A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

25KV AC SINGLE PHASE 20MVA TRANSFORMER

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Transnet Freight Rail

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1.0 SCOPE

This specification covers the Transnet Freight Rail's requirement for the design, manufacture, testing and delivery of 20MVA single phase power transformer for 25kV AC traction substations.

2.0 STANDARDS AND PUBLICATIONS

Unless otherwise specified all materials and equipment supplied shall comply with the latest editions of the relevant SANS and Transnet Freight Rail's publications where applicable.

The following publications are referred to in this specification:

2.1 SOUTH AFRICAN NATIONAL STANDARDS

SANS 121:	Hot Dip Galvanized Coatings on Fabricated Iron and Steel articles.
SANS 555:	Unused and Reclaimed mineral insulating oils for transformers and switchgear.
SANS 1091:	National Colour Standards.
SANS 9001:	Quality Management Systems – Requirements.
SANS 10142-1:	The wiring of premises Part 1- Low voltage installations.
SANS 60044-1:	Instrument Transformers Part 1- Current Transformers.
SANS 60076-1:	Power Transformers Part 1- General.
SANS 60076-2:	Power Transformers Part 2- Temperature rise for liquid immersed transformers.
SANS 60076-3:	Power Transformers Part 3- Insulation levels, Dielectric tests and External clearances in air.
SANS 60076-5:	Power Transformers Part 5- Ability to withstand short circuit.
SANS 60076-7:	Power Transformers Part 7- Loading Guide for Oil-immersed Power Transformers.
SANS 60137:	Insulated Bushings for Alternating Voltages above 1000V.

2.2 TRANSNET FREIGHT RAIL'S PUBLICATIONS

CEE 0045:	Painting of Steel Components of Electrical Equipments.
CEE 0224:	Drawings, Catalogues, Instruction manuals and Spare lists for electrical equipments supplied under the contract.

3.0 TENDERING PROCEDURES

3.1 Tenderers shall indicate clause by clause compliance or non-compliance with the specification. This shall take the form of a separate document listing all the specifications clause numbers indicating the individual statement of compliance or non-compliance. This document can be used by tenderers to elaborate on their response to a clause.

3.2 A statement of non-compliance shall be motivated by the tenderer.

3.3 A preliminary design shall be submitted with the tender. And test certificates can only be submitted after the manufacturing.

3.4 Tenderers shall complete Appendix 2, "Information to be provided by tenderers.

3.5 Tenderers shall submit descriptive literature consisting of detailed technical specifications, general constructional details and principal dimensions, together with clear illustrations of the equipment offered. These shall be in English

3.6 Failure to comply with clauses 3.1, 3.2, 3.3, 3.4 and 3.5 could preclude a tender from consideration.

4.0 APPENDICES

The following appendices form an integral part of this specification and shall be read in conjunction with it.

4.1 Appendix 1: “Schedule of Requirements”

This appendix details the specific requirements for this specification and the requirements shall be filled by the Project manager.

4.2 Appendix 2: “Information to be provided by the tenderers.

This appendix calls for specific technical information to be furnished by tenderers.

5.0 SERVICE CONDITIONS

5.1 ATMOSPHERIC CONDITIONSB

The equipment shall be designed and rated for installation and continuous operation under the following conditions:

Altitude:	0 to 1800m above sea level.
Ambient temperature:	-10°C to +55 °C.
Relative humidity:	10% to 90%.
Lightning Conditions:	Up to 20 ground flashes per square kilometre per annum.
Pollution:	Heavily salt laden or polluted with smoke from industrial sources.

5.2 ELECTRICAL CONDITIONS

5.2.1 Frequency: The AC high voltage supply will normally be supplied by Eskom. The frequency will be 50 ±2.5 Hz.

5.2.2 Supply Voltage: Under normal conditions the system supply voltage will be maintained at ±5% of the nominal voltage over a 24 hour period. Under crippled supply network conditions the voltage can be expected to drop up to 15%.

5.2.3 Nominal Supply Voltage: Shall be as follows indicated in Appendix 1.

6.0 MAIN TRANSFORMER

6.1 GENERAL

6.1.1 Unless specified the transformer shall be for outdoor use and of the oil natural air natural (ONAN) cooled type and shall comply with specification SANS 60076-1/2/3.

6.1.2 The design rated power of the transformer shall be 20MVA at the frequency of 50Hz.

6.1.3 The primary winding connection of the main traction transformer shall be phase to phase.

6.1.4 The secondary winding connections of the main transformer shall be single phase and earth. The secondary output voltage shall be 25kV AC of the main transformer.

6.1.5 The responsible Senior Engineer at Transnet Freight Rail shall be consulted before any transformer design is finalised.

6.1.6 The primary and the secondary winding connections of the transformer shall be fully insulated.

6.1.7 The tertiary winding shall be rated to supply a 16 kVA 27 500 kV/ 240 V auxiliary transformer unless otherwise specified.

6.1.8 Tap changer type shall be OFF- Load.

6.1.9 The tapped windings shall be on the secondary.

6.2 TEMPERATURE RISE AND RATING

6.2.1 The transformer shall be subjected to cyclic overloads up to 2 per unit (maximum duration of 2 minutes).

6.2.2 For thermal consideration the overall loading requirement shall be in accordance with specification SANS 60076-7.

6.2.3 The transformer shall be able to withstand short circuit faults and it must be stated on the ability of the transformer offered to meet this requirements.

6.3 VOLTAGE RATIO AND TAPINGS

6.3.1 The transformer shall be designed to operate at the nominal system voltage as specified in the schedule of requirements.

6.3.2 Tapping range shall be 6 equal steps of 2.5 % each (0 % to +15 %).

The minimum voltage shall be 25kV and the maximum shall be 15 % above the nominal.

6.3.3 The transformer shall supply full load output at all tapings.

6.3.4 The full load regulation of the transformer shall not be more than 5%.

6.3.5 The tap changing gear shall be externally, manually operated, positively locking, off load type. The arrangement shall be such that excessive backlash will not affect the making of proper contact when the tap changing gear is operated in either direction. Rotary type having high-pressure type contacts is preferred.

6.3.5.1 The tap changing switch shall be lockable with provision for a padlock.

6.3.5.2 The positions of the tap changing switch shall be clearly marked.

6.4 BUILT IN CURRENT TRANSFORMERS.

6.4.1 Built in current transformers if required, shall be in accordance with specification SANS 60044 -1.

6.4.2 Protection current transformers on the primary side shall be fitted on the transformer primary bushings for primary voltages of 88kV and less. For voltages above 88kV, the primary protection current transformers will be separate units. All protection current transformers on the secondary side (25kV AC) shall be fitted on the transformer secondary bushings.

6.5 TRANSFORMER IMPEDANCE

6.5.1 The transformer impedance shall be as low as possible taking into account the voltage regulation as specified in clause 6.3.4 but shall not be less than 10 % (min 10% - max 12%).

6.6 MECHANICAL STRENGTH OF TRANSFORMER WINDINGS

6.6.1 The transformer shall be able to handle the AC supply voltages specified in the Appendix 1.

6.6.2 The transformer windings shall be able to withstand the electromagnetic and mechanical stresses caused by high fault currents up to 10kA.

6.6.3 In the adjudication of tenders particular attention will be given to:

- The mechanical design of the solid bolted clamping arrangement of the windings.
- The coil stacks in order to withstand short circuit forces.
- The methods employed to ensure thorough pre-shrinking and pre-stressing of the coils

6.6.4 Tenderers shall describe fully with the aid of detailed drawings of the construction of the windings and clamping arrangements.

6.6.5 Tenderers shall quote for transformers having the following design features listed below. No alternative to the requirements laid down in the following sub clauses will be considered unless complete details are submitted giving the advantages and improvements that will result.

6.6.5.1 Primary and secondary coil stacks shall be provided with solid bolted clamping arrangements which will distribute the clamping force over the whole end periphery of each coil stack.

6.6.5.2 Tenderers shall state the actual force anticipated under the worst fault conditions and the effective force applied by the clamping bolts on each winding.

6.6.5.3 Round conductor shall not be used for any windings.

6.6.5.4 High voltage windings shall be of the continuous disc type while low voltage windings shall be of the helix winding type.

6.6.5.5 Reliance shall not be placed on any resin used on the windings for increasing the mechanical stability of the coils, nor shall such resin have any detrimental effect on the transformer oil.

6.6.5.6 If laminated insulating material is subjected to mechanical compression forces, the construction shall be such that these forces are normal to the plane of the laminations.

6.6.5.7 All spacers and clacks on packing shall be suitably locked in position. Reliance shall not be placed on the pressure applied to the windings, or an adhesive, to keep the packing pieces in position.

6.6.5.8 The end frames shall be well braced and be of substantial construction.

6.6.5.9 The internal copper connections between the windings and connections to the leads shall be crimped and bolted.

6.6.5.10 Only high tensile steel bolts shall be used for the bolted connections.

6.6.5.11 Standard machine locknuts or approved locking plates shall be used to lock the nuts of the bolted connections.

6.7 INSULATION AND CLEARANCE LEVELS

6.7.1 Transformer bushings shall comply with specification SANS 60137.

6.7.2 Test voltages and minimum creepage distances for normal and polluted atmospheres shall be in accordance with specification SANS 60137.

6.7.3 The clearances between phase to earth and phase to phase shall be in accordance to specification SANS 60076-3.

6.8 INSULATION OF WINDINGS.

6.8.1 The transformers are required to operate in severe lightning areas. Surge arresters will be connected between the high voltage busbars and the substation earth. The neutral of the primary Star connected windings is not required to be brought out

6.8.2 All windings are to be fully insulated. Full and detailed particulars of the insulation and methods employed to reduce the risk of damage by overvoltage caused by system surges and lightning must accompany the tender.

6.8.3 The primary windings shall be insulated to withstand the test pressures referred to in specification SANS 60076-3.

6.8.4 The primary windings shall have a rated insulation level based on an equivalent 3 phase system as indicated in the following table:

Nominal system voltage	88 kV	132 kV	220 kV
Highest voltage for equipment	100 kV	145 kV	245 kV
Rated lightning impulse withstand voltage	450 kV	550 kV	850 kV
Rated power-frequency withstand voltage	185 kV	230 kV	360 kV

Table 1: Insulation Levels.

6.8.5 The secondary windings of the 25kV shall have a rated insulation level based on an equivalent 3 phase system with a highest voltage for equipment of 52kV r.m.s, i.e., a rated lightning impulse withstand voltage of 250kV peak, and a rated power frequency withstand voltage of 95kV r.m.s.

6.9 TERMINALS AND BUSHINGS

6.9.1 All terminals shall be extended to the top of the transformer tank through suitable outdoor type bushings.

6.9.2 The bushings shall conform to the insulation levels as specified in specification SANS 60137 for the system nominal supply voltage at which the equipment must operate.

6.9.3 All bushings, stems and terminals shall be of sufficient size to ensure sufficient mechanical strength for attaching and supporting external connections and shall not be smaller than 26 mm in diameter for primary and secondary connections.

6.9.4 Provision shall be made for two earthing terminals on opposite sides of the transformer to be fitted on the outside of the transformer tank for to facilitate connection to the substation main earth mat.

6.9.5 The clearance from the lowest, high voltage connection of the transformer to the finished ground level shall not be less than 3,6m for supply voltages up to 88kV, and not less than 4,1m for supply voltages exceeding 88kV.

6.9.6 The bushings shall be rated in accordance to clause 6.8.4 and 6.8.5.

6.10 TANK AND COOLING RADIATORS

6.10.1 The transformer tank shall be constructed of steel plate not less than 6 mm thick and shall be able to handle the fault currents of up to 10kA.

6.10.2 Transformers shall not be fitted with rollers, but be provided with a substantial base, which will enable it to be supported on steel skid rails, which are embedded in a concrete plinth. The spacing between centers of the skid rails is 1000 mm.

6.10.3 Provision shall be made on the transformer base for the attachment of a tackle for this purpose.

6.10.4 Four jacking lugs shall be provided for lifting the transformer complete with oil. Tenderers shall submit dimensioned drawings showing details of the tank and base construction.

6.10.5 Transformers shall be fitted with detachable radiators with drain and filling plugs.

6.10.6 Provision shall be made for radiator shut off valves to allow the removal of the radiators without having to drain the oil from the transformer tank.

6.10.7 The design of the cooling radiators shall ensure sufficient circulation of cooling oil.

6.10.8 Hot dipped galvanized radiators shall be used for coastal areas or were specified. The radiators shall be galvanized in accordance to the requirements of specification SANS 121.

6.10.9 The transformer cover shall be bolted to the tank. For this purpose a flange will be welded on to the tank. An “O-ring” gasket will be installed between the cover and the tank to prevent oil leaks.

6.10.10 All access covers shall be bolted to the transformer tank and shall be provided with “O-rings” to prevent oil leaks. And they shall have handles and lifting lugs.

6.11 FITTINGS ON THE TRANSFORMERS

The following fittings shall be provided:

6.11.1 A Conservator tank with a silica gel dehydrating breather, oil level gauge and drain cock.

6.11.2 The connecting pipe to the conservator shall extend at least 50 mm into the tank to form a sediment trap. All pipe connections shall have flange joints.

6.11.3 If required as specified in Appendix 1, a gas monitoring device shall be mounted on the transformer monitoring internal faults in the transformer. The device shall provide warning levels in order to provide preventative maintenance.

6.11.4 If specified in Appendix 1 the conservator shall be provided with a sealed oil preservation bag.

6.11.4.1 The bag shall not restrict the normal draining of the conservator or the flow of oil to the transformer.

6.11.4.2 The bag shall allow for expansion without any increase in pressure or the causing of a partial vacuum over the specified temperature range.

6.11.5 The transformer shall be fitted with a weatherproof dial type thermometer graded in °C for registering “top oil” temperature and winding temperature. The instruments shall be fitted with a resettable maximum temperature indicator.

6.11.6 The winding temperature and pressure relief device shall be fitted with normal open (no) and normal close (nc) contacts.

6.11.7 Adjustable contacts shall be fitted to the thermometer. The contacts shall normally be set to operate at a temperature of 90°C.

6.11.8 A single float Buchholz relay fitted with contacts for trip and alarm functions must have normal open and normal close contacts.

6.11.9 A thermal type overload relay to protect the transformer windings against sustained overloads. This relay shall have a load-temperature characteristic approximately the same as the transformer winding hot spot. Suitable means for compensation for variation of ambient air temperature shall be provided. Full details shall be submitted.

6.11.10 The relay shall be provided with trip and alarm contacts. The tenderer is to recommend the temperature setting for these contacts, which are normally set at 100 °C.

6.11.11 A drain cock, two sampling cocks and thermometer pockets on the main tank. The sampling cock shall be arranged that an oil sampling bottle may be easily filled.

6.11.11.1 The drain cock shall be of a lockable type to prevent vandalism or theft.

6.11.11.2 It is preferred that the drain cock be made of non-corrosive material and material such as brass should be avoided.

6.11.12 A pipe entering the top of the main tank at the conservator end, with a cock easily accessible from ground level, and one cock on the opposite side of the main tank, at its lowest point, for connecting up to an oil filtering system. The cocks shall be screwed 50mm gas or metric equivalent female thread. If desired, the cock at the lowest point of the tank can be combined with the drain cock required in clause 6.11.11 by the addition of a suitable fitting having a 50mm gas or metric equivalent female thread.

6.11.13 All pipe joints and inspection covers shall be sealed using “O-ring” gaskets

6.11.14 A suitable pressure relief device fitted on the main tank if it is considered necessary by the manufacturer. The provision of the pressure relief device shall not affect the efficiency of the Bucholz relay in the event of a transformer fault.

6.11.15 Tenderers shall ensure that the pockets for the temperature indication are located in areas where the oil is freely circulating, thus avoiding the possibility of incorrect oil temperature measurement. Ambient temperatures can be very high in summer, and the location of the thermometer pockets must take solar radiation into account.

6.11.16 Where a marshalling box is fitted to the transformer the degree of protection shall be IP55 in accordance with specification SANS 10142-1 and corrosion protected.

6.11.17 All terminals in the marshalling box shall be clearly labeled.

6.11.18 All the protection equipments shall have a normal close and normal open contacts.

7.0 CORROSION PROTECTION AND PAINTING

7.1 PREPARATION OF TRANSFORMER TANK

7.1.1 Rust and milliscale shall be removed by shot blasting or acid cleaning. Welds which are not ground smooth shall be shot blasted or otherwise descaled and cleaned.

7.2 PAINTING

7.2.1 The outer surface of the transformer tank shall be painted Grey to the colour code G12 in accordance with specification SANS 1091.The total paint thickness shall be at least 75 microns. For coastal or heavily polluted conditions it shall be at least 125 microns.

7.2.2 The conservator tank shall be painted white.

7.2.3 Internal surfaces of the conservator above oil level shall be cleaned and painted with one coat of oil resistant rust inhibiting etch primer. The radiators shall be hot dipped galvanized. It is recommended that galvanized radiators used at heavily polluted areas be painted.

8.0 TRANSFORMER OIL

8.1 Only unused mineral insulating oil shall be used.

8.2 The transformer oil shall meet with the requirements specified in specification SANS 555.

8.3 The oil shall be readily miscible with the oil supplied in conformity with the above mentioned specification by the major oil companies in South Africa, without detriment to the chemical, physical and electrical properties of the oil.

9.0 RATING PLATES

A non-corrosive metal plate (stainless steel) shall be fixed to each transformer tank (not cooling tubes), giving the following information:

- Maker's name.
- Maker's serial No.
- Transnet Freight Rail's contract No.
- Rated output in MVA
- Frequency.
- Secondary voltage and current.
- Primary voltage and current
- Primary voltage tapings
- Transformer reactance (%)
- Transformer impedance (%)
- Diagram of connections
- Quantity of oil in litres
- Conservator fitted with bag.
- Total mass of transformer inclusive of oil in kg
- Transport mass of transformer in kg.
- Year of manufacture.

10.0 TESTS AND DATA TO BE SUBMITTED BY SUCCESSFUL TENDERERS

10.1 Routine tests as well as impulse voltage withstand including chopped—wave type tests shall be carried out on the transformers in accordance with specification SANS 60076-1/2/3/5.

10.2 Type tests and heat runs shall be carried on the first transformers of a new design.

10.3 The temperature rise of the transformer windings after thermal equilibrium and a steady temperature has been reached on continuous full load, shall not exceed 65°C.

10.4 The temperature rise of the windings shall be measured by the increase of resistance method. Standard correction for cooling during the measurement of resistance shall be applied.

10.5 Transnet Freight Rail shall be provided with type test certificates (In English) and two copies of test sheets, which record the values of the routine tests, or special tests that are carried out on the transformers.

10.6 Transnet Freight Rail reserves the right to be present/witness all routine including type tests were required.

10.7 Transnet Freight Rail reserves the right to order the repeat or abandonment of a test in the event that the transformer is deemed non-compliant.

10.8 Type tests and all special tests including impulse tests must be quoted for separately.

10.9 The supplier must compile a comprehensive specification document detailing all tests and testing procedures to be performed on the transformer. The specification document shall be submitted to the Senior Electrical Engineer – Technology Management for review prior to the acceptance tests being done.

