TRANSNET
freight rail

TECHNOLOGY MANAGEMENT

SPECIFICATION

HIGH VOLTAGE SUPPLY TRANSFORMERS IN ACCORDANCE WITH IEC 60076 AND BS 171. (For nominal system voltages 33 kV up to 132 kV)

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DOCUMENT HISTORY:

BBB 8405: HIGH VOLTAGE SUPPLY TRANSFORMERS

IN ACCORDANCE WITH IEC 60076 AND BS 171.

(For nominal system voltages 33 kV up to 132 kV)

Dates Amended	Author	Version	Amendments
2008	D O Schulz	2	Old specification
10/11/2016	L Makhathini	3	• Standards and publications • Constructional Requirement has been added • Rating Plate has been added
25/06/2018	L Makhathini	4	On appendix 1 and 2, the Yes/no: has been confusing on selection. It has been changed to yes ☐ no ☐ To tick in the correct box 11.6 Tap changer gear re-arranged to be on point form for clarity. One tap changer gear should operate all 3 phase

1.0 SCOPE

This specification covers Transnet freight rail's requirements for the design, manufacture, testing and delivery of three phase supply transformers with ratings up to 3MVA and the HV windings rated for nominal system voltages from 33kV up to 132 kV.

2.0 BACKGROUND

2.1 Supply transformers are used on Transnet freight rail as step down transformers for power distribution of the 11kV and 6,6 kV Transnet freight rail reticulation systems and the 11 kV and 6,6 kV transmission line network.

3.0 STANDARDS AND PUBLICATIONS

The transformer shall comply with all relevant requirements of the latest edition of the following specifications unless otherwise specified. The standards used in this specification are as follows.

3.1 INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60076-1:	Power Transformer. Part 1 General
IEC 60137:	Insulated bushings for alternating voltages above 1000V
IEC 60354:	Loading guide for oil immersed power transformers.

3.2 BRITISH STANDARDS

BS 171:	Power Transformers

3.3 SOUTH AFRICAN NATIONAL STANDARDS

SANS 121:	Hot-dip Galvanized coatings for fabricated iron or steel articles.
SANS 555:	Unused and reclaimed mineral Insulating Oil for Transformers and Switchgear.
SANS 1019:	Standard voltages, currents and insulation levels for electricity supply.
SANS 1091:	National colