporate the *Employer's* comments and resubmit the document to the *Employer* for acceptance prior to implementation unless specifically identified by the *Employer* as approved with comments, fabrication can proceed. The *Employer's* acceptance to proceed with fabrication does not relieve the *Contractor* of its obligation to adhere to all the requirements of this specification and all applicable laws and regulations. The *Employer's* acceptance to proceed with fabrication shall not relieve the *Contractor* of any responsibility for sufficiency, accuracy, or quality of workmanship.

2.3.13 Not Accepted: Indicates that the document as submitted does not satisfy the requirements of this specification or the quality expectations of the *Employer*. The *Employer* shall provide a reason (not necessarily specific comments) for not accepting the document. If the *Employer* requires the document, the document shall be revised and resubmitted for acceptance. The document cannot be used for fabrication until it has been dispositioned by the *Employer* as accepted or accepted with comments,

2.3.14 Class A (or Class 3) Non-conformance: Submitted to the *Employer* for Approval.

- Non-conformance from the Contract Document, plus agreed amendments, or the *Employer* Specifications.
- Non-conformance from data submitted in accordance with statutory codes and/or regulations.
- Non-conformance from *Contractor* specifications that have been approved by the *Employer*.
- Where the Non-conformance affects a terminal point, the mating part of which is not in the *Contractor's* scope of supply.
- Non-conformance that affects interchangeability of parts between components where this has been contractually agreed or defined in the *Contractor* documents submitted to the *Employer*.

2.3.15 Class B (or Class 2) Non-conformance: Submitted to the *Employer* for Review.

- Non-conformance that affects standard operating, maintenance and post installation inspection procedures.
- Non-conformance that affects the ordering of spares.

2.3.16 Class C (or Class 1) Non-conformance: Submitted to the *Employer* for Information and Acknowledgment.

- Any Non-conformance not covered by Class A or B above.

2.4 Abbreviations

Abbreviation	Explanation
AR	Availability Related
ASME	American Society of Mechanical Engineers
CSR	Critical Safety Related
DSE	System Description Manuel (Dossier du Système Élémentaire)
FAT	Factory Acceptance Test
FMEA	Failure Modes and Effects Analysis
FP	Full Power
FRS	Functional Requirement Specification
HMI	Human Machine Interface
HWI	Heater Well Insert
KNPS	Koeberg Nuclear Power Station
MM	Maintenance Manual
NC	Non Classified
ND	Non Destruct
NEV	No Environmental Classification
NNR	National Nuclear Regulator
NSF	No Safety Function
NSSS	Nuclear Steam Supply System
OE	Operating Experience
OEM	Original Equipment Manufacturer
ORT	Operating at Reduced Temperature
OTS	Operating Technical Specification
PSI	Pre-Service Inspection
QA	Quality Assurance
QADP	Quality Assurance Data Package
QC	Quality Control
QCP	Quality Control Plan
RP	Radiation Protection
SR	Safety Related
SWP	Site Work Package
TRS	Technical Requirement Specification

2.5 Roles and Responsibilities

Not applicable.

2.6 Process for Monitoring

Not applicable.

2.7 Related/Supporting Documents

Not applicable.

3. Existing Design

In the reactor coolant system (RCP), the pressuriser is a pressure vessel in which liquid and vapour can be maintained in equilibrium under saturated conditions for pressure control purposes. The base of the pressuriser is equipped with banks of electrical heaters, referred to as the pressuriser heaters, which have the function of maintaining the pressuriser at the saturation temperature (T_{sat}) corresponding to the RCP system pressure. The centre of the pressuriser upper head is equipped with a spray nozzle connected to a spray line. The spray line is connected to two RCP system cold legs.

The RCP system pressure is controlled by either increasing power to the heaters to increase the saturation conditions or by spraying water into the steam space to condense some steam and reduce saturation conditions.

Three pneumatically operated pressure relief valves and three safety valves that protect the RCP system against over-pressure conditions are located on the top of the pressuriser.

The purpose of the pressuriser is as follows:

a) It maintains the RCP system pressure at its setpoint value of 15,4 MPa in order to avoid any boiling in the RCP system coolant,

b) It acts as a surge tank for the RCP system in absorbing volume changes as the temperature changes,

c) Relieves high-pressure steam in emergency conditions by means of relief valves,

d) To limit and compensate for variations in RCP system pressure during operation.

The Koeberg pressuriser heaters were manufactured by SODERN in France. These heaters are manufactured by wrapping the insulation (magnesium oxide) and heating element in an austenitic stainless steel sheath (316 and 316L). The sheath is mechanically worked (crimped) to ensure good contact between the sheath and the insulation. This mechanical working or cold working results in high residual tensile stresses in the heater sheath.

The heater is inserted through the heater well insert (HWI) and welded at the lower extremity of the HWI.

The heaters are supported in the pressuriser by a lower and an upper support plate. These plates are designed to maintain the position of the heaters and to distribute flow evenly during pressuriser in-surges.

There are 78 penetrations in the bottom head. Of the 78 penetrations, 68 contain heaters. 60 heaters are operational and 8 are spare. In the event that an operating heater fails, it is electrically isolated and a spare heater is connected. There are two types of heater, i.e. proportional and ON-OFF. The proportional heaters remain energised for normal operation to maintain pressuriser pressure. The ON-OFF heaters remain de-energised under normal operation until there is a plant condition/transient with pressure reduction requiring activation of the ON-OFF heaters.

3.1 Electrical:

The existing pressuriser heaters are arranged around the surge line nozzle and divided into 6 groups (4 groups with fixed heaters and two groups with variable heaters):

3.1.1 Fixed Heaters (4 groups):

a) RCP 001RS comprising 9 elements with a total power of 216 kW
b) RCP 002RS comprising 9 elements with a total power of 216 kW
c) RCP 005RS comprising 12 elements with a total power of 288 kW
d) RCP 006RS comprising 12 elements with a total power of 288 kW

RCP 005 and 006RS are supplied from the essential boards and are therefore diesel backed. The four groups of fixed heaters are mainly used during start-up of the unit but they can also be used to control the pressure, (pressure control system).

3.1.2 Variable heaters (2 groups):

a) RCP 003RS comprising 9 elements with a total power of 216 kW
b) RCP 004RS comprising 9 elements with a total power of 216 kW

The variable heaters are in service continuously during normal operation. In this steady state condition the heater output is approximately 50% to compensate for heating of the continuous spray flow and heat losses to ambient.

3.1.3 Automatic Actions:

During normal operation the heaters are controlled by the pressuriser pressure control chain (RCP 014MP) in order to maintain RCP system pressure at its setpoint of 15,4 MPa (reference pressure).

3.1.3.1 Actions on pressure increase:

a) An increase in RCP system pressure will linearly decrease the output of the variable heaters,
b) When the RCP system pressure increases to 105 kPa above the reference pressure, the variable heaters will be at 0% power.

3.1.3.2 Actions on pressure decrease:

a) A decrease in RCP system pressure will linearly increase the output of the variable heaters,
b) A RCP system pressure decrease to 105 kPa below the reference pressure, will cause the variable heaters to be switched to 100% and at a further drop to 170 kPa below the reference pressure, all fixed heaters will be energised and an alarm (RCP 443AA) will be generated.

3.2 Electrical Supplies:

The existing RCP heaters are supplied from 380 V ac boards on the 7.00m level of the electrical building.

Equipment	Supply Breaker	Cell Number	Voltage/Description
RCP 001RS RCP 002RS		LKC 101 LKB 205	380 V ac Non-essential supplies to the Pressuriser back up (fixed) heaters groups 1 & 2.
RCP 003RS RCP 004RS		LKA 103 LKB 207	380 V ac Non-essential supplies to the Pressuriser variable heaters groups 3 & 4.
RCP 105RS RCP 205RS RCP 106RS RCP 206RS		LLC 107 LLC 105 LLD 105 LLD 103	380 V ac Essential supplies to the Pressuriser back up (fixed) heaters groups 5 and 6.

4. Problems with Existing Design

EDF has identified a risk of pressure boundary leakage as a result of failure of pressuriser heater sheaths. There are presently no inspection techniques or mitigative actions that can be taken to detect initiation of degradation or assure heater integrity and functionality until the end of design life.

Koeberg has Thermocoax heaters which have been designed, manufactured, installed and operated in a similar manner to those in EDF, and therefore the risk of heater sheath and sleeve failure exists before the end of the 40 year equipment design life.

5. Design Change Requirements

The existing heaters on both pressurisers at KNPS will be replaced by new, improved items in order to eliminate the risk of RCP system pressure boundary leakage as a result of heater sheath degradation.

The replacement heaters will be designed to fit into the existing pressuriser HWIs.

A detailed requirements matrix containing all requirements associated with the design change is provided in Appendix A. Supporting information is provided in the sections below.

5.1 Normal Operating Conditions (System Parameters)

Working pressure	:	15,4 MPa	[62]
Working temperature	:	344,27°C (T_{sat} @ 15,4 MPa)	[62]
Radiation	:	250 kGy for normal operation during the forty years operating life of the unit.	[70]
Humidity	:	100%	[70]

5.2 Accident Conditions (System Parameters)

Working pressure	:	0,55 MPa (abs) at the start	[70]
Working temperature	:	156°C (abs) maximum at the start	[70]
Radiation	:	Rate between 150 and 750 kGy/h	
		integrated dose 600 kGy	[70]
Humidity	:	100%	[70]

5.3 Classification

5.3.1 Component electrical classification

Components	Classification number	Safety Class	Seismic Class	Environmental Class	Quality Level	Importance Class
1/2 RCP 001 RS	0427/87Q	NSF	NC	1	Q3	SR
1/2 RCP 002 RS	0427/87Q	NSF	NC	1	Q3	SR
1/2 RCP 003 RS	0427/87Q	NSF	NC	1	Q3	SR
1/2 RCP 004 RS	0427/87Q	NSF	NC	1	Q3	SR
1/2 RCP 005 RS	0427/87Q	1E	1A	4	Q1	CSR
1/2 RCP 006 RS	0427/87Q	1E	1A	4	Q1	CSR

5.3.2 Component mechanical classification

Components	Classification number	Safety Class	Seismic Class	Environmental Class	Quality Level	Importance Class
1/2 RCP 001 RS	M0008/21C	1	1	NEV	Q1	CSR
1/2 RCP 002 RS	M0008/21C	1	1	NEV	Q1	CSR
1/2 RCP 003 RS	M0008/21C	1	1	NEV	Q1	CSR
1/2 RCP 004 RS	M0008/21C	1	1	NEV	Q1	CSR
1/2 RCP 005 RS	M0008/21C	1	1	NEV	Q1	CSR
1/2 RCP 006 RS	M0008/21C	1	1	NEV	Q1	CSR

5.3.3 Service classification

Services	Classification number	Quality Level	Importance Class	RD-0034 Level
Design service	0011/99Q	Q1	CSR	L1
Installation service(s)	0027-95Q	Q1	CSR	L1

5.4 Chemical Characteristics of Process Fluid(s)

Parameter	Process Fluid 1 / RCP System	
	Value	Reference
Conductivity	Determined by boric acid and lithium concentrations	[71]
pH @ 296°C	Determined by boric acid and lithium concentrations	[71]
Pressuriser Boron	ΔB < 50 mg B/kg	[71][59]
Dissolved Oxygen	less than 0.10 mg O2/kg	[71][59]
Dissolved Hydrogen	20 to 50 ml H2/kg water, at STP (desired value: 25 to 35 ml H2/kg)	[71][59]
Lithium	< 3.68 mg Li/kg	[71][59]
Chloride	less than 0.15 mg Cl/kg	[71][59]
Fluoride	less than 0.15 mg F/kg	[71][59]
Sulphate	less than 0.15 mg SO_4/kg	[71][59]
Solids in suspension	< 50mg/kg	[71][59]

5.5 General Requirements

5.5.1 The *Contractor* shall provide a detailed design document, in accordance with the requirements of 331-86 [23], on the prescribed Employer template. The design document must describe the following:

a) Mechanical and electrical design for the replacement heaters;

b) Removal of the existing pressuriser heaters;

c) Mechanical and electrical design for replacement heater installation on the existing pressurisers;

d) All testing and commissioning of the replacement heaters and modified system.

5.5.2 The *Contractor* must ensure that all design interfaces such as civil, mechanical, thermo-hydraulic, electrical and control and instrumentation connections are fully compatible with the existing plant and systems in use. Deviations shall be submitted to the Employer for acceptance.

5.5.3 The design shall comply with all references stated in this specification. The latest authorised revisions at the time of Contract award shall be used, unless editions or revisions are stated by the *Employer*.

5.5.4 The equipment and components supplied under this TRS shall conform in all respects with applicable International codes, standards and regulations.

5.5.5 The equipment and components supplied under this TRS shall be designed and manufactured as direct replacements for the existing pressuriser heaters at KNPS, with similar electrical and mechanical interfaces.

5.5.6 As a minimum, the equipment and components supplied under this TRS shall be designed and manufactured in accordance with the edition and addenda of the codes, standards, and regulations identified in section 2.2.1 of this specification. A detailed reconciliation report, in accordance with references [9] and [21] shall be supplied if an *Employer* approved code other than ASME Section III is used for the mechanical design of the replacement heaters.

5.5.7 The requirements of this specification shall take precedence if they are more stringent than the requirements specified in the applicable codes, standards, and regulations

5.5.8 The *Contractor* shall comply with the Pressure Equipment Regulations [3] under the South African Occupational Health and Safety Act 85 of 1993 [2] as it relates to the design, manufacture, modification, construction, erection, commissioning, testing, and certification of pressure equipment.

5.5.9 The *Contractor* shall comply with the requirements of SANS 347 [4].

5.5.10 The *Contractor's* local (SA) representative shall be considered as the importer in terms of SANS 347 [4]

5.5.11 Initial design drawings shall be submitted for review and acceptance by the *Employer* as part of the design. Manufacturing shall not proceed before these drawings are accepted by the *Employer*.

5.5.12 A complete set of post manufacturing "as built" drawings for the replacement pressuriser heaters shall be provided as part of the QADP.

5.5.13 A complete set of post installation "as built" drawings for the replacement pressuriser heaters shall be provided as part of the QADP.

5.5.14 Welding compatibility between the replacement pressuriser heaters material and existing pressuriser HWI material shall be considered.

5.5.15 The *Contractor* shall verify, by performing a detailed plant walk down before using the information, that the general layout drawings represent the actual plant design layout. Any deviations must be reported to the *Employer*.

5.6 Equipment Qualification Requirements

The *Contractor* is to supply a quality assurance data package (QADP) for the replacement of the RCP pressuriser heaters.

The QADP shall include, but not limited to, the following documentation for the replacement pressuriser heaters:

5.6.1 Certificate of conformance;

5.6.2 Certificate of manufacture;

5.6.3 Copy of Eskom order;

5.6.4 Copy of the specifications;

5.6.5 Manufacturing QCP;

5.6.6 Material certificates;

5.6.7 Welder qualification and certificates;

5.6.8 Weld qualifications;

5.6.9 NDE/NDT reports;

5.6.10 PSI reports;

5.6.11 Hydrotest procedure;

5.6.12 Hydrotest reports;

5.6.13 Dimensional report ensuring that the heaters can be fitted to KNPS RCP systems' pressurisers;

5.6.14 Eskom waivers (if applicable);

5.6.15 Non-conformance reports;

5.6.16 Final supplier QA release; and

5.6.17 The Certified Material Test reports (CMTRs) shall be supplied as part of the QADP.

5.6.18 A detailed Code Reconciliation Report to ASME III NB shall be supplied if an Employer approved code other than ASME III is used.

5.6.19 Seismic qualification report;

5.6.20 Proof of qualification shall be supplied with the environmental qualification test reports. The cable is classified as Class 1E and shall be qualified by testing in accordance to IEEE Standard 323 and 383 for use in a harsh environment. K1 qualification in accordance to RCC-E, Design, and construction rules for nuclear island electrical equipment may be considered;

5.6.21 Installation QCP;

5.6.22 End of Manufacturing Report.

6. Quality Assurance and Inspection Requirements

6.1 Quality Assurance Program

6.1.1 The *Contractor* shall be qualified in accordance with DSG-318 087 Rev. 1 [48] to perform RD 0034 Level 1/Q1 work in accordance with classifications contained in section 5.3.

6.1.2 The *Contractor,* and its subcontractors, shall have a Quality Management System that conforms to the applicable requirements of ISO 9001:2015.

6.1.4 The *Contractor* shall identify, in purchase documents to subcontractors, all applicable quality and QA requirements imposed by the *Employers* specification on the *Contractor* and shall ensure compliance thereto.

6.1.5 The *Contractor* shall provide Quality Control Plans (QCP's) as well as Inspection and Test Plans (ITP's) to the *Employer* for review and acceptance for various phases of all works carried out prior to commencement of the works. The *Employer* reserves the right to add hold and witness points.

6.1.6 The *Employer*, the *Employer* Quality Control (QC) representative and the *Contractor* shall review these QCP's/ITP's jointly and the actual scope of quality control and inspection required for the *Contract* agreed upon.

6.1.7 The *Contractor* shall submit an updated copy of the QCP's and ITP's.

6.1.8 At least one of the *Contractor* engineering personnel required to sign as Compiler, Reviewer or Approver of documents and drawings, for the required processes in KAA-501 [28] and 331-86 [23], shall be a registered professional engineer or equivalent, as approved by the *Employer* in accordance with ECSA guidelines.

6.1.9 The *Contractor* is hereby informed that any work product arising from this specification may be submitted to the National Nuclear Regulator or other regulatory bodies as required by South African laws and regulations

6.1.9 *Contractor* personnel performing the design and installation work shall be qualified by means of formal technical qualifications and have sufficient experience with work of similar nature.

6.1.9 *Contractor* personnel performing the design and installation work shall be qualified by means of formal technical qualifications and have sufficient experience with work of similar nature.

6.1.10 All test certificates and documentation shall be in English, using SI units.

6.2 Inspections

6.2.1 The *Employer* shall have the right to establish inspection and hold points for which the *Contractor* shall give advance notification. In addition, the *Employer* can establish temporary notification points to ensure resolution of temporary quality problems.

6.2.2 Mandatory hold points are considered to be those tests, inspections, and operations which require witnessing by the *Employer's* Quality Representative (EQR) and beyond which operations shall not proceed without written consent of the *Employer*.

6.2.3 Witness points are critical steps in manufacturing and testing where the *Contractor* and subcontractors are required to notify the *Employer* in advance of the activity so it can be witnessed. The *Contractor* and subcontractors can proceed with work past the activity if the EQR is not available at the designated time.

6.2.4 Shop inspection performed by the *Employer* shall not relieve the *Contractor* of its obligation to maintain an adequate test, inspection, and documentation program or any other obligation under this specification. Furthermore, the fact that the EQR might inadvertently overlook a deviation from some requirement of this specification shall not constitute a waiver of that requirement nor the *Contractors* obligation to correct the condition when it is discovered nor any other obligation under this specification.

6.3 Non-conformances

6.3.1 No deviation from applicable codes and standards is acceptable. Furthermore, no deviation or departure from any requirement of this specification is acceptable without written approval from the *Employer*.

6.3.2 The *Contractor* shall promptly document and notify the *Employer* of all non-conformances from the specification and proposed remedial actions.

6.3.3 Non-conformance shall be identified as correctable or uncorrectable. Uncorrectable non-conformances are considered to be conditions that cannot be corrected within the specification requirements by rework or replacement.

6.3.4 Requests for deviations from codes and standards are not permitted.

6.3.5 All non-conformances shall be classified in three categories, Class A, Class B or Class C. The *Employer* has the right to reject an assigned classification after being notified of the non-conformance by the *Contractor*. Refer to definitions of non-conformance classes in section 2.2.

6.3.6 The *Employer* shall be notified of any Class A and B non-conformances immediately. All Class A non-conformances shall be submitted to the *Employer* for review and approval by the *Employer's* Engineering Representative, and Class B non-conformances shall be submitted to the *Employer's* Engineering Representative for review of the classification and acceptance of the recommendation. Class C non-conformances shall be reported to the *Employer's* Engineering Representative for information and acknowledgment of receipt.

6.3.7 The *Employer* reserves the right to reject a component following the assessment of any Class A non-conformance.

6.3.8 The non-conformance register and all closed non-conformances, inclusive of all engineering work, justifications, corrective actions history and *Contractor* and *Employer* approvals, shall be part of the End of Manufacturing report.

6.3.9 All subcontractor non-conformances shall be reported, addressed and managed as stated above.

7. Site Work Requirements

7.1 Spares and Special Tools

7.1.1 The *Contractor* shall ensure that all special tools are provided, as required, for the removal of the old pressuriser heaters and installation of the new heaters.

7.2 Rigging Requirements

7.2.1 The *Contractor* is responsible for all rigging and lifting requirements to implement the works as required in this specification.

7.2.2 All rigging and lifting operations of suspended loads shall be in accordance with and comply with requirements listed in the *Employer's* Lifting and Rigging Programme [42].

7.2.3 The *Contractor* shall submit comprehensive Lift Plans in accordance with KSA-132 [42] for each lift. The dimensions and masses of components / assemblies to be rigged shall be clearly indicated. The Lift Plans shall be compiled and documented in a Rigging File. Also included in the Rigging File should be the rigging personnel qualifications and certification and the rigging and lifting equipment inspection certificates.

7.2.4 The Rigging File must be submitted to the *Employer* for review and approval before any rigging and lifting activities commence.

7.3 Inspection and Testing Requirements

7.3.1 The *Contractor* shall be responsible for the performance of all tests in accordance with ASME Section V and other applicable Codes and Standards plus all additional requirements of this TRS. The *Contractor* shall be responsible for furnishing all facilities necessary for the performance of such tests.

7.3.2 All Non Destructive Testing (NDT) done must comply with the following *Employer* standard:

240-83539994: Standard for Non-Destructive Testing (NDT) on Eskom Plant [43].

7.3.3 Prior to the performance of any test, the *Contractor* shall submit copies of the test procedures to the *Employer* for review and approval. Testing shall not commence until the *Contractor* has received a copy of the procedure that has been approved by the *Employer* and all of the *Employer's* comments have been incorporated.

7.3.4 All instrumentation and equipment used for the performance of any test shall be calibrated. The calibration standard shall be traceable to the National Bureau of Standards. Furthermore, the instrumentation shall be of the appropriate range and shall be certified to have the accuracy required by the procedure. The calibration and accuracy shall be marked on the instrument, and full documentation shall be available for review.

7.3.5 All pressure gauges used for the hydrostatic testing must have a calibration certificate. Gauge calibration certification validity is a period of maximum 6 months. Gauges to be calibrated by approved SANAS laboratory, or equivalent if abroad.

7.3.6 Material test certification and reports as specified in this specification shall be included as part of the End of Manufacture report.

7.3.7 The following tests shall be required as a minimum for all material supply:

a) Chemical analysis

b) Tensile testing. This is not required at temperature unless the applicable material or design code requires it.

c) Notched bar impact testing

d) Ultrasonic testing as required by material specification.

e) Liquid penetrant testing is required on all weld preparations to ensure sound material will be welded on. MPI testing can also be used.

7.4 Welding Requirements

7.4.1 All welders shall be qualified to either ASME Section IX or EN ISO 9606-1 requirements, as required by the applicable code or standard.

7.4.2 All on-site welding and brazing shall comply with the requirements given in ASME Section III or the *Contractor's* construction code as applicable and ASME Section XI. In addition, all welding repair/replacement activities shall comply with KNM-001 [39] as well as SANS 347 [4].

7.4.3 Welding procedure specifications (WPS) shall comply with the requirements of KNM-001 [39] and 331-172 [21].

7.4.4 Each WPS shall specify the design details of the weld geometry as per design drawing or weld map.

7.4.5 All welding documentation will be subject for approval by the *Employer's* welding Engineer, to current *Employer* requirements as set out in the *Employer's* Maintenance Welding Program [39] . Welding can be performed using only procedures that have been reviewed and approved by the *Employer* for the application. The welding documentation shall be compiled and documented in a welding file/databook.

7.4.6 The weld repair rate shall be tracked on a daily basis and reported to the *Employer*.

7.4.7 The *Employer* shall be notified of all major weld defects and defects identified. Major defects are defined as imperfections that exceed 25 % of the wall thickness. Weld defects shall be removed by chipping or grinding to sound metal. The area shall then be examined using magnetic particle inspection (ferritic materials) or liquid penetrant inspection (non-magnetic materials) to verify that the defect has been satisfactorily removed prior to repair welding.

