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Title	**NEUTRON SAFETY CHANNEL GUARDED FISSION CHAMBER DETECTOR WITH MINERAL INSULATED CABLE SPECIFICATION**

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REVISIONS

This document has been revised in accordance with the following schedule:

Rev. No.	Date Approved	Nature of Revision	Prepared
00	See Title Page	First issue	DA Tselane

1 PURPOSE

The purpose of this document is to provide the technical specifications for the replacement of the Neutron Safety (NS) Channel Guarded Fission Chamber Detector with Mineral Insulated (MI) Cable.

2 SCOPE

This document specifies the technical requirements that define the deliverable items for the replacement of the NS Channel Guarded Fission Chamber Detector with MI Cable.

3 ABBREVIATIONS

The following abbreviations are associated with this document:

ANSI	American National Standards Institute
CPS	Count per Seconds
FAT	Factory Acceptance Test
FMEA	Failure Mode Effects Analysis
NS	Neutron Safety Channel
NNR	National Nuclear Regulator
MI	Mineral Insulated Cable
HV	High Voltage
U^{235}	Uranium 235

4 DEFINITIONS

Burn-up life	The amount of time that the detector can continue to operate effectively before its performance begins to degrade.
Guarded Fission Chamber	A guarded fission chamber is a type of radiation measurement device used to detect and quantify the presence of nuclear radiation. It consists of three cylinders of which the two inner cylinders is coated with a layer of uranium and filled with Gas. Two cables are connected to the fission chamber, one is for HV, and the other carries the neutron pulses.
Mineral Insulated Cable	This cable provides a high degree of protection against heat, fire, moisture, and other environmental hazards, making MI cable ideal for use in harsh and demanding environments. It consists of an inner conductor, solid copper covered with plastic coating. This is then surrounded by magnesium oxide powder. The outer sheath consists of a copper inner tube and Stainless-steel outer tube. This cable impedance is 50Ω ± 2Ω

Sensitivity	The minimum level of radiation that the detector can detect accurately

5 REFERENCES

The following codes or standards are applicable:

ANSI 45.2-2	:	Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plants
SHEQ-INS-0244	:	Control of Handling, Storage, Packaging, Preservation, and Delivery of Product
SHEQ-INS-0238	:	Control of Procurement
10CFR50 Appendix B	:	Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
RR-PRG-1000	:	Procedure For the Release of Procured and Manufactured Products (Items) Within SAFARI-1
RR-TSR-0001	:	Safety Classification of Safari-1 Structures, Systems and Components
SHEQ-INS-0270	:	QMS requirements for the supply of quality class 1 products for nuclear installations

6 TECHNICAL REQUIREMENTS

The component is classified as SC-1 as per RR-TSR-0001 and should therefore comply with the requirements SHEQ-INS-0270. The specifications for each component are defined in table 1 and 2 below.

6.1 DETECTOR SPECIFICATION

Table 1: Guarded Fission Chamber Detector specification

Item Description: Guarded Fission Chamber Detector specification	
Mechanical	
Diameter	80.02 mm (3.15 inches)
Overall Length	331.7 mm (13.06 inches)
Distance from nose to start of sensitive length	22mm (0.88 inches)
Sensitive Length	9.25 inches
Net weight	2.4Kg (5.29 pounds)

Connectors	
Connector Type	No connector on chamber
Insulator type	NA
Material Requirements	
Detector Housing Material	Aluminium Grade 1000 series
Electrodes	Aluminium Grade 1000 series
Insulator type	Alumina Ceramic
Neutron Sensitive Material	Content: ≥ 93% enriched U-235
	Thickness: 0.6 to 2.0 mg/cm2
	Total Quantity of Uranium: 0.72 to 1,3 grams Specifically total mass and U 235 mass must be provided per detector serial number
Gas Filling	95%(min) of Argon with 5% Nitrogen(max)
Gas Pressure	14.7 psi (1 bar)
Impedance	
Resistance at 25 °C (Minimum)	$> 10^{12}$ Ohms
Capacitance	Signal Electrode to Case: >135 pF
	High Voltage Electrode to Case: >240 pF
Maximum Ratings	
Voltage Between Electrodes	1000 Volts
Temperature	300°C
Thermal Neutron Flux(ϕ)	$1.5 < \phi < 2.0 \times 10^{10}$ nv
Burn-up life 10% decrease in sensitivity	3.0×10^{20} nvt
Typical Operation	
Operating Voltage	300 volts
Operating Voltage Plateau	200 to 800 volts
Thermal Neutron Flux Range	1.5 to 2.0×10^{10} nv
Sensitivity	0.7 cps/nv
Thermal Neutron Sensitivity	$>1.2 \times 10^{-13}$ Amps/nv(min)
Gamma Sensitivity	$<5 \times 10^{-11}$ Amps/R/hr(max)

Notes:

1. Supplier to provide Factory Acceptance Testing (FAT) Report or traceability of manufacturing. As part of the test data the following must be provided by supplier
    a. Certificate of gas content and fill pressure
    b. Certification of the amount of Uranium and the isotope analysis
        i. Nominal Isotope Analysis
            U^{234} <1%
            U^{235} ≥ 93%
            U^{236} <0.8%
            U^{238} <6.5%
    c. Test data of alpha current, Insulation resistance, Inter-electrode capacitance and Neutron Sensitivity
    d. Integral Bias Curves of Noise, Noise plus Alpha, Noise plus Alpha plus Neutrons

6.2 CABLE SPECIFICATION

Table 2: Mineral Insulated (MI) Cable Specification

Item Description: Mineral Insulated (MI) Cable Specification	
Dimensions	
Outer Diameter	5.0 ±0.05 mm
Inner Diameter	3.0 ±0.15 mm
Wire Diameter	0.75 ±0.10 mm
Cable Length	±21 m
Connectors	
Connector at Amplifier box	N Type male
Material	
Wire	Copper CuA1
Insulator	SiO2 purity > 99.5%
Sheath	Stainless Steel AISI 304L(external)-copper inside (CuA1) (internal)
Electrical Characteristics	
Line Resistance	approx. 0.035 Ohms/m ±0.1
Insulation Resistance	≥10^{12} Ohms.m at 20°C under 1000VDC

Dielectric test	≥1.10^{10} Ohms.m at 200°C under 1000VDC
	≥1500 VDC/1min between wire and sheath
Typical Impedance	50 Ohms ± 2Ohms
Other Characteristics	
Minimum Bend Radius	250 mm
Minimum Bend Radius (once-on installation)	50 mm

Notes:

1. The mineral insulation cable connections/splicing at the Detector must be done by the supplier. Supplier to supply end connections for MI cable.

7 ENVIRONMENTAL REQUIREMENTS

The system shall be capable of achieving all functional and performance requirements as specified in this document, during and after exposure to environmental conditions as indicated below:

Table 3: Temperature & Humidity Conditions

Equipment	**Location**	**Environmental limits**				
		Temperature °C			**Humidity % RH**	
		Min.	Operating	Max.	Min.	Max.
Detector assembly	Detector Well	10	32	50	10	100
MI cables to Preamplifier Junction Box	Confinement	10	30	45	10	80

8 OTHER REQUIREMENTS

8.1 TRANSPORTABILITY

a) The equipment and associated packaging shall allow the equipment to be transported by road, rail, sea, or commercial air transport without exceeding any environmental limitations of the equipment.

b) Crate size shall be limited to the following dimensions: length <5 m, width <2 m, height <1.5 m, with a maximum mass of 200 kg.

8.2 DOCUMENTATION

The following documentation should be supplied by the supplier for release and certification of conformance to requirements:

8.2.1 Equipment Manual or Data Pack

An equipment manual or data file describing the detector and cable shall be supplied. The data pack shall, as applicable, have the following:

a. Installation procedures
   - Handling precautions and limits
   - Detector handling instructions
   - Cable terminating procedures.

b. Commissioning procedures and tests
   - Commissioning checklists

c. Procedures and schedules for system maintenance procedures
   - Detector and Channel alignment procedures
   - Schematic and wiring diagrams

d. Parts list for reference and Certificate of Conformance for the assemblies

e. Configuration list of sub-assemblies and modules for each assembly as agreed.

f. Analysis of system reliability which includes Failure Mode Effects Analysis (FMEA)

g. Life cycle management letter of the equipment with commitment period of support after procurement of goods.

h. Recommended maintenance strategy with clear maintenance tasks and their frequency.

i. Document providing: Specificly total mass and U 235 mass of each detector per serial number of detector

8.2.2 Drawings

A complete set of As-built drawing to enable maintenance and installation, as a minimum supplied drawings shall include:

- Outline drawings
- Assembly drawings
- Circuit diagrams (If available)

8.3 SUPPLIER QUALIFICATION REQUIREMENTS

Since the component is classified as a Safety Class SC-1 it also categorised the quality requirements as Quality Class level as QL-1. Thus, Necsa have the prerequisite to perform a supplier qualification audit on the supplier as per the requirements of the SAFARI-1 and Nesca QMS requirements. The following documents needs to be provided in advance:

- Company profile
- Quality Manual
- Quality Management system and other certification

The supplier must ensure compliance with Quality Assurance (QA) Requirements as detailed in the following standards and procedures.

- SHEQ-INS-0238,
- RR-PRG-1000
- 10 CFR 50 **Appendix B**

8.4 PREPARATION FOR DELIVERY

All export and import permits shall be duly authorized prior to shipment. Shipping requirements must comply with ANSI 45.2-2 Level B and SHEQ-INS-0244

8.4.1 Marking and Labelling

All items supplied, down to the level of maintenance replaceable items, shall bear name plates indicating at least the following:

- Manufacturer name
- Part number
- Serial number

8.4.2 Shipping and Freightage

All export and import permits shall be duly authorized prior to shipment.

i. The shipping route shall be selected to ensure that the equipment is handled with minimum transport and shipment activities between the country of origin/manufacture and South Africa.

ii. Essential shipping permits shall be the responsibility of the supplier. The supplier is responsible for obtaining the required export permits.

iii. NECSA SAFARI-1 shall be responsible for the supply of end-user certification.