KOEBERG NUCLEAR POWER STATION

PLANT ENGINEERING

LIFE OF PLANT PLAN

CONTAINMENT BUILDINGS

KBA 0022 N NEPO LOPP 164

Rev 4

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1 PLANT STRUCTURES, SYSTEMS AND COMPONENTS

The containment buildings at KNPS are a set of 2 units, comprising of the external walls and dome. It is referred to as the 'Third Barrier' in the Safety Analysis Report (SAR §III 3.4). The Nuclear Installation License NIL-01 stipulates the requirement to perform inspections and tests on the Containment Structures applies to the post tensioned, reinforced concrete structure itself, as referred to the 'Third Barrier' in Safety Analysis Report (SAR §III 3.4).

Furthermore, both units house the monitoring or EAU system, as described in section 1.5, monitoring the long-term deformation of the containment structures ensuring that the buildings remain within the design parameters specified for the force in the post-tensioning cables. The results are trended, as per Section 4.5, to ensure that the structures' functions as initially intended.

1.1 Scope

This Life Of Plant Plan (LOPP) addresses the preventative maintenance, testing and inspection regimes, and life cycle plans for the Containment Buildings (1/2 HRX 00 BG) at KNPS.

The Containment Building is also referred to as 'The Third Barrier' in the Safety Analysis Report (SAR §III 3.4). Its function is:

- Sheltering the primary systems from an aggressive environment (rain, wind, wind-carried sand, salt spray) and external missiles,
- Ensuring satisfactory biological radiation protection by acting as a barrier to the spread of radioactive materials to the environment in case of a Loss of Coolant Accident (LOCA).
- 1/2HRX are also classified as 'pressure vessels' and hence, fall under the jurisdiction of the plant appointed GMR 2.1 as specified in the PER of the OH&S Act. 1994

This LOPP only considers the external containment wall & dome and part of the upper raft and base mat within the containment circumference. The internal concrete structures of the containment building are also included.

The Containment structures at Koeberg Nuclear Power Station (KNPS) were originally licensed for 40-years' service life. Eskom is in the process of extending the operational life of the station for an additional 20 years. Therefore, a service life of 60 years is considered in this LOPP.

1.2 Containment Description

The Containment buildings are founded [22] on the Aseismic Island which comprises the upper and lower rafts separated by aseismic bearings.

A cross-section illustration of Containment is shown in Figure 1, and a summary of the illustrated components' dimensions are provided in Table 1.

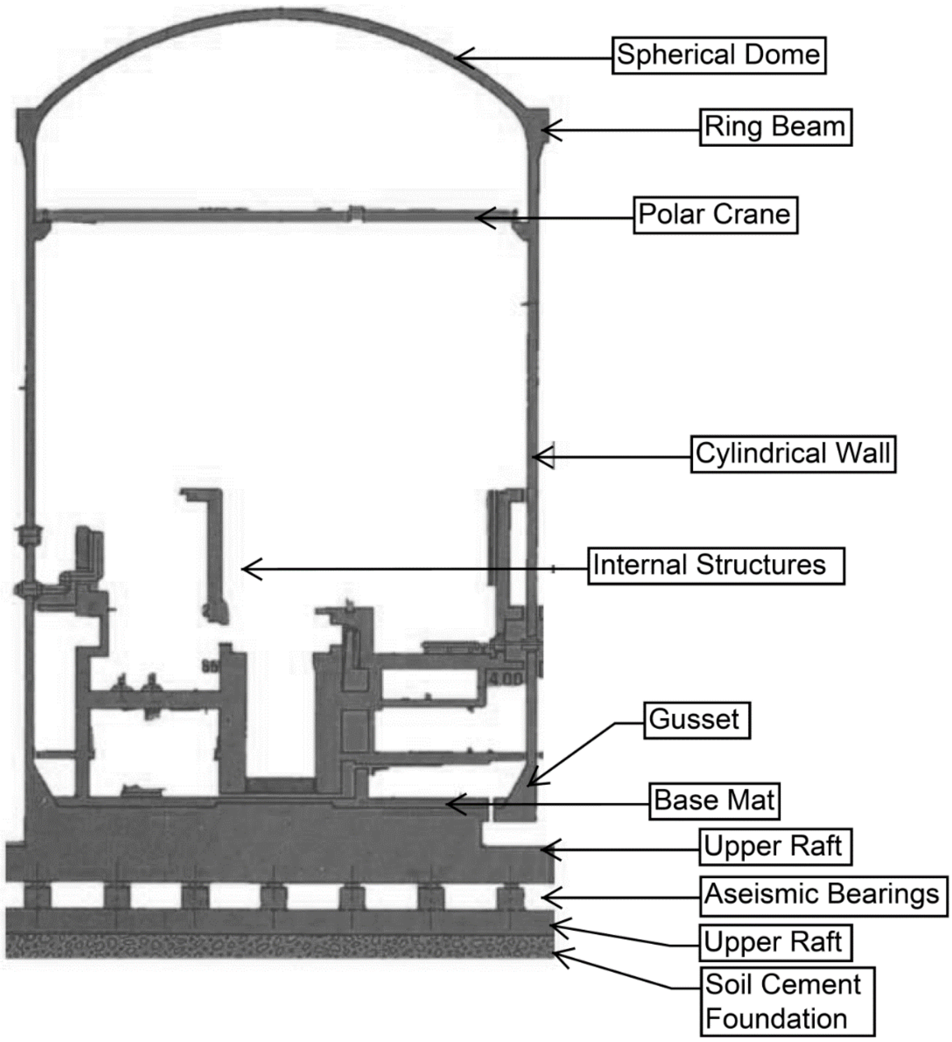


Figure 1: Cross-section illustration of a Koeberg Containment Building

Table 1: Summary of Containment Structural Elements' geometrical dimensions

Element	**Geometric Description**	**Dimension**	**Level**
Upper Raft	Thickness	5.5m	-10m – -4.5m
Gusset	Thickness	1.2m – 0.9m	-4.5m to -0.5m
Cylindrical Wall	Internal Diameter	38.6m	-4.5m to 44.83m
	Thickness	0.9m	

Element	Geometric Description	Dimension	Level
	Height	45.33m	
Ring Beam	Thickness	Varies (0.9m to 3.3m)	44.83m to 51.4m
	Radius of Beam Chamfer	6m	
Dome	Spherical Radius	24m	56.68m
	Thickness	0.8m	

There are other SSC (Structures, Systems and Components) forming part of the containment structure, which are excluded from this LOPP. These include:

- The Steel Liner,
- Openings and penetrations,
- Biological Doors,
- Gantries and Cranes,
- Equipment on the Dome,
- Other non-structural equipment.

1.2.1 Upper Raft

The containment raft foundation is a part of the upper raft of the Aseismic Island. Its geometric characteristics are as follows:

- the 3 m thick upper raft extends over the complete aseismic island and is the foundation for both reactor buildings,
- the level at the top of the 3 m thick upper raft adjacent to the reactor building is -7.00 m below terrace level,
- the thickness of the upper raft is increased to 5.5 m below the reactor building,
- at the centre of the reactor building a 8.80 m diameter by 0.60 m high shear key is provided to transfer all horizontal forces from the internal structure to the upper raft in the event of an earthquake,
- the level at the top of the shear key in the centre of the reactor building is -3.90m below terrace level

1.2.2 Base Mat

The loads from the internal structures of containment are distributed via the 1.00 m thick reinforced concrete slab called the base mat to the upper raft. The concrete base mat provides space for channels and sumps; it also provides protection to the liner. The base mat is separated from the liner by a sliding membrane on the concrete screed, which is placed on top of the liner to protect the weld control channels.

1.2.3 Gusset

The gusset connects the cylinder wall to the upper raft.

1.2.4 Cylindrical Wall

The cylindrical wall of containment is a 900mm thick reinforced concrete structure, with an outer diameter of 38.6m. The wall is post-tensioned, vertically and horizontally, with each cable consisting of nineteen 15.2mm strands.

There are 216 vertical cables placed on the 19.13m radii with spacings of 550mm, which extend along the shell circumference from the Aseismic Vault, through the Upper Raft and Gusset to the top of the Ring Beam. The trumpets for each post tensioned cable are embedded in the upper raft at the bottom, and in the ring beam at the top.

There are 255 three quarter turn hoops which have the trumpets anchored in the vertical ribs. The cables are placed in two layers which are on cylindrical radii of 19.03 m and 19.23 m.

The post-tensioned cables were placed in ducts, and the ducts were grouted after the cables were tensioned.

NOTE: All ducts are grouted, except for 4 vertical post tensioned cables on Unit 1 (1HRX). Refer to section 1.5.4.

1.2.5 Ring Beam

The ring beam connects the cylindrical wall with the containment dome, and houses the vertical post-tensioning's trumpets

1.2.6 Dome

The Spherical dome is reinforced concrete and contains post-tensioning which ensures that the entire containment structure can act as a pressure vessel. There are 162 cables grouped into three families having 60^{o} angles between them.

1.3 Internal Structures

The internal structures of containment are included in this LOPP and are included in the relevant sub-sections of this document.

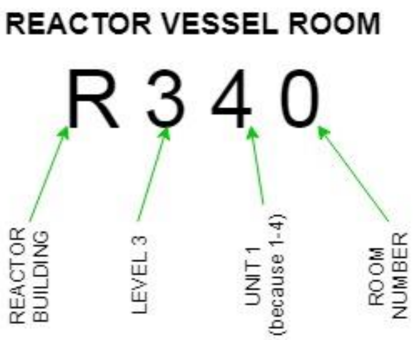
1.3.1 Internal Concrete Structures

Internal concrete structures are the reinforced concrete walls, floors and columns inside the HRX structures used for SSC supports, shielding and conventional dividing.

The structures are divided internally into different levels and rooms.

Level	GMSL Reference Height	Room Numbers 1HRX/2HRX
Level 1	-3.40m	R1$\mathcal{XZ}$ /R1$\mathcal{YZ}$
Level 2	+0.00m	R2$\mathcal{XZ}$ /R2$\mathcal{YZ}$
Level 3	+5.00m	R3$\mathcal{XZ}$ /R3$\mathcal{YZ}$
Level 4	+8.00m	R4$\mathcal{XZ}$ /R4$\mathcal{YZ}$
Level 5	+10.40m	R5$\mathcal{XZ}$ /R5$\mathcal{YZ}$
Level 6	+15.00m	R6$\mathcal{XZ}$ /R6$\mathcal{YZ}$
Level 7	+20.00m	R7$\mathcal{XZ}$ /R7$\mathcal{YZ}$

R refers to the Reactor Building, $\mathcal{X}$ = 1-4 and $\mathcal{Y}$ = 5-8 corresponding, i.e. 1 corresponds to 5 and 2 to 6 etc. and $\mathcal{Z}$ is a number assigned to the room, as illustrated below:



1.3.2 Radiological Shields

1.3.2.1 Primary Shield

The primary shield is a reinforced concrete cylinder with an internal diameter of 5.20 m, and is situated between the -3.50 m and +20.00 m levels and supported by the upper raft. The wall thickness of the reactor pit (primary shield) varies between 1.80 to 2.10 m.

The primary shield supports the reactor vessel and withstands the pressures and forces in the event of a break in either a primary or secondary circuit pipe.

The shield protects the adjacent systems of the NSSS (primary circuits, heat exchangers, etc.) from excessive radiation during normal operation and provides biological protection from neutron dose of reactor core. Heat generated by the reactor is removed in the interface between the reactor and the primary shield by a dedicated ventilation system (EVC [13]).

1.3.2.2 Secondary Shield

The secondary shield is an internal cylindrical barrel, which has an external radius of 15.50 m.

The secondary shield consists of walls and floor slabs which, with the primary shield forms bunkers enclosing all major systems and equipment of the primary circuit, i.e. the pressuriser, three safety injection accumulators, reactor coolant pumps, reactor piping and three steam generators. The external wall of the reactor cavity is also part of the secondary shield.

1.3.3 Missile Shields

Missile shields are removable reinforced concrete slabs which are placed over the reactor cavity during operation. The shields protect against potential missiles generated by the hypothetical ejection of a control rod.

1.3.4 Steel Structures

There are numerous internal steel structures inside the containment structures. These structures have various functions, and some are discussed in Section 3.

1.4 Access Doors (Air Locks and Penetrations)

Containment airlocks are part of the EPP system however access doors i.e. bulked head and civil penetrations are discussed on Section 3 and outlined in KWR-IP-CIV-024.

1.5 Monitoring Instrumentation (EAU-systems)

1.5.1 Pendulums

The Pendulums measures the relative horizontal displacement of the cylindrical walls. There are three pendulums fixed at three levels (+10.00 m, +26.00 m and +42.00 m level) at four points on the circumference of the containment (at 90°). The indicator or reading tables are rigidly fixed to the side of containment at the -6.70 m level, giving a measurement of the radial displacement of the cylindrical wall the various levels relative to the raft.

1.5.2 Invar Wires

The Invar Wires are connected to the Cylindrical Wall of containment at the +42.00m level. There are 4 invar wires which measure the vertical elongation of the containment structure relative to the base.

1.5.3 Stress and temperature measurements

Acoustic strain gauges are grouped in twos or threes and each group is associated with a thermocouple. This set is called a “measuring point”. Such measuring points are located in the containment raft, wall and dome at positions on the interior, centre and exterior of the containment wall.

In the raft the directions of the acoustic strain gauges are horizontal, radial or tangential. In the cylinder two directions are used viz. vertical and horizontal tangential.

The tested sections are along two source lines (virtually at 90°).

1.5.4 Dynamometers

The tension existing in the four un-grouted cables on Unit 1 only are measured at the upper anchorage by three dynamometers of 150t load capacity each.

COMPONENT	TRIGRAMME	DESCRIPTION
Pendulums	$\mathcal{X}$ EAU 1$\mathcal{Y}\mathcal{Z}$ LZ*	Instrumentation measuring horizontal movement of the structure, at that location
Invar Wires	$\mathcal{X}$ EAU 2$\mathcal{Y}$1 LZ	Instrumentation measuring vertical elongation of the structure external wall
Strain Gauges		Instrumentation installed to measure the strain the cylindrical containment wall
Thermocouples		Instrumentation installed to measure the temperature the cylindrical containment wall

* $\mathcal{X}$ = Unit; $\mathcal{Y}$ = Station 1 – 4; $\mathcal{Z}$=Location (1=top, 2=bottom, 3=middle)

Current indications are that the second order effects of creep and shrinkage of the concrete and the relaxation of the post tensioning cables have stabilized and no significant movement is expected in the future. This assumption was considered at length during LTO and verified through a Time-Limited Ageing Analysis.

1.6 Non-Structural or Non-License Binding components

1.6.1 Other components of the structure

Other components of the structure are classified as being either aesthetic or having conventional safety classifications. They are not load bearing, and complete loss of these components, would not impact on the structural performance nor be a breach of the operating license. The components are none-the-less still important for functionality and include:

- Reinforced Concrete Components
- Stairs on the dome
- Parapet wall
- Steel Components
- Hand Railings
- Lightning conductor
- Cat Ladders
- Supports to the pendulum and invar wire ducts
- Water Proofing

- Seals between the other nuclear island structures and containments
- Down Pipes for rain water run-off
- Sumps

1.7 Classification

The Classification for the Reactor Building Structures [1], [2] is as follows:

- Safety : **2**
- Seismic : **Category I**
- Quality : **Q2**
- Environmental : **NEV**
- Importance : **SR**

2 HISTORY/ BACKGROUND

The containment structures' design is based on the French design codes that considered various design loads. Since construction, the concrete has, however, been exposed to a harsh marine environment which led to corrosion of the external layer of reinforcement. The corrosion causes surface delamination to the external façade. This phenomenon was first identified in 2000 and repaired in 2002, which included the coating of the entire surface.

Further delamination was identified in 2014 and subsequently a complete repair initiative was performed which was completed in 2018. This included a complete refurbishment of the external façade and other minor superficial repairs such as the re-coating of the tendon heads and the sealing of the non-structural dome crack.

As part of the investigations into the delamination, several engineering analyses were performed, and it was concluded that the surface delamination has no impact on the structural integrity of the containment structures. Other events and interventions which occurred over the history of the structures' lifespan are provided in Table 2.

Table 2: History of major events & interventions on Containment

DESCRIPTION	REFERENCE	YEAR
Average concrete casting date		1979
Unit 2: De-lamination of Unit two containment building on 21/12.	GC 15099	2002
2 HRX 000 BG – Spalling of concrete from Unit 2 Containment building	NC 15184	2003
Damage to supports under removable floor in Containment.	NC 15724	2003
Defective Invar Wire Stations	NC 20842	2004
Defective Invar Wire Stations	NC 20841	2004
Extended period with abnormal containment pressurisation before existence of USQ on RRI thermal barrier isolation valves determined	GC 23779	2005
Unit 1 Reactor Building 1 HRX 000 BG abnormal pressure increase rate.	NC 23057	2005
Unit 2 Reactor Building, 2 HRX 000 BG, abnormal pressure increase rate.	NC 23615	2005

DESCRIPTION	REFERENCE	YEAR
2HRX000BG – INVAR WIRE P3 (Lose weight) – weight removed during CP1 modification	GC 28231	2006
A chunk of concrete broke out of the North side Unit 2 containment wall	GC 31474	2007
Concrete falling from containment wall due to poor workmanship by contractor previously.	GC 31202	2007
2HRX – Containment building Chloride Ingress leading to concrete spalling and potential loss of functionality.	NC 85076	2014
Unit 2 Containment Building Concrete Spalling	NC 78294	2014
1HRX – Containment building chloride ingress leading to concrete spalling and potential loss of functionality.	NC 88731	2015
TAF 15004 – 2HRX000BG- This TAF allows for the trial installation of a surface mounted Fibre Optic Sensor	GC 88347	2015
EPR linked to non-conformance (NC 88731) is overdue.	CR 91627	2016
Tendon Duct damaged during repair of 1 HRX (Patch 310)	CR 98139	2017
Concrete Patch Repairs 2HRX completed	NC 78294	2017
Concrete Patch Repairs 1HRX completed	N.KB00314.M.02	2018
Delamination due to rebar corrosion in areas close to recently implemented repairs observed on both Unit 1 and Unit 2	JN802-NSE-ESKB-IR-7884 & JN811-NSE-ESKB-L-8045	2019

As part of the license binding inspection programme (and other ad-hoc activities) the following inspections and tests have been performed:

Table 3: History of Inspection Programme

Document Description	Reference Number	Year
MONITORING THE STRUCTURAL INTEGRITY OF THE CONTAINMENT STRUCTURES REV2	WCGD/I 0240/18	1985
KNPS CONTAINMENT 2 STRUCTURAL INTEGRITY TESTS	ACC2002490	1986
KNPS STRUCTURAL INTEGRITY TEST ON CONTAINMENT BUILDING 2 OUTA GE 201	ACC2004513	1987
KNPS UNIT-2 PRELIMINARY REPORT ON THE STRUCTURAL INTEGRITY TEST OUTAGE 201	ACC 1121811	1987
KNPS UNIT-2 PRELIMINARY REPORT ON THE STRUCTURAL INTEGRITY TEST OUTAGE 201	MM 10818	1987
STRUCTUR INTEGRITY TEST RESULTS CONTAINMENT UNIT 2,201, REPORT NO1 VOL A&B	K-7033-E	1987
e	K-6778-E	1987
KNPS UNIT-1 STRUCTURAL INTEGRITY TESTS OUTAGE 102	ACC 2005013	1988
KNPS CONTAINMENT STRUCTURAL INTEGRITY TESTS UNITS 1 & 2	K-4234	1988
KNPS UNIT-1 STRUCTURAL INTEGRITY TESTS OUTAGE 102	K-7017-E	1988
KNPS CONTAINMENT UNIT-2 STRUCTURAL INTEGRITY TEST	K-3673	1988
UNIT 1 STRUCTURAL INTEGRITY TESTS - OUTAGE 102	ACC1123450	1988
KNPS CONTAINMENT UNIT-2 STRUCTURAL INTEGRITY TEST	K-4204	1988
KNPS STRUCTURAL INTEGRITY TESTING CONTAINMENT STRUCTURE UNIT-1 OUTAGE 102	16403056	1988
KNPS CIVIL MONITORING PROGRAMME CONTAINMENT STRUCTURE INTEGRITY TESTS	MCS91059	1991
KNPS NON-PRESSURISED CONTAINMENT TEST UNIT-2	MCS91001	1991
KNPS MONITORING THE STRUCTURAL INTEGRITY OF	HO4391005	1992

Document Description	Reference Number	Year
CONTAINMENT (OUTAGE 204)		
KNPS MONITORING THE STRUCTURAL INTEGRITY OF CONTAINMENT (OUTAGE 104)	HO4391001	1992
MONITORING STRUCTURAL INTEGRITY OF CONTAINMENT STRUCTURE OUTAGE 104	H043/91-001	1992
KNPS MONITORING THE STRUCTURAL INTEGRITY OF CONTAINMENT (OUTAGE 204)	K-9686-E	1992
CONTAINMENT STRUCTURAL INTEGRITY MONITORING	MCS92076	1992
MONITORING STRUCTURAL INTEGRITY OF CONTAINMENT STRUCTURE OUTAGE 204	H043/91-005	1992
KNPS MONITORING THE STRUCTURAL INTEGRITY OF CONTAINMENT (OUTAGE 104)	K-9685-E	1992
STRUCTURAL INTEGRITY TESTING UNIT 2 DEC 1994	OL94076	1995
SABS CERTIFICATE OF CALIBRATION NO. A170(B)	815/87922/2	1996
SABS CERTIFICATE OF CALIBRATION NO. A170(A)	815/87922/1	1996
VISUAL INSPECTION OUTAGE 210 2MBI027BG 2HRX000BGG	C304912	1999
VISUAL INSPECTION CONTAINMENT LIGHTING MAST	P349891	2000
e	C354683	2001
VISUAL CONTAINMENT MONITORING	C354684	2001
VISUAL CONTAINMENT MONITORING OUTAGE-112	WK05587	2001
VISUAL: MISCELLANEOUS INSPECTION REPORT OUTAGE 112	WK02696	2001
VISUAL CONTAINMENT MONITORING	P399387	2002
VISUAL CONTAINMENT MONITORING INSPECTION REPORT	320944090	2003
VISUAL: MISCELLANEOUS INSPECTION REPORT CONTAINMENT MONITORING	321108430	2003
VISUAL: INVAR STATIONS INSPECTION REPORT	320783907	2003
VISUAL: MISCELLANEOUS INSPECTION REPORT	320561624	2003
VISUAL CONTAINMENT MONITORING INSPECTION	320983034	2003

Document Description	Reference Number	Year
REPORT		
INVAR STATIONS INSPECTION REPORT	320666492	2003
INVAR STATIONS INSPECTION REPORT	320831740	2003
DYNAMETER READING INSPECTION REPORT	321667288	2004
VISUAL CORROSION INSPECTION REPORT	321276963	2004
VISUAL CORROSION INSPECTION REPORT	321276943	2004
VISUAL CORROSION INSPECTION REPORT OUTAGE-114	320981169	2004
VISUAL CORROSION INSPECTION REPORT OUTAGE-114	320981170	2004
VISUAL CORROSION INSPECTION REPORT OUTAGE-114	320981171	2004
VISUAL CORROSION INSPECTION REPORT OUTAGE-114	320981172	2004
VISUAL CORROSION INSPECTION REPORT OUTAGE-114	320981168	2004
VISUAL REACTOR BUILDING CIVIL INSPECTION REPORT OUTAGE-114	320981242	2004
VISUAL CONTAINMENT MONITORING INSPECTION REPORT OUTAGE-114	320981241	2004
CONTAINMENT MONITORING INSPECTION REPORT	321565461	2004
CONTAINMENT MONITORING INSPECTION REPORT	321466222	2004
e	321733638	2004
CONTAINMENT MONITORING INSPECTION REPORT	321570432	2004
CONTAINMENT MONITORING INSPECTION REPORT	321570431	2004
CONTAINMENT MONITORING INSPECTION REPORT	321303060	2004
CIVIL CONTAINMENT MONITORING INSPECTION REPORT	321733639	2004
CONTAINMENT MONITORING INSPECTION REPORT	321903040	2005
CONTAINMENT MONITORING INSPECTION REPORT	321903039	2005

Document Description	Reference Number	Year
CONTAINMENT MONITORING INSPECTION REPORT OUTAGE 214	321497443	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096315	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096319	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096337	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096338	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096036	2005
CONTAINMENT MONITORING INSPECTION REPORT	322072431	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096306	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096330	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096334	2005
CONTAINMENT MONITORING INSPECTION REPORT	322414172	2005
CONTAINMENT MONITORING INSPECTION REPORT	322096344	2005
LOAD CELL CALIBRATION CERTIFICATES	DE2006/041	2006
CONTAINMENT MONITORING	322748757	2006
ONLINE CONTAINMENT MONITORING INSPECTION REPORT - CONTAINMENT INTEGRITY	322917189	2006
CONTAINMENT MONITORING	322917188	2006
CONTAINMENT MONITORING	20060516	2006
CONTAINMENT INTEGRITY - CONTAINMENT BUILDING UNIT 2 INSPECTION REPORT	322080862	2006
CONTAINMENT MONITORING UNIT 1	20060323	2006
CONTAINMENT MONITORING UNIT 2	20060323	2006
CIVIL STRUCTURE INSPECTION REPORT	323546717	2007
CIVIL STRUCTURE INSPECTION REPORT	323045395	2007
CIVIL STRUCTURE INSPECTION REPORT	323426558	2007
CIVIL STRUCTURE INSPECTION REPORT	323254973	2007
HRX CONTAINMENT UNIT-1 CIVIL STRUCTURE	1HRX-1/2007	2007

Document Description	Reference Number	Year
INSPECTION SUMMARY REPORT 1HRX-1/2007		
HRX CONTAINMENT UNIT-1 CIVIL STRUCTURE INSPECTION SUMMARY REPORT 1HRX-1/2007	323254973	2007
2HRX CONTAINMENT UNIT-2 CIVIL STRUCTURE INSPECTION SUMMARY REPORT 2HRX-1/2007	2HRX-1/2007	2007
2HRX CONTAINMENT UNIT-2 CIVIL STRUCTURE INSPECTION SUMMARY REPORT 2HRX-1/2007	323254851	2007
CIVIL STRUCTURE INSPECTION REPORT 1HRX	323727410	2007
CIVIL STRUCTURE INSPECTION REPORT 2HRX	323781302	2007
CIVIL INSPECTION INTERNAL STRUCTURE UNIT 1 CONTAINMENT	323121848	2007
OUTAGE 116 - ASSESSMENT OF THE MEASURED TEMPERATURE DISTRIBUTION IN THE REACTOR PIT	JN094-NSE-EK-L-526	2007
CIVIL STRUCTURE INSPECTION CONTAINMENT UNIT2 OUTAGE 216	JN098-NSE-EK-R-1144	2008
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT 2	JN192-NSE-EK-IR-2444	2009
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT 1	JN192-NSE-EK-IR-2443	2009
CIVIL STRUCTURE INSPECTION SUMMARY REPORT UNIT 2 CONTAINMENT BUILDING OUTAGE 217	JN192-NSE-EK-IR-2445	2009
CIVIL STRUCTURE INSPECTION REPORT UNIT 2 CONTAINMENT BUILDING EXTERNAL	JN192-NSE-EK-IR-2406	2009
CIVIL STRUCTURE INSPECTION REPORT UNIT 1 CONTAINMENT BUILDING EXTERNAL	JN177-NSE-EK-IR-2364	2009
CIVIL STRUCTURE INSPECTION SUMMARY REPORT UNIT 1 CONTAINMENT BUILDING OUTAGE 117	JN177-NSE-EK-IR-2221	2009
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT 1	JN205-NSE-EK-IR-2558	2009
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT 2	JN205-NSE-EK-IR-2559	2009
MEASUREMENT OF LEVELS OF GREASE IN SLEEVE OF UNGROUTED TENDONS	JN234-NSE-EK-L-2893	2010

Document Description	Reference Number	Year
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT UNIT 2	JN233-NSE-EK-IR-3037	2010
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT UNIT 1	JN233-NSE-EK-IR-3036	2010
CIVIL STRUCTURE INSPECTION REPORT TRENDING OF CONTAINMENT MONITORING DATA 2010	JN247-NSE-EK-R-3644	2011
REPLACEMENT OF VERTICAL INVAR WIRE AT KNPS	JN308-NSE-ESKB-R-4117	2011
CURRENT UNDERSTANDING OF THE UNIT 2 CONTAINMENT STRUCTURAL INTEGRITY	JN391-4496	2012
UNIT 1 AND 2 CONTAINMENT ONLINE MONITORING TRENDING REPORT - 2012	JN382-NSE-ESKB-R-4369	2013
CONCRETE REPAIRS OF EXTERNAL SURFACES TO THE CONTAINMENT BUILDINGS PHASEONE QCP	JN420-NSE-EKSB-L-5153	2013
CONDITIONAL RELEASE EVALUATION FOR NC 78294 DEGRADATION OF UNIT 2 CONTAINMENT STRUCTURE 40M LEVEL DUE TO CORROSION OF THE EXTERNAL OUTERMOST LAYER OF REINFORCEMENT IN THE CONCRETE REV.3	JN426-NSE-ESKB-4988	2014
KNPS DETERIORATION OF THE COVER CONCRETE OF CONTAINMENT BUILDINGS REV.3	JN426-NSE-ESKB-4988	2014
KNPS CONDITIONAL RELEASE EVALUATION FOR NC-78294 REV.0	JN426-NSE-ESKB-4988	2014
KNPS CONDITIONAL RELEASE EVALUATION FOR NC-78294 REV.1	JN426-NSE-ESKB-4988	2014
KNPS CONDITIONAL RELEASE EVALUATION FOR NC-78294 REV.2	JN426-NSE-ESKB-4988	2014
KNPS ENGINEERING PROBLEM REPORT E13-0041 NC-78294 REV.0	JN426-NSE-ESKB-4988	2014
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT UNIT 1 6 FEB 14 CONTAINMENT UNIT 2 6 FEB 14	JN439-NSE-ESKB-L-5142	2014
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT UNIT 2 OUTAGE 220 INTERNAL	JN439-NSE-ESKB-IR-5144	2014
CIVIL STRUCTURE INSPECTION REPORT UNIT 2 CONTAINMENT BUILDING OUTAGE 220 EXTERNAL	JN439-NSE-ESKB-IR-5145	2014

Document Description	Reference Number	Year
CIVIL STRUCTURE INSPECTION SUMMERY REPORT CONTAINMENT UNIT 2 28MAY2014 CONTAINMENT UNIT 1 28MAY2014	JN454-NSE-ESKB-L-5272	2014
CONTAINMENT ONLINE MONITORING & TRENDING REPORT FOR UNIT 1&2	JN458-NSE-ESKB-L-5616	2014
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ON LINE MONITORING UNIT-1 AND UNIT-2	JN456-NSE-ESKB-IR-5447 REV.1	2014
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT BUILDING OUTAGE 220	JN439-NSE-ESKB-IR-5144	2014
KOEBERG NUCLEAR POWER STATION - IMPROVED IDENTIFICATION TECHNIQUES FOR ALKALI-SILICA REACTION CONCRETE DEGRADATION AT NUCLEAR POWER PLANTS (INCLUDES ASR TEST REPORT FOR KNPS)	JN411-NSE-ESKB-L-6049	2015
CIVIL STRUCTURE INSPECTION REPORT UNIT-2 CONTAINMENT BUILDING OUTAGE 221	JN585-NSE-ESKB-IR-6106	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ONLINE MONITORING UNIT-1 AND UNIT-2	JN585-NSE-ESKB-R-6105	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ONLINE MONITORING UNIT-1 AND UNIT-2	JN585-NSE-ESKB-L-6105	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ONLINE MONITORING UNIT-1 AND UNIT-2	JN637-NSE-ESKB-R-6289	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ONLINE MONITORING UNIT-1 AND UNIT-2	JN637-NSE-ESKB-L-6289	2015
DETERIORATION OF THE COVER CONCRETE OF CONTAINMENT BUILDINGS AT KNPS	JN426-NSE-ESKB-4988	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT ON LINE MONITORING UNIT-1 AND UNIT-2	JN583 NSE-ESKB-IR-5907	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT BUILDING (EXTERNAL) OUTAGE 121	JN511-NSE-ESKB-IR-5739 REV.1	2015
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT BUILDING (INTERNAL) OUTAGE 121	JN511-NSE-ESKB-IR-5738 REV.1	2015

Document Description	Reference Number	Year
CIVIL STRUCTURE INSPECTION REPORT CONTAINMENT BUILDING ONLINE MONITORING UNIT-1 AND UNIT-2	JN511-NSE-ESKB-L-5737	2015
SYSTEM DESIGN ACCEPTANCE OF THE UNIT-1 ILRT OUTAGE-121 STRUCTURAL INTEGRITY TESTS RESULTS	JN411-NSE-ESK-L-6081 REV.0	2015
SYSTEM DESIGN ENGINEERING ACCEPTANCE OF THE UNIT-1 ILRT OUTAGE-121 STRUCTURAL INTEGRITY TESTS RESULTS	JN411-NSE-ESK-L-6235 REV.0	2015
CIVIL STRUCTURE INSPECTION ASSESSMENT OF CONTAINMENT MONITORING TRENDING AND INTERPRETATION OF RESULTS	JN391-NSE-ESKB-L-6585	2016
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT-1 OUTAGE-122 EXTERNAL INSPECTION	JN713-NSE-ESKB-IR-6702	2016
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT-1 OUTAGE-122 EXTERNAL INSPECTION	JN319-NSE-ESKB-L-6793	2016
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT UNIT 1/2 MONITORING RESULTS	JN-713-NSE-ESKB-L-6701	2016
RE-ASSESSMENT OF EDF REPORT ON OUTAGE 221 ILRT	JN411-NSE-ESKB-L-6427 REV.1	2016
SYSTEM DESIGN ENGINEERING ACCEPTANCE OF THE UNIT-2 ILRT OUTAGE 221 STRUCTURAL INTEGRITY TESTS RESULTS	JN411-NSE-ESKB-L-6427 REV.1	2016
SYSTEM DESIGN ENGINEERING ACCEPTANCE OF THE UNIT-2 ILRT OUTAGE 221 STRUCTURAL INTEGRITY TESTS RESULTS	JN411-NSE-ESKB-L-6426 REV.0	2016
SYSTEM DESIGN ENGINEERING ACCEPTANCE OF THE UNIT-2 ILRT OUTAGE 221 STRUCTURAL INTEGRITY TESTS RESULTS	JN411-NSE-ESK-L-6386 REV.0	2016
CONTAINMENT MONITORING RESULTS FIRST QUARTER TRENDING AND INTERPRETATION OF RESULTS	JN664-NSE-ESKB-R-6366	2016
CONTAINMENT MONITORING RESULTS FIRST QUARTER TRENDING AND INTERPRETATION OF RESULTS	JN664-NSE-ESKB-L-6366 REV.1	2016
CONTAINMENT MONITORING RESULTS SECOND QUARTER TRENDING AND INTERPRETATION OF	JN695-NSE-ESKB-AP-6561	2016

Document Description	Reference Number	Year
RESULTS		
CONTAINMENT MONITORING RESULTS SECOND QUARTER TRENDING AND INTERPRETATION OF RESULTS	JN695-NSE-ESKB-L-6561	2016
CONTAINMENT BUILDING SURFACE DEFECTS NUMERICAL ANALYSIS	JN411-NSE-ESKB-R-5830	2016
DETERIORATION OF THE COVER CONCRETE OF CONTAINMENT BUILDINGS	JN426-NSE-ESKB-4988	2016
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT MONITORING RESULTS 4TH QUARTER 2016 UNIT-1 AND UNIT-2	JN723-NSE-ESKB-L-6756	2016
CIVIL STRUCTURE INSPECTION SUMMARY REPORT CONTAINMENT MONITORING RESULTS 1ST QUARTER 2017 UNIT-1 AND UNIT-2	JN729-NSE-ESKB-L-6819	2016
HRX 1ST QTR 2017 CONTAINMENT MONITORING	JN-729-NSE-ESKB-L-6819	2017
HRX 2ND QTR 2017 CONTAINMENT MONITORING	JN-729-NSE-ESKB-L-7102	2017
HRX 3RD QTR 2017 CONTAINMENT MONITORING	JN-729-NSE-ESKB-L-7017	2017
HRX 4TH QTR 2017 CONTAINMENT MONITORING	JN-729-NSE-ESKB-L-7188	2017
CONTAINMENT BUILDING (EXTERNAL) UNIT 2	JN778-NSE-ESKB-IR-7588	2018
CONTAINMENT BUILDING (EXTERNAL) UNIT 1	JN811-NSE-ESKB-IR-8045	2019
CONTAINMENT BUILDING (EXTERNAL) UNIT 2	JN834-NSE-ESKB-IR-8258	2020
CONTAINMENT BUILDING (EXTERNAL) UNIT 1	JN851-NSE-ESKB-IR-8398	2021
TENDON INSPECTION	LI 38811-001 LI-009 GA	2022
CONTAINMENT BUILDING (EXTERNAL) UNIT 2	JN868-NSE-ESKB-IR-8760	2022
CONTAINMENT BUILDING (EXTERNAL) UNIT 1	JN876-NSE-ESKB-IR-881	2022
CONTAINMENT BUILDING (INTERNAL) UNIT 2(OUTAGE 225)	JN868-NSE-ESKB-IR-8759	2022
HRX 1ST QTR 2017 CONTAINMENT MONITORING	JN875-NSE-ESKB-L-8785	2022
HRX 2ND QTR 2017 CONTAINMENT MONITORING	JN881-NSE-ESKB-L-8931	2022
HRX 3RD QTR 2017 CONTAINMENT MONITORING	JN888-NSE-ESKB-L-8950	2022
HRX 4TH QTR 2017 CONTAINMENT MONITORING	JN897-NSE-ESKB-L-9026	2022

Document Description	Reference Number	Year
CONTAINMENT BUILDING (EXTERNAL) UNIT 1(OUTAGE 126)	JN899-NSE-ESKB-IR-9086	2022
HRX 1ST QTR 2017 CONTAINMENT MONITORING	JN902-NSE-ESKB-L-9148	2023
HRX 2ND QTR 2017 CONTAINMENT MONITORING	JN907-NSE-ESKB-L-9230	2023
HRX 3RD QTR 2017 CONTAINMENT MONITORING	JN910-NSE-ESKB-L-9314	2023
HRX 4TH QTR 2017 CONTAINMENT MONITORING	JN917-NSE-ESKB-L-9428	2023

3 KNOWN OR POTENTIAL THREATS

This section refers to the 'threats' to the structural integrity of the containment buildings (i.e., the third barrier). These threats have the potential to challenge the design base or the operation of the structures.

3.1 Known Threats

There are multiple possible failure mechanisms which can impact the performance of safety-related concrete structures, in accordance with IAEA Nuclear Energy Series: No. NP-T-3.5, *Ageing Management of Concrete Structures in Nuclear Power Plants*, which were considered below:

COMPONENT	TYPE OF FAILURE	DEGRADATION MECHANISMS	TEST/EVALUATION
Cylindrical walls	Structural integrity	• Cracking • Chloride Induced Corrosion (of External Facades) • Coating degradation	Planned civil visual inspection and concrete non-destructive testing
Domes	Structural integrity	• Cracking • Chloride Induced Corrosion (of External Facades) • Coating degradation	Planned civil visual inspection and concrete non-destructive testing
Internal concrete structures (walls, slabs, beams, columns, floors, plinths, anchor plates)	Structural integrity	• Cracking • Spalling • Leaching • Corrosion of reinforcing steel • Coating degradation • Irradiation	Planned civil visual inspection
Internal steel structures (floors, beams, columns, baseplates, stairs)	Structural integrity	• Corrosion • Cracked and broken welds • Loose connections • Deformation of sections • Loss of protective coating	Planned civil visual inspection

COMPONENT	TYPE OF FAILURE	DEGRADATION MECHANISMS	TEST/EVALUATION
Post Tensioning systems and Tendon grease	Structural integrity	• Corrosion • Elevated temperature • Irradiation • Fatigue • Loss of tensioning force • Hydrogen Embrittlement risk generated by ICCP	Hydrogen embrittlement linked to ICCP was considered in TRS [4] and to be taken into account as part of the design and subsequent installation, which will become available as the ICCP project progresses. Furthermore, CR 109937-008 GA has been raised to compile Ageing Management programme for Containment ICCP which will be procured as part of TRS [4].
Pre-stressing tendon anchoring end caps (located on the dome and upper raft)	Structural integrity	• Corrosion	Planned civil visual inspection
Online monitoring equipment	Functionality	• Weathering on ducts/wires • Corrosion on brackets supporting invar wires/pendulums pipes.	Planned civil visual inspection
Bulked head doors/Access doors	Functionality	• Corrosion • Water tightness due to wear of locks, hinges and closure mechanisms and cracking due to irradiation.	Planned Civil inspection
Containment penetrations	Functionality	• Aging effects of mortars and grouts due to elevated temperatures and irradiation	Planned civil inspection
Waterproofing/joints	Functionality	• Cracking • General wear and vibration fatigue • Ageing of polymers	Planned civil inspection

COMPONENT	TYPE OF FAILURE	DEGRADATION MECHANISMS	TEST/EVALUATION
Gutters/Downpipes	Functionality	• Corroded brackets • Missing down pipes	Planned civil inspection
Ladders/Stairs platforms	Functionality	• Corrosion	Planned civil inspection
Polar crane rail	Structural integrity	• Corrosion on the corbels supporting the polar crane rail • Loose connections	Planned civil inspection

Eskom is aware of various chemical degradation mechanisms which could affect reinforced concrete. These failure mechanisms were eliminated as threats (as discussed in an NEPP) and the most detrimental degradation mechanism at the station have shown to be Chloride Ingress (Chemical Threat) related degradation.

The history of delamination on the containment structures is discussed in § 2 while the plan for future works are discussed in § 1.1.

4 MONITORING AND TRENDING

4.1 Inspection Regime

The inspection regime of KNPS is governed by KNPS ISI PRM Manual 240-119362012 which include Module E-L (ASME Section XI, "American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section XI, Division 1, Rules for the In-Service Inspection of Nuclear Power Plant Components", 2007 Edition with Addenda up to and including 2008 [7] as part of the 4th In-Service Inspections interval). The regime is conducted in accordance with KAU-030. The inspection frequencies are stipulated in Table 4.

Table 4: Component Inspection frequency

Component/Section	Frequency	Procedure
HRX – External Note: Tendon end caps in the Vault are inspected as part of KWR-IP-CIV-014	1RO	KAU-030, 240-119362012 (Module E-L) KWR-IP-CIV-005
HRX – Internal	2RO	KAU-030, 240-119362012 (Module E-L) KWR-IP-CIV-024
Dynamometer	Quarterly	KAU-030 - KWR-IP-CIV-015
Invar Wires & Pendulums	Quarterly	KAU-030 - KWR-IP-CIV-017 & KWR-IP-CIV-018
Strain Gauges and Thermocouples	Quarterly	KAU-030 - KWR-IP-CIV-016
Topographical Survey (Upper & Lower Rafts)	5 Yearly	KAU-030- KWR-IP-CIV-023
ILRT	10 Yearly	KBA 0028 NES MA CLR 003 & KGU-042

The inspection regime referred to above identifies any degradation on the containment structures inclusive of degradation of minor components (handrails, downpipes, cat ladders, etc.) and structural components (concrete, tendon heads, etc.). The inspections form part of the basis of the ageing management programme of the structures.

4.2 Preventative Maintenance

Regular implementation of the remedial actions /maintenance repairs identified through the civil surveillances are intended to serve as a preventative maintenance strategy. This includes for example the coating of the tendon heads although the corrosion identified was only superficial, and the sealing of the cracks on the domes which are non-structural and does not impact the integrity of the structures.

It is noted that there have been delays to repair concrete degradation (as identified through the surveillances) resulting in large patches amounting to approximately 11% of the containment building surface area being delaminated and chloride ingress extending past the rebar cover depth. If left unattended, corrosion of the post tensioning ducts can be expected in the future. It is important to note that the surface repairs have no impact on structural integrity.

The resultant maintenance repairs have grown into large-scale refurbishment works to be conducted on an ad-hoc required basis as part of the maintenance projects. Refer to Appendix 9.1 for more maintenance and modification information until end-of-life 2045 + 10 years for decommissioning.

4.3 Structural Integrity

The current status of the containment structures can be summarized as follows (with more information in the subsequent sections):

- The Structures' integrity is not compromised, and the tendons remain intact.
- The Dynamometers have recently been re-calibrated.
- The on-line monitoring equipment require refurbishments.
- There is extensive delamination on the structures' external facades, although the delamination has been shown to have a negligible effect on the structures' robustness.
- There are several degraded minor components. This includes the downpipes, handrails, cat ladders, etc.

Accordingly, the degraded condition of the structures are tracked under the CURA Risk (R027141). The Risk is level II, with a Consequence Level 6 (highest), and likelihood level B.

4.3.1 Concrete Repairs

Extensive patch repairs were completed in 2018 on unit 1 and 2 containment buildings. This was conducted as part of a project under an Equivalency [21]. The repairs included all the delamination identified at the time on both cylindrical walls and domes. Additional work was included as preventative maintenance including coating of sections, re-coating of steel components and the sealing of the dome cracks. The repairs are non-structural and only about 11% of the structures' surfaces have been rehabilitated.

4.3.2 Delamination

The trend from the inspection reports notes that the delamination on the containment buildings are increasing and will continue to increase. This is due to the continual ingress of chlorides on the containment structures. These inspection reports also noted that areas around the patch repairs on the containment buildings induce further delamination. Thus patch repairs to the structures are not sustainable. This can be attributed to the phenomena where the anode (part of the structure which corrodes) 'moves' next to where the anode used to be, i.e. the area which the patch repair is applied to. The areas adjacent to the patched areas will now corrode at an accelerated rate.

Thus, an expert panel [10] was appointed by Eskom which looked at long-term permanent solutions. The recommendation of the long-term solution is discussed under § 5.3.

4.3.3 Anomalies

As part of the design, the structure has a significant variability in the thickness in concrete where the cylindrical dome joins the thick ring beam, and then reduces to the dome. This has caused cracking along the circumference of the dome, in the form of a continuous ±110m crack.

As part of the 10 yearly ILRT testing these cracks were measured and monitored as part of the ILRT tests to determine the significance of the cracks. It was shown that the cracks are not influenced by the increase in pressure and are only influenced by environmental temperatures, i.e., the cracks are non-structural and are not impacted by internal mechanical stresses. The cracks were sealed as part of N.KB00314.M.02 (Civil Recovery project) (referred to in § 4.3.1).

4.4 Time-Limiting Aging Analysis

Extension of the operational lifespan of the containment unit 1 and 2 is in progress. A comprehensive evaluation detailed **Error! Reference source not found.** was completed. This report analysed time-dependant (ageing) parameters linked to the containment buildings structural integrity and demonstrated that the containment building can safely continue operating for the period 60 years.

Furthermore KNPS embarked on a Safety Aspects Long Term Opereation (SALTO) mission. The findings for the containment unit 1 and 2 are stated below:

4.4.1 Functionality of the monitoring system

The functionality of the monitoring system regarding the number and distribution of operating measurement devices and the quality of device signals was confirmed through SALTO. The project however makes the following recommendations, with status comments:

- install additional strain gauges fixed to the exterior surface of both domes (planned as part of the ILRT)
- recalibrate the load cell or exchange it (re-calibration completed),
- perform the outstanding repair of the 4 erratic pendulums in Unit 1 (planned for August 2024)
- install additional temperature gauges to improve the temperature (planned as part of Mod 23002)

4.4.2 Inspections and Repair regime

The inspection program and recommended repair regime are sufficient to ensure the structural integrity of the post tensioned containment structures of unit 1 and unit 2. It was recommended to extend the containment surface repairs considerably in the following period of LTO in order to ensure the structural integrity of the containment structures of unit 1 and 2 if the ICCP is not pursued.

This is in line with the allowance for periodical repairs of the Containment Buildings' facades. Additionally, the inspection reports' recommendations shall be followed.

Concrete repairs shall be initiated if a depth of concrete loss of 60 mm is detected, or if delamination is identified on a surface area of 100 m². However, if uncovered reinforcement bars are detected by inspection, the concrete repair must be performed immediately and independent from depth of concrete loss and relating surface area. **N.B:** there is currently no uncovered reinforcement bars.

4.5 EAU System

For the containment structures, monitoring and trending is performed using the Online Monitoring system (trigramme EAU). The monitoring is licence binding in accordance with the Nuclear Installation License NIL-01 and KAU-030 [12]. Other procedures for how the measurements are conducted for the different instrumentation are captured in references [15] – [18].

The trending is done quarterly, and currently there are no concerns associated with the results of the on-line monitoring. It is however noted that some devices provide erratic readings due to degradation of the monitoring devices themselves which has no impact on the structures' integrity. To this extent the dynamometers was recently re-calibrated as recommended.

A project to refurbish the Pendulums and Invar Wires on Unit 1 and Unit 2 Reactor Buildings at Koeberg Operating Unit is currently in the procurement process, with implementation planned to begin in March 2024 to solve the erratic behaviour of the on-line monitoring devices. This is similar to works performed during 2005-2006 (see § 5.1).

4.6 Intergrated Leak Rate Test

The intergradted leak test (ILRT) in accordance with KNPS ISI PRM 240-119362012 (ASME XI, IWL-5000) requires that the ILRT be conducted on containment structure unit 1 and 2 to test the linearity of the structures under accident pressuresthe testing is scheduled on a 10 yearly basis with the last undertaken in 2015 yeilding successful results. The next ILRT is planned for the X27 outage cycle, aligning with the scheduled testing intervals.

4.7 Impressed Current Cathodic Protection

The installation of Impressed Current Cathodic Protection (ICCP) system on both HRX structures (Modification 16002), is planned for implementation in November 2024. The design of the ICCP system is done by an external specialist consultant with reviews and acceptance by Eskom. Furthermore, it has been submitted to the National Nuclear Regulator (NNR) for review. A mock-up of the ICCP system was constructed at KNPS as part of the verification and validation of its compatibility with the containment structure and as an additional measure to verify the use of ICCP.

Considering that the ICCP installation will start in November 2024, all the delamination that has been identified up to now, and will further develop before the commissioning of the ICCP, will be repaired as part of the ICCP installation project which is planned to run over the next 3 to 4 years.

The existing delamination does not compromise structural integrity and the timing of the repairs will ensure that the ICCP is installed on a sound substrate with no delamination which may compromise the functionality of the ICCP.

ICCP is planned for installation during 2024. Furthermore, other key dates for the ICCP project is noted below:

Phase		Pre-Project.		Concept Phase		Definition Phase				Execution Phase							
	PLCM Del. Mil	SOW-AU	CRA	FS-CO	DRA	TRS-CO	ERA	DC-CPA-CO		DDA-CO	IH-DD-CO	ICC-CO	SC-KORC-AP	DNS-CO	NIL-AU	MOS-CO	IMPL
		T-48	T-46	T-39	T-38	T-33	T-32	T-23	T-19	T-14	T-14	T-13	T-10	T-9	T-5	T-3	T-0
Project	MILESTONES	SOW-AU	CRA	Feasibility Study (FS)	DRA	Tech Req. Spec (TRS)	ERA	D/Design Contract	Scheme Design Accepted	D/Design Approval	Inhouse Design	Install. Contract	S/Case KORC	NNR Submission	D/D & S/C NNR AU.	Material on Site	Construct / Impl. Start
ICCP 16002	PLANNED	01-Nov-20	01-Jan-21	01-Aug-21	01-Sep-21	01-Feb-22	01-Mar-22	01-Dec-22	01-Dec-22	01-Sep-23	01-Sep-23	01-Oct-23	01-Jan-24	01-Feb-24	01-Jun-24	01-Aug-24	01-Nov-24
	ACTUAL	23-Aug-16	N/A	31-Mar-17	N/A	22-Jun-18	20-Mar-20	07-Feb-21			#N/A						
	Aspirations								01-Sep-21	01-May-22		01-Sep-22	01-Jan-23	01-Feb-23	30-May-23	31-Aug-23	01-Jul-23

5 MODIFICATIONS

5.1 Modification(s) Completed

Modification Number	Description	Comment
	Coating of Containment Structures	Completed in 2002
	Concrete Repairs 1 & 2 HRX	2002-2003
	Invar wire replacements	2005-2006
EMERGENCY BUY	Concrete Patch Repairs 2HRX	Completed in 2017
N.KB00314.M.02	Concrete Patch Repairs 1HRX	Completed in 2018

5.2 Cancelled Modification(s)

N/A

5.3 Modification(s) in Progress and Future Modification(s)

The following modification(s) are currently planned for installation within the next ten years:

Mod #	**Description**	**Comment**
16002	ICCP	Design of ICCP has been accepted by Eskom and is currently under NNR review for acceptance
23002	Modification for online instrumentation for both Unit 1 and Unit 2	Modifications for the Containment Online Monitoring Equipment in progress.

6 LIFE CYCLE PLAN AND EXPENDITURE

The life cycle plan and expenditure for planned and future modifications on the containment structures appear below. The objective is to plan for a 60-year plant life i.e. until 2045 plus 10 years decommissioning.

YEAR	COST (R)	CAPITAL/ R&E	REASON	IDENTIFICATION
2023	350K	R&E	Inspection as per KAU-030 (including online monitoring)	Monitoring
2023	40M	R&E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment, maintenance replacement	Refurbishment
2023-2025	140M	Capital	ICCP on 1&2 HRX (Design/Mock-up/Implementation)	Mod:N.GN16002
2022	350K	R&E	Inspection as per KAU-030 (including online monitoring)	Monitoring
2023	350K	R&E	Inspection as per KAU-030 (including online monitoring)	Monitoring
2023	50M	R&E	ILRT (ISIPRM 240-119362012) 1&2 HRX	Monitoring
2024	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2025	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2026	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2027	45M	R&E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment maintenance replacement/ICCP maintenance	Refurbishment
2027	400K	R&E	Inspection as per KAU-030	Monitoring

YEAR	COST (R)	CAPITAL/ R&E	REASON	IDENTIFICATION
			(including online & ICCP monitoring)	
2028	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2029	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2030	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2031	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2032	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2033	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2033	45M	R7E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment maintenance replacement/ICCP maintenance	Refurbishment
2033	50M	R&E	ILRT (ISIPRM 240-119362012) 1&2 HRX	Monitoring
2034	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2035	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2036	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2037	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2038	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring

YEAR	COST (R)	CAPITAL/ R&E	REASON	IDENTIFICATION
2039	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2039	45M	R&E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment maintenance replacement/ICCP maintenance	Refurbishment
2040	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2041	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2042	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2043	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2043	50M	R&E	ILRT (ISIPRM 240-119362012) 1&2 HRX	Monitoring
2044	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2045	45M	R&E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment maintenance replacement/ICCP maintenance	Refurbishment
2045	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2046	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2047	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2048	400K	R&E	Inspection as per KAU-030	Monitoring

YEAR	COST (R)	CAPITAL/ R&E	REASON	IDENTIFICATION
			(including online & ICCP monitoring)	
2049	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2050	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2051	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2051	45M	R&E	Concrete repairs/Waterproofing/ Coatings/Online monitoring equipment maintenance replacement/ICCP maintenance	Refurbishment
2052	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2053	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2053	50M	R&E	ILRT (ISIPRM 240-119362012) 1&2 HRX	Monitoring
2054	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring
2055	400K	R&E	Inspection as per KAU-030 (including online & ICCP monitoring)	Monitoring

*** Values excludes CPI**
**** Assumes a 5 yearly Civil Recovery Project and 10 yearly ILRT.**

***** The current setup for civil recovery project is covered under R&E maintenance budget from KOU.**

7 CONCLUSION

The containment structures remain compliant and sufficient against design base loads and the ageing management programme is being implemented as required by the statutory requirements. Engineering analysis confirms that the structures are not compromised by surface delamination. In fact, the Time-Limited Ageing Analysis has indicated that the structures will remain compliant to design requirements for an additional 20-years.

The main structural threat for the buildings is chloride induced corrosion. Without a permanent intervention the delamination on the structures will continue until they are degraded thus needing to be decommissioned. Therefore the implementation of ICCP is necessary so as to protect the post-tensioning cables from degradation ensuring structural integrity for long term operation.

The monitoring trending reports shows concerns regarding failures of the monitoring devices and thus loss of baseline measurements, thus provision shall be made for 5yearly replacement of Invar and Pendulum wires, including strain gauge, thermocouple augmentation/replacement, and calibrations of all these monitoring equipment to ensure availability until 2045 with an additional 10years for decommissioning. This is based on operational experience and failure rates and subsequent loss of monitoring baselines currently experienced.

The containment and its sub-categories as mentioned in preceding sections form part of comprehensive role in the containment integrity. Thus, necessitating periodic inspections and maintenance.

8 REFERENCES

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9 APPENDICES

10.1 MAINTENANCE REQUIRED AND NOTIFICATIONS

10.2 JUSTIFICATION

9.1 Maintenance Required and Notifications

	Component	Condition	Planned Rehabilitation	Notification/Project
Main Structural Components	Base Mat	None	-	
	Gusset	None	-	
	Cylindrical Wall	Extreme	ICCP Required to ensure continuous operation of KNPS	Mod 16002
	Ring Beam	Urgent	ICCP required to protect embedded tendon heads	Mod 16002
	Dome	Extreme	ICCP Required to ensure continuous operation of KNPS	Mod 16002
Internal Structures	Concrete Structures	None	-	
	Missile Shields	None	-	
	Steel Structures	None	-	
On-line Monitoring	Invar Wires	Long Term	Continuous monitoring of condition - no mitigation in-place and failure is anticipated	CE 17339
	Strain Gauges	None	Failure is occurring, however no rehabilitation or modification planned	CE 17339
	Thermocouples	Long Term	Failure is occurring, however a rehabilitation or modification is planned	CE 17339
	Dynamometers	Urgent	Calibration of the dynamometers-	CE 17339
Non-Structural and Non-Licence Binding Components	Other Components	Urgent	Non-structural elements of the structure in poor condition, maintenance required	
	Water Proofing	Long Term	-	
	Down Pipes	Urgent	A design is in place for the repair, implementation required	
	Sumps	None	-	

9.2 Justification

Revision 0

1. First Compilation

Revision 1

2. Update of new projects, strategy and defects.

Revision 2

3. Update to include SALTO mission gaps.

Revision 3

4. Annual Revision with minor updates