7.4.8 The *Employer's* standards and procedures listed in KNM-001 are applicable and must be complied with for all on-site welding activities [39] .

7.4.9 The following documentation shall be added to the databook for all pressure bearing parts:

a) Welder performance qualifications

b) Procedure qualification records

c) Welding procedure specifications

d) Certified welding material test reports

7.4.10 The Contractor responsible for on-site welding must be SANS 3834-2 [8] certified.

7.5 Lagging Requirements

7.5.1 The *Employer* is responsible for the removal of the cladding and mineral wool insulation from the associated equipment for the execution of the work as described in this TRS.

7.5.2 The *Employer* is responsible for the reinsulating of the associated equipment. New cladding must be provided if the old cladding do not fit the new line geometry. The re-insulation shall conform to the *Employer* specification KBA1222D0004 [64].

7.6 Shielding Requirements

7.6.1 To apply the ALARA policy, the application of temporary shielding shall be required. The material for the shielding shall be supplied by the *Employer* but the management of the shielding shall be under the *Contractor* responsibilities.

7.6.2 However, the *Employer* RP representatives shall always be included in the engineering process. The temporary shielding shall only be installed once an engineering evaluation has been performed and acceptance for its use has been provided by the *Employer* RP representatives.

7.6.3 A Temporary Shielding Log Book shall be written by the *Contractor* indicating the status of the temporary shielding for its activities. The installation shall be controlled by the RP Decontamination Supervisor during the work. The documents KGH-007 [37] and KGU-013 [66] describe all the requirements related to the temporary shielding.

7.7 Decontamination of Equipment and generated waste

7.7.1 Preferences shall go to the process developed by the *Contractor* that has proven to function well during former Pressuriser Heater Replacement projects (process AND equipment);

7.7.2 Preferences shall go to the process developed by the *Contractor* that minimise the costs of the waste treatment for final storage;

7.8 ALARA Approach for the Pressure Heater Replacement Project

7.8.1 The ALARA approach and the responsibilities relating to optimisation of radiation shall be implemented in accordance with the *Employer's* Policy 32-227 [46] and the *Employer's* standard 32-226 [45] relating to radiation protection and safety of radiation sources.

7.8.2 The ALARA policy shall be applied to all components during planning, design, modifications and operation (see GGS 1302 [49]).

7.8.3 The process and responsibilities are described in the procedure KAA-632 [54].

7.8.4 The responsibilities for the control, qualification and authorisation of personnel requiring access to Radiological Controlled Zones are described in the document KAA-637 [53]. This document is applicable to all site personnel requiring access to Radiological Controlled Zones. The *Contractor's* personnel shall be considered as radiation workers (see GGS 1315 [50]). It imposes medical control and radioprotection training and certification.

7.8.5 For workers who do not work in the controlled area, basic radiation training shall be required.

7.8.6 A radiological controlled area shall be classified as a radiation zone if the estimated or measured occupational exposure to an individual exceeds 1 mSv per year.

The controlled areas are divided into four different types of working area which are:

a) a radiation zone shall be classified as a green zone when the ambient dose rate is greater or equal to 5 x 10-4 mSv/h but less than 2,5 x 10-2 mSv/h.

b) a radiation zone shall be classified as a yellow zone when the ambient dose rate is greater than or equal to 2,5 x 10-2 mSv/h but less than 1 mSv/h.

c) a radiation zone shall be classified as an orange zone when the ambient dose rate is greater than, or equal to 1 mSv/h but less than 10 mSv/h.

d) a radiation zone shall be classified as a red zone when the ambient dose rate is greater than, or equal to 10 mSv/h.

7.8.7 The *Employer's* RP shall have the final responsibility to authorise surveys that are realized in the different zones (see document KAH-002 [57]).

7.8.8 For the Pressurizer Heater Replacement project, collective dose estimation, collective dose follow up, and ALARA plans shall be required by the *Employer* for each activity or groupings of activity.

7.8.9 According to the calculated dose, the activities shall be classified in four different categories. This classification shall define the requirements applicable to the activities. These are described in the document KWH-AL-004 [69]. The dose rate shall be updated daily. The *Employer* shall put at disposal a detailed listing of the doses per worker.

7.8.10 The *Contractor* shall split the doses per activity and work area.

7.9 Radioactive Material Control Program

7.9.1 All equipment entering the controlled zone shall be controlled before any clearance. If any doubt exists about releasing the equipment, no clearance shall be given. The conditions for an unconditional release shall be as follows (see GGS 1304 [52]):

a) The alpha surface contamination is less than 3,7 x 10-2 Bq/cm2 averaged over 300 cm² area;

b) The beta or gamma surface contamination does not exceed 3,7 x 10-1 Bq/cm2 averaged over 300 cm² area.

c) Once the material is cleared, it can be collected at the Radioactive Material Exit Point.

7.9.2 All equipment hot containers brought to the site at Koeberg shall require radiological and contamination surveys with full inventory lists taken before departure to South Africa.

7.9.3 The transfer of radioactive material shall require a specific ALARA review. The control rooms affected by the transport shall be notified because it can activate the alarms.

7.9.4 Before any storage, the contamination level shall be under 5000 ccpm and with no smearable contamination.

7.9.5 The *Contractor* shall follow the requirements in terms of waste packing. All these requirements are explained in further detail in the document KWH S-037 [68].

7.10 Radiation Dose Limitations

7.10.1 The maximal allowed dose for a nuclear co-worker shall be 20 mSv per year; averaged to 5 years (100 mSv), with a further provision that the effective dose shall not exceed 50 mSv in any single year. The different type of exposure are described in the document GGS 1303 rev. 0 [51].

7.10.2 The *Contractor* and his Sub-Contractors shall be responsible for their personnel management. When a worker is no longer accepted in the controlled area (dose too high, no more dose credit), the *Contractor* or his Sub-Contractors must be able to replace this worker without any delay. The *Contractor* and his Sub-Contractors shall pay special attention to the exposure of the highly qualified personnel that they set at work.

8. Commissioning and Performance Testing

8.1 Commissioning

8.1.1 It is the *Contractor's* responsibility to perform the commissioning in accordance with the agreed commissioning procedures in the design document and to conform to this TRS.

8.1.2 The *Contractor* shall submit a full commissioning plan in accordance with KFA-006 [35] and KAA-648 [29] and shall be submitted to the *Employer* for acceptance.

8.1.3 The *Contractor*, with the assistance of the *Employer's* commissioning team, is responsible for commissioning.

8.1.4 It is the *Contractor's* responsibility, with the assistance and input from the *Employer's* commissioning team, to establish project commissioning policies and plans which cover:

a) Approval of commissioning programs and procedures.

b) The coordination of the *Contractor's* commissioning interfaces.

c) The scheduling and progressing of commissioning activities.

d) The availability of manpower, plant, material and equipment resources.

e) Safety assurance and statutory requirements.

f) The completion of contractual obligations.

g) Any other relevant commissioning issues.

h) Review and integration of the *Employer's* existing commissioning programs and procedures.

i) Development of appropriate check lists.

j) Plan, implement and control the applicable commissioning activities.

k) Conduct inspections necessary for the issue of a completion certificate.

l) Ensure that defects are timeously rectified.

9. Documentation

9.1 General

9.1.1 The *Contractor* shall provide the *Employer* with detailed drawings of the replacement heaters as well as the post-installation configuration.

9.1.2 Drawings submitted to the *Employer* by the *Contractor* shall fulfil the *Employer* standard drawing practice as per 240-86973501 [18].

9.1.3 All symbols shall be used as specified in reference KBA0000G001000 [32].

9.2 Detailed Final Design

9.2.1 The *Contractor* shall provide the *Employer* with a detailed design document according to the requirements of 331-86 [23] that includes all information relating to the design, supply, installation, testing and commissioning of the modified system as required in this specification.

9.2.2 It is the *Employer's* preference to concur with the scheme design (Part A) before work commences on the installation and procurement specifications (Parts B and C). This is done to ensure agreement is reached, between the *Contractor* and the *Employer* and other stakeholders, on important technical design and manufacturing aspects and to facilitate approval of the final and complete deliverable.

9.2.3 The *Contractor's* Detailed Design shall contain all the requirements as stated in the *Employer*'s Detailed Design review report 331-433 (KFU-026) [47].

9.2.4 The detailed design shall be presented to the *Employer's* Design Engineering (DE) Group at Koeberg. The *Employer* shall review all design and technical documents completed by the *Contractor* for acceptance and thus also reserves the right to forward any such documents to third party reviewers as part of the *Employer's* internal procedures.

9.2.5 For the modification, as described in this TRS, an Equipment Reliability (ER) Preventative Maintenance (PM) strategy input sheet QFR-026 [70] must be populated by the *Contractor* in accordance with the *Employer* Integrated Equipment Reliability Process KAA-913 [55]. The *Employer* will use the populated QFR-026 form to initiate an ER change request in accordance with KAA-913.

9.2.6 The final design and design documents will be issued for review by the *Employer*. Only after all review comments have been successfully resolved and the document updated will the document be accepted and signed by the *Employer*.

9.2.7 The *Contractor* will be informed by the *Employer* when the final design is accepted.

9.2.8 Manufacturing may only proceed after acceptance of the relevant design documents.

9.3 Calculations, Reports, Models, Drawings, etc.

9.3.1 The *Employer* shall have complete and unrestricted ownership right to all calculations, technical reports, models, drawings, design documents, (except computer codes that constitute a pre-existing program or method and are designated as proprietary to the *Contractor*), procedures and other written information developed solely for the *Employer* by the *Contractor* in the course of its performance under the contract. Where design basis documents are retained by the Contractor or others due to propriety information and/or intellectual property, the Contractor will state how Eskom and National Nuclear Regulator of South Africa (NNR) access to this information, for audit and review purposes, will be provided.

9.3.2 A complete set of post-manufacturing "as built" drawings shall be provided as part of the QADP.

9.3.3 A complete set of post-installation "as built" drawings shall be provided as part of the QADP.

9.4 Operating and Maintenance Manual Requirements

9.4.1 Installation, operation, and maintenance updates (mark-ups) contained in a maintenance manual and other relevant documents shall be submitted to the *Employer* as part of the detailed design.

9.4.2 The maintenance manual shall include spare lists and maintenance programs.

9.5 Testing and Commissioning

9.5.1 The *Contractor* shall provide the *Employer* with a post-installation testing and commissioning plan which shall be submitted to the *Employer* as part of the detailed design.

10. Plant Computer Interface (KIT) Requirements

N/A

11. Human Factor

11.1 Human Factor Engineering

N/A

11.2 Design for safety

N/A

12. Acceptance

This document has been seen and accepted by:

Name	Designation
Neelan Rama	Senior Engineer
Kelvin Browning	RP Engineer
Evan Kerr	Senior Engineer (Electrical)
Louis Uys	Chief Technologist (Mechanical)
Noloyiso Mtoko	Nuclear Technical Plan Manager
Ravid Goldstein	Design Engineering Manager

13. Revisions

Date	Rev.	Compiler	Remarks
April 2021	1	E. Williams & K. Govender & R. Aschmann	Original
March 2020	0	E. Williams & S. Linose	Draft

14. Development Team

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

- Eugene Williams
- Keshnie Govender

- Riana Aschmann

15. Acknowledgements

None.

Appendix A: Detailed Requirements Matrix

Reference	Requirement (Level 1)	Requirement (Level 2)	Requirement (Level 3)	Justification Source	Codes and Standards	Verification and Testing (Design & Plant)	Commissioning	Certificates Required (QA Requirement)	Record of Change
0.0	**General Requirements**								
0.1	The scope of supply as described in Section 2.1 shall be provided in accordance with the processes prescribed by reference [28] and [23].			KAA-501 331-86					
0.2	The modification shall comply with all references stated in Section 2.2.1. The latest authorised revisions at the time of contract award shall be used, unless revision specifically stated.								
0.3	The *Contractor* may review all design and manufacturing information of the existing RCP pressurizer heater and RCP pressurizer vessel in the possession of KNPS at its documentation centre. KNPS shall not deliver or supply the information to any *contractor*. The *Employer* will provide the necessary access to the *Contractor* to view the said information after all NDA have been signed								
1.0	**Design Requirements**								
1.1	The pressurizer heaters shall be designed in accordance with ASME Section III, Division 1, NB, 2001 edition, up to 2003 addenda. A detailed reconciliation report shall be supplied if an approved code other than ASME is used.								
1.2	Mechanical requirements								
1.2.1		Design temperature	The heaters shall be designed to operate under a design temperature of up to 360 ºC	KBA1207E00002					
1.2.2		Design pressure	The heaters shall be designed to operate under an external design pressure of up to17.13 MPa	KBA1207E00002					
1.2.3		Normal operating temperature	The heaters shall be designed to operate at the pressuriser normal operating temperature of 345 ºC	KBA1207E00002					
1.2.4		Normal operating pressure	The heaters shall be designed to operate at the pressuriser normal operating pressure of 15.5 MPa	KBA1207E00002					
1.2.5		Hydrostatic test condition temperature	The heaters shall be designed to operate at the	KBA1207E00002					

			pressuriser hydrostatic test temperature range of 40 ºC minimum to 60 ºC maximum						
1.2.6		Hydrostatic test condition pressure	The heaters shall be designed to operate at the pressuriser hydrostatic teste pressure of 23.6 MPa	KBA1207E00002					
1.2.7		The parts of the heater that are not immersed in the pressuriser vessel (cold length, connector, power cable) shall be design to with stand the following air temperature	For 1 hour: 150 ºC For 6 hours: 120 ºC	KBA1207E00002					
1.2.8		The parts of the heater that are not immersed in the pressuriser vessel (cold length, connector, power cable) shall be design to with stand the following humidity condition	For 1 hour: 100% For 6 hours: 100%	KBA1207E00002					
1.2.9		The parts of the heater that are not immersed in the pressuriser vessel (cold length, connector, power cable) shall be design to with stand the following pressure	For 1 hour: 0.5 MPa For 6 hours: 0.5 MPa	KBA1207E00002					
1.2.10		Terminal connector	The terminal connector shall be designed to withstand an internal pressure of 17.13 MPa and a temperature of 360 ºC without leakage to the atmosphere even in case of tubular sheet damage.	KBA1207E00002					
1.2.11		Make and model of heaters	The *Contractor* shall provide Thermocoax designed and manufactured double barrier heaters.	SOW					
1.2.11.1			The heaters shall be direct immersion straight tubular sheath type with grounded heater sheath and	KBA1207E00002					

			ungrounded power supply and with a hermetically sealed terminal connector at one end (on the exterior of the pressuriser vessel) and a welded plug on the other end of the heater.						
1.2.12		Length of the heaters	a) Overall length: 2250 mm b) Heating part of the heater (tube): 1100 mm c) Cold length (on the connector side): 410 mm approximately d) Cold length (on the end plug side): 540 mm approximately	KBA1207E00061					
1.2.13		Diameter of the heaters	22.2 mm	KBA1207E00061					
1.2.14		Heater outer sheath heat treatment	The heater outer sheath shall be designed/ treated to minimise the potential for stress corrosion cracking of the heater sheath following the swaging process.	SOW					
1.2.15		Sheath Surface finish	The tubular sheath surface finish shall be 63 micro inches or less	KBA1207E00002					
1.2.16		Heater Identification	The pressuriser heaters shall have the following information: - Rated Power - Voltage supply - Name of Supplier and or manufacturer Identification number	KBA1207E00002					
1.2.17		Minimum design life of each heater	10 000 Hours at full power with 5000 “on-off” cycles.	KBA1207E00002					

			20 00 Hours at ½ power with 10 000 voltage cycles of +50% and -40% from the ½ power level						
1.3	Electrical requirements								
1.3.1		Power rating of each heater	24kW +- 6% / 380V	KBA1207E00002 KBA1207E01001 KBA1207E00061					
1.3.2		Rated voltage	380 V. 50 Hz	KBA1207E00002 KBA1207E01001K BA1207E00061					
1.3.3		Connection	Delta (Note: The heaters installed at KNPS are arranged in a delta configuration in order to be supplied by 3-pahse 380V power supply)	KBA1207E00002 KBA1207E00061 KBA1207E01001					
1.3.4		Maximum power density per unit of tubular sheath exterior surface	32 W/cm^2	KBA1207E00002 KBA1207E00061					
1.3.5		Power supplies	Power supply of the heater shall be ungrounded	KBA1207E00002 KBA1207E01001					
1.3.6		Terminal connector	The terminal connector shall be hermetically sealed, qualified for use in harsh environments and withstand system rated electrical parameters.	KBA1207E00002 KBA1207E01001					
1.3.7		Cabling							
1.3.7.1			The heaters shall be supplied complete with integral cables with a minimum length of 5m	KBA1207E01001 KBA0915K09016					
1.3.7.2			All- cabling shall be supplied by the *contractor* that will have a length sufficient to extend from the junction boxes to the immersion heaters.	KBA1207E01001 KBA0915K09016					

1.3.7.3			Integral cables are required to withstand the following conditions (minimum) for 1 hour; – air temp. 150°C; – humidity 100%; – pressure 5 bar.	KBA1207E00002 KBA0915K09016	IEEE 323 and 383 (2015): Qualifying of Class 1E Electric Cables				
1.3.7.4			Integral cables are required to withstand the following conditions (minimum) for 6 hours; – air temp. 120°C; – humidity 100%; – pressure 5 bar.	KBA1207E00002 KBA1207E01001 KBA0915K09016	IEEE 323 and 383 (2015): Qualifying of Class 1E Electric Cables				
1.3.8		No loss of insulation shall occur during the application of a 1000 V potential between the heating element and heater sheath.	–	KBA1207E00002 KBA1207E00061					
1.3.9		The heaters shall be designed to be connected to a 3-phase power supply of 380V		KBA1207E01001					
1.4	Seismic requirements								
1.4.1		The heaters shall be qualified to operate during and after an Operating Based Earthquake (OBE) and Safe Shutdown Earthquake (SSE)	The following earthquake spectra details applicable to KNPS can be found in Appendix B of this specification: a) OBE horizontal spectra with 2% damping b) OBE vertical spectra with 2% damping c) SSE horizontal spectra with 2% damping d) SSE vertical spectra with 2% damping	KBA0022E01020	IEEE Std 344: IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations				

1.5	Material selection								
1.5.1		The materials chosen shall be based on an analysis of the environment in which the equipment will operate, as well as the process fluid characteristics as described in section 5 of this specification.							
1.5.2		Heater outer sheath material	Austenitic Stainless Steel Gr 316L						
1.5.3		Heater end plug material	Austenitic Stainless Steel Gr 316L						
1.5.4		Heating Element Material for the heated section of the heater	The heating element of the heater shall be of nichrome (Ni-Cr) embedded in compacted magnesium oxide	KBA1207E00002 KBA1207E00061					
1.5.5		Heating Element Material for the cold section of the heater	The heating element for the cold section of the heater shall be copper.						
1.6	Special tooling and equipment	The *contractor* shall be responsible for supplying all special tools required for the removal and replacement of the pressurizer heaters							
2.0	**Procurement Requirements**								
2.1	RD-0034 level of suppliers: Suppliers of goods and services shall conform (or be assessed to conform if required) to the relevant RD-0034 level as indicated in Section 5.3.2 of this specification.								
2.2	Obsolescence considerations: The heater spares that are required according to the OEM maintenance program shall be available and								

	procurable for the duration of equipment operation as stipulated in 14.3 of this detailed requirements matrix.								
3.0	**Manufacturing Requirements**								
3.1	The ASME III Section NB edition 2001, with addenda up to 2003, used for design shall be used for fabrication, manufacturing and examination of the pressurizer heaters.	The approved work plans shall demonstrate consideration of the following factors, as a minimum, in accordance with the specified codes, operational experience, and international best practice:							
			Elimination of sensitised stainless steel.						
			Judicious use of thermal cutting						
			Cleanliness requirements and material control.						
			The cobalt content in the material shall be lower than 0.2%.						
			Procedures to control and limit material such as mercury, lead, aluminium, cadmium, magnesium, tin, zinc, silver, indium, gallium, antimony, arsenic, bismuth, copper, sulphur, chlorides, halogens, and phosphorous shall be detailed by the *Contractor*						
			Red lead-graphite-mineral oil or molybdenum disulphide lubricants shall not be used on the heaters. Metallic lead, mercury, cadmium, or other low melting point metals or alloys shall not be used; i.e., these materials are prohibited from contact with						

			the heater materials at any time.						
			Foreign material control. Foreign material includes grit, metal, particulate matter, oil, slag, scale, rust, fibre, tools, tooling, and "product" materials. See Reference 3.22						
			The responsibility for establishing, ensuring, and maintaining cleanliness shall rest with the *Contractor*. The hardware shall be delivered to the *Employer* in a clean condition, free of contaminants and loose parts, and suitable for the intended service.						
			The *Contractor* shall state and document to the *Employer*, the final inspection criteria, contamination limits and requirements in the approved specification. No foreign material is allowed.						
			When rust occurs on corrosion-resistant material, the cause shall be determined and corrected. The surface shall be checked for residual rust-producing materials.						
			The *Contractor* shall provide a listing of acceptable expendable materials and products to be used. These products shall include adhesives, NOE consumable materials (i.e., those materials used in the performance of penetrant examination,						

			including penetrant agent, penetrant remover, emulsifier, developer, and post-cleaning agents), rust preventatives, tapes, temperature indicating sticks, ultrasonic testing couplants, weld purge dams, welding/cutting compounds, wrapping materials, temporary insulating materials, cleaning agents, and solvents.						
			Factory welders must be qualified and their certificates issued in accordance with the ASME Section III and Section IX code requirements.						
			Prevention of build-up of excessive residual stresses in welds or parent material due to the manufacturing activities.						
3.2	In order to meet the system design requirements, the pressurizer heaters shall withstand a design base safe shutdown earthquake (SSE) and be designed to remain operational and leak proof. Attachment B of this specification provides the seismic data to apply for this assessment.								
3.3	The *Contractor* shall ensure that the new pressuriser heaters shall be manufactured to fit into the existing RCP pressuriser vessel and heater sleeve.								

3.4	The *Contractor* shall complete the manufacturing specification for the electrical cables and terminal connectors with the latest editions of IEEE 323, IEEE 308, IEEE 383, IEEE 344 and RG 1-75	The manufacturing specification shall be submitted to the Employer for approval prior to commencement of manufacture.		KBA1207E01001 IEEE 323 IEEE 308 IEEE 383 IEEE 344 RG 1-75					
4.0	**Installation Requirements**								
4.1	The *Contractor* shall submit a comprehensive rigging and lifting plan in accordance with reference [42] for lifting and rigging of al special tools required for the installation work.								
4.2	The *contractor* shall submit a scaffolding plan for all scaffold required for the removal and installation of the heaters.								
4.3	The *contractor* shall be responsible for setting up all special platforms required for the removal and installation of the heaters.								
4.4	The *contractor* shall be responsible for setting up all special tools required for the removal and installation of the heaters.								
4.5	The *contractor* shall be responsible for setting up all special tools required for the removal of stuck heaters.								
4.6	The *contractor* shall be responsible for disconnecting all the heaters electrically. The *Contractor* shall be responsible for compiling and submitting an electrical isolation plan.								
4.7	The *contractor* shall be responsible for machining the existing HWI to heater welds to facilitate heater removal.								
4.8	The *contractor* shall be responsible for withdraw/removal of all the old heaters								
4.9	The *contractor* shall be responsible for the removal of all stuck heaters from the pressuriser vessel.								
4.10	The *contractor* shall be responsible for installing the new heaters.								
4.11	The *contractor* shall be responsible for welding the new heaters in place.								
4.12	The *contractor* shall be responsible for connecting the heaters electrically. The *Contractor* shall be responsible for compiling and submitting an electrical isolation plan.								
4.13	The *contractor* shall be responsible testing and commissioning of the newly installed heaters.								

4.14	The *Contractor* shall be responsible for developing and submitting an RP/ALARA Plan for RCP pressuriser Heater Replacement project. The RP/ALARA plan shall include the following:								
4.14.1		Minimise Radiation Exposure	Measures to minimise radiation exposure to workers will be described in the RP/ALARA Plan. Examples include the use of shielding, low dose waiting areas, use of remote and automated equipment for cutting, machining and welding						
4.14.2		Dose Estimation	The dose estimation methodology will be described in the RP/ALARA Plan. This includes dose estimation for the different tasks and for the overall project. The dose follow-up and tracking system per task and per individual will be described						
4.14.3		Shielding Plan	The appropriate use of shielding will be estimated and described. The shielding will comply with the requirements of procedure KGH-007: Radiation Protection Use and Control of Temporary Lead Shielding.	KGH-007 KGU-013					
4.14.4		Remote Controlled Equipment	The use of remote controlled or semi-automated equipment for dose intensive activities will be described in the plan. This includes cutting, machining and welding equipment.						
4.14.5		Operating Experience (OE)	The management and use of internal as well as external RP related OE will be described in the RP/ALARA						

			Plan. The sourcing of relevant OE will be described.						
4.14.6		Radioactive Material and Contamination Control	The control and transport of radioactive material will be described in the RP/ALARA Plan. Measures taken to control both airborne and surface contamination during all activities will be described.						
4.14.7		RP Protective Clothing and Equipment	The quantities of required protective clothing and respiratory protection equipment will be estimated in the plan.						
4.14.8		Dosimetry Devices	The quantities of required EPD and TLD devices will be estimated in the RP plan.						
4.14.9		Consumables	An estimate of the required amounts of consumables such as plastic, bags, swipes etc. will be included in the plan.						
4.14.10		RP Equipment	An estimate of the amount of RP equipment such as shielding, PVU's, vacuum cleaners, radiation and contamination monitoring instruments etc. will be included in the plan. All special RP equipment not in use at KNPS already will be purchased by the *contractor*.						
4.14.11		RP Support Personnel	An estimate of the number of RP monitor and RPDC support personnel will be included in the plan.						
4.15	RP support services during specific activities, e.g. decontamination of old heaters, cutting and packaging of old heaters, establishment of controlled zones, etc., has to be requested by the *Contractor*.								
4.16	The *contractor* shall apply the ALARA principle to all the workings activities and its radiation workers management.								

4.17	The *contractor* shall be responsible for Waste characterization - including the breakdown of each waste generated, volume, mass and expected dose rates								
5.0	**Storage Requirements**								
5.1	The heaters shall be protected for shipment in a manner that will ensure that the surfaces are not exposed to the environment and remain clean and dry.								
5.2	Packaging, storage levels and shipping of the heaters shall be in accordance with ASME NQA-1 Part 2.2 (Reference [6]).				ASME NQA-1 Part 2.2				
5.3	The *Contractor* shall be responsible for defining how the material shall be stored on site.								
5.4	The *Contractor* shall be responsible for informing the *Employer* and for resolving any non-conformances found on the heaters when the packaging is removed at KNPS.								
6.0	**Transport Requirements**								
6.1	Packaging for shipment of the equipment shall be supplied by the *Contractor*, including supply of shipping rig/frame as necessary								
6.2	Transportation of equipment or modules shall be by qualified carrier to the *Employer's* premises								
6.3	Offload of equipment or modules at the *Employer's*								

	premises is the *Contractor's* responsibility								
7.0	**Interface Requirements**								
7.1	The pressurizer heaters interfaces with the following equipment on the plant:								
7.1.1		RCP 001 BA – RCP pressurizer vessel (PZR Type 40)							
7.2	All interfacing connecting welds between the new heaters and the existing pressurizer vessel heater sleeves shall be demonstrated to conform to the requirements of references [9] and [10].				ASME III NB ASME XI				
8.0	**Testing and Commissioning Requirements**								
8.1	The *Contractor* shall produce a full testing and re-qualification procedure/plan. The approved a full testing and re-qualification procedure/plan shall demonstrate consideration of the following factors, as a minimum, in accordance with the specified codes, operational experience, and international best practice:								
8.1.1			Inspection personnel qualification, training and experience.						
8.1.2			Examination procedures, records, and acceptance standards.						
8.1.3			ASME III hydrostatic pressure test examination, of which the results will serve as baseline data. PSI of the welds is to be performed in accordance with references [10] and [60].	KBA-0028 NES MA ISI 02 : ISI Programme Requirements	ASME XI				
8.1.4			Surface examination procedures, records, and acceptance standards						

8.1.5		Weld examination to comply with the requirements set by Reference [21].		ASME III NB				
8.1.6		Visual examination.						
8.1.7		Dimensional inspections. The *Contractor* shall measure and record the heaters as-built dimensions.						
		Hydrostatic pressure test. An Authorized Inspector shall witness the hydrostatic pressure test. No leakage during the hydrostatic pressure test is acceptable						
8.2	The installation on the plant shall be comprehensively tested as follows:							
8.2.1		Insulation and continuity testing on all new cables (electrical)						
8.2.2		Wire to wire checks are to be performed (electrical)						
8.2.3		All alarms, control and instrumentation systems must be requalified (instrumentation)						
8.2.4		Radiography on welds (mechanical)						
8.2.5		Liquid penetrant tests on welds (mechanical)						
8.2.6		Hydrostatic test on the RCP pressurizer vessels.						
8.3	All OEM prescribed test prior to first start-up shall form part of the testing plan prescribed in 8.1							
8.4	Valid calibration certificates shall be provided for all measuring equipment used during and after installation as well as during commissioning and testing of the newly installed heaters.							
8.5	The *Contractor* shall provide a start-up checklist to be used prior to putting the equipment into operation.							

9.0	**Waste and Disposal Requirements**							
9.1	All non-contaminated waste generated by the pressurizer heater replacement project shall be disposed of by the *Contractor* in accordance with reference [56].		KAE-012 – Hazardous and Non-Hazardous Waste and Scrap Disposal					
9.2	The Contractor shall be responsible for ensuring that on-site storage of all contaminated waste will be done in accordance with reference [67].		KSA 048					
9.3	RP support services during specific activities, e.g. decontamination of old heaters, cutting and packaging of old heaters, establishment of controlled zones, etc., has to be requested by the *Contractor*.							
10.0	**Personnel Requirements**							
10.1	*Contractor* engineering personnel required to sign as compiler, reviewer and approver of documents and drawings shall be registered professional engineers or equivalent as approved by Eskom in accordance with ECSA guidelines.							
10.2	Staff performing the design and installation work shall be qualified by means of formal technical qualifications and have sufficient experience with work of similar nature.							
10.3	Factory welders must be qualified and their certificates issued in accordance with ASME Section III and ASME Section IX code requirements							
10.4	All welders and brazers must be qualified and their certificates issued in accordance with ASME III and ASME IX code requirements							
11.0	**Documentation Requirements**							
11.1	The *Contractor* may review all existing information related to the modification in possession of the *Employer* at its documentation centre							
11.2	The *Employer* will not deliver or supply the information to any *Contractor*. The *Employer* will provide the necessary access to the *Contractor* to said information. Documentation clerks will be made available to assist with information retrieval							
11.3	All equipment manuals shall be added to the documentation system. If a system or maintenance manual does not exist for the system or sub-system, one shall be created. If one exists it shall be comprehensively updated							

11.4	All existing drawings and documentation that will be affected by this project will be updated as part of the documentation for this project								
11.5	A complete installation, operating and maintenance manual shall be provided by the *Contractor*.								
11.6	All documentation shall be provided to Eskom in searchable PDF electronic format								
11.7	The following documentation shall be provided by the *Contractor* to Eskom:								
11.7.1	Design Documentation	A detailed design shall be presented to the Design Engineering Group at Koeberg for review and acceptance.							
11.7.2	Operating Documentation	Start-up, shutdown & operating procedures							
11.7.3	Maintenance Documentation	Pre-operational fault finding and diagnostic actions.							
		Information required to perform maintenance on the new equipment (drawings, circuit diagrams, component values, software programs, vendor literature).							
		The maintenance manuals shall include spare lists and maintenance programs							
11.7.4		All documentation as specified in 16.2 of this detailed requirements matrix							
11.7.5	Quality Assurance Documentation	The following, as a minimum, shall be submitted as part of a comprehensive Quality Assurance Data Package:							
11.7.5.1			Manufacturing & Test Records						
11.7.5.2			Supplier's Certificates of Conformance						
11.7.5.3			Supplier's Inspection & Test Certificates						
11.7.5.4			Equipment Qualification Test Reports						
11.7.5.5			Inspection Release Reports						

11.7.5.6			Completed FATs & SATs shall form part of the QADP						
11.7.5.7			Bill of Material, Material Numbers & Suppliers						
11.7.5.8			Overhaul Procedures and Specifications						
11.7.5.9			Test Procedures and Specifications						
11.7.5.10			Serial Numbers of Installed Items						
11.7.6.11			Recommended Spares List						
11.7.5.12			Detailed Manufacturing Drawings						
11.7.5.13			Isometric drawings and wiring diagrams						
11.7.5.14			Commissioning-related documentation						
11.8	A documentation list, as part of the Configuration Management Document, shall be compiled and kept current and updated at all times								
11.9	The documents & drawings shall be in English and technical parameters shall be in SI units								
11.10	Provide all drawings in either the .pdf file or the Drawing Interchange File (.DXF) format and or (.DWG) format								
11.11	All final drawings and documents shall be in international size paper and format								
11.12	Eskom shall provide the *Contractor* with a sequence of KBA drawing numbers that shall be used on any new drawings								
11.13	Drawings submitted to Eskom by the *Contractor* shall fulfil the Eskom standard drawing practice as per reference [18], [26] and [32].								
11.14	All mark-ups of existing KNPS documents / drawings shall use the latest revision available in the documentation centre at the time of submission to Koeberg.								
12.0	**Environmental Requirements**								
12.1	The heaters shall be designed and manufactured to be able to operate in the conditions described in sections 5.1, 5.2 and 5.4 of this specification document.								

13.0	**Regulatory Requirements**								
13.1	The following documents shall be compiled and submitted by the *Contractor* to enable Eskom to submit the design package to the NNR for implementation approval:								
13.1.1		Safety Review							
13.1.2		Risk Impact Analysis							
13.1.3		Manufacturing, Implementation and Procurement Specifications							
13.1.4		Implementation Safety Case							
13.1.5		Commissioning Requirements Document							
13.1.6		Configuration Management Document							
13.1.7		Maintenance and Inspection Programme for New Components							
13.1.8		Functional Testing Programme							
13.1.9		Independent Design Review Report							
14.0	**Performance Requirements**								
14.1	The performance requirements as set out in section 1.0 of this detailed requirements matrix of this specification shall be adhered to.								
15.0	**Quality Requirements**								
15.1	The *Contractor* shall have the appropriate Quality Management System in place as required by the applicable RD-0034 level classification								
15.2	In accordance with service classifications 0011/99Q & 0027-95Q, the quality level for the specified work scope is Q1 for design and Q2 for installation.								
15.3	The *Contractor* shall provide a Quality Control Plan to Eskom for review for various phases of the works prior to commencement of the works. Eskom may add QC hold and witness points.								

15.4	The *Contractor* shall supply a quality assurance data package (QADP) for the replacement of the RCP pressurizer heaters.	The QADP shall include, but not be limited to the following:							
15.4.1			Certificate of conformance						
15.4.2			Certificate of conformance (electrical)	SANS 10142-1					
15.4.3			Certificate of manufacture						
15.4.4			Copy of the Eskom order						
15.4.5			Copy of the specifications						
15.4.6			QCP (Quality Control Plan)						
15.4.7			Material certificates						
15.4.8			Welder qualification and certificates						
15.4.9			Weld qualifications						
15.4.10			NDE/NDT reports						
15.4.11			PSI reports						
15.4.12			Hydrotest procedure						
15.4.13			Hydrotest reports						
15.4.14			Dimensional tests						
15.4.15			Eskom waivers (if applicable)						
15.4.16			Non-conformance reports						
15.4.17			Final supplier QA release						
15.4.18			The Certified Material Test Reports (CMTRs) shall be supplied as part of the QADP.						
			Environmental Qualification test report for cables						
16.0	**Training Requirements**								
16.1	To be authorised to work in a Koeberg Nuclear Power Station controlled zone, the Contractor employees shall respect the associated regulation and organisation by completing the following courses/training:								
16.1.1		Plant Access Training (PAT)							

16.1.2		Radworker's Training							
16.1.3		Medical Examination for radiation workers							
16.1.4		Whole Body Count							
16.1.5		Respiratory Training (if required)							
16.2	Training documents/materials shall be provided by the Contractor to Eskom Koeberg Engineering personnel in order to familiarise them with design aspects of the new equipment. These documents shall include as a minimum:								
16.2.1		Design of the equipment							
16.2.2		System operation							
16.2.3		Fault-finding with regards to start-up, shutdown, off-normal operation and component failure							
17.0	**Maintenance Requirements**								
17.1	The *Contractor* shall provide Eskom with a preventative maintenance activity list including the frequency of such activities and major overhauls.								
17.2	The *Contractor* shall provide Eskom with a list of spare parts required to perform preventative maintenance on the new equipment. This list will include relevant OEM part numbers for procurement purposes								

18.0	**Safety Requirements**								
18.1	Nuclear Safety								
18.1.1		A safety screening and/or evaluation performed in accordance with reference [30] and [36] will be required for this modification. The *Employer* shall assist the *Contractor* in this regard.		KAA-709 KGA-025					
18.2	Conventional Safety								
18.2.1		The modification shall not introduce additional risks to personnel or plant integrity							
18.2.2		The system must be completely isolated to prevent any electrical shock during installation in accordance with an authorised work plan and within plant safety regulations							
18.2.3		Applicable civil codes/building regulations must be identified and complied with							
19.0	**Project Management Requirements**								
19.1	The management of this project shall be in accordance with references [28] and [23]								

Appendix B: Seismic Spectra Details for the Nuclear Island

1 NUCLEAR ISLAND HORIZONTAL ENVELOPE FLOOR RESPONSE SPECTRUM FOR KOEBERG NUCLEAR POWER STATION: 2% DAMPING; OBE

* RANGE TYPE=FREQUENCY (HERTZ)
* ORDINATE TYPE=ACCELERATION (MM./SEC/SEC)
* INTERPOLATION FOR BOTH AXES=LOGARITHMIC.

* FREQUENCY (HZ)	ACCELERATION (MM/SEC/SEC)
0.1	98.1
0.7	13734
1.00	13734
1.60	6278.4
15.0	6278.4
33.0	2452.5
80.0	2452.5

2 NUCLEAR ISLAND VERTICAL ENVELOPE FLOOR REPONSE SPECTRUM FOR KOEBERG NUCLEAR POWER STATION: 2% DAMPING; OBE

* RANGE TYPE=FREQUENCY (HERTZ)
* ORDINATE TYPE=ACCELERATION (MM./SEC/SEC)
* INTERPOLATION FOR BOTH AXES=LOGARITHMIC.

* FREQUENCY (HZ)	ACCELERATION (MM/SEC/SEC)
0.14	98.1
0.17	156.96
0.30	353.16
0.47	686.7
0.63	686.7
0.78	882.9
1.18	1667.7
3.08	4414.5
3.84	5101.2
5.20	5101.2
8.02	10104.3
9.50	10104.3
9.86	10202.4
16.6	10202.4
21.3	3727.8
33.0	2550.6
90.0	2550.6

3 NUCLEAR ISLAND HORIZONTAL ENVELOPE FLOOR RESPONSE SPECTRUM FOR KOEBERG NUCLEAR POWER STATION: 2% DAMPING; SSE

* RANGE TYPE=FREQUENCY (HERTZ)

* ORDINATE TYPE=ACCELERATION (MM./SEC/SEC)

* INTERPOLATION FOR BOTH AXES=LOGARITHMIC.

* FREQUENCY (HZ)	ACCELERATION (MM/SEC/SEC)
0.1	147.15
0.7	21582
1.00	21582
1.61	10791
15.0	10791
33.0	3924
80.0	3924

4 NUCLEAR ISLAND VERTICAL ENVELOPE FLOOR RESPONSE SPECTRUM FOR KOEBERG NUCLEAR POWER STATION: 2% DAMPING; SSE

* RANGE TYPE=FREQUENCY (HERTZ)
* ORDINATE TYPE=ACCELERATION (MM./SEC/SEC)
* INTERPOLATION FOR BOTH AXES=LOGARITHMIC.

* FREQUENCY (HZ)	ACCELERATION (MM/SEC/SEC)
0.1	107.91
0.17	304.11
0.31	706.32
0.47	1373.4
0.64	1373.4
1.16	3335.4
3.14	9025.2
3.87	10006.2
5.00	10006.2
6.00	11772
6.71	15499.8
8.06	19521.9
10.9	19521.9
12.3	18933.3
16.7	18933.3
21.0	7651.8
33.0	4610.7
90.0	4610.7