10.10 The Senior Engineer, Technology Management must be notified timeously for routine or impulse test to be witnessed.

11.0 DRAWINGS AND MAINTENANCE MANUALS

11.1 Drawings, instruction manuals and spares lists shall be supplied in accordance with Transnet Freight Rail's specification CEE.0224.

11.2 Three copies of each of the following drawings shall be submitted to the responsible project manager for approval within 7 days of the order being placed.

11.2.1 Dimension drawings showing external arrangements of transformer.

11.2.2 External wiring diagrams for the transformer.

11.2.3 Rating plate information.

12.0 GUARANTEE AND DEFECTS

12.1 The contractor shall guarantee the transformer and accept liability for maker's defects, which may appear in design, materials and workmanship.

12.2 The guarantee period for the transformer shall expire after a period of 12 months commencing on the date of commissioning of the equipment.

13.0 QUALITY ASSURANCE

13.1 Tenderers must indicate what steps have been taken to implement a Quality Assurance system in terms of the specification SANS 9001 series of recommendations.

END

14.0 APPENDIX 1

SCHEDULE OF REQUIREMENTS
(To be completed by Project Manager)

SYSTEM DETAIL

1.0 Transformer required for: _____ substation/location

2.0 Nominal system voltage: _____kV

3.0 Frequency: 50 Hz

TRANSFORMER DETAIL

1.0 Rated power: 20 MVA

2.0 Impedance %: 10 % to 12 %

3.0 Primary voltage rating: _____kV

4.0 Secondary voltage rating: 25 kV

5.0 Vector group: Single phase

CURRENT TRANSFORMERS

1.0 Built in current transformers required: Yes/No.

2.0 Current transformer data:

	Protection	Metering
Ratio:	_____	_____
Class:	_____	_____
VA Rating	_____ VA	_____ VA

OFF CIRCUIT TAPPING SWITCH ON THE SECONDARY

1.0 No of positions: _____ %Steps: _____

TRANSFORMER DIMENSIONS

1.0 Dimensions (if critical)

Length: _____mm. Breadth: _____mm. Height: _____mm

SPECIAL REQUIREMENTS

1.0 Conservator to be fitted with oil preservation bag. Yes / No

2.0 Radiators galvanised. Yes / No

3.0 Gas monitoring device Yes / No

4.0 Other special requirements:

_____

_____

_____

_____

15.0 APPENDIX 2

INFORMATION TO BE PROVIDED BY TENDERERS

GENERAL

1.0 Manufacturers name_____

TRANSFORMER DETAIL

1.0 Primary voltage rating: _____kV

2.0 Secondary voltage rating: _____kV

3.0 Rated power: _____MVA

4.0 Impedance %: _____

5.0 Off Circuit Tap Switch.

No of positions: _____ %Steps: _____

TANK AND TANK COVER

1.0 Free-breathing: Yes/No

2.0 Tank cover bolted to tank: Yes/No

3.0 Radiators galvanised. Yes/No

4.0 Method of Cooling: _____

5.0 Overall dimensions: Length_____mm. Breadth_____mm. Height_____mm.

6.0 Winding material: HV_____ LV_____

7.0 Mass of core and windings: _____kg

6.0 Oil capacity: _____(Litres)

7.0 Mass of transformer complete with oil: _____kg

8.0 Adjustable axial coils provided: Yes/No

9.0 Type of breather and dehydrating agent _____

10.0 The following information refers to the transformer when connected on the principal tapping and appropriate reference temperature for the class of insulation used.

11.0 Iron loss (Watts): _____

12.0 Copper loss at full load: _____at_____°C

13.0 Total load losses (Watts): _____at _____°C

14.0 Impedance at full load (%Z): _____

15.0 Reactance (% X): _____;

16.0 Regulation at full load at: 1.0 PF _____Percent, 0.8 PF _____ Percent at _____°C

17.0 Efficiency at full load at: 1.0 PF _____Percent, 0.8 PF _____Percent at _____ °C

18.0 Temperature rise at rated voltage and power of:

Windings: _____°C

Top oil: _____°C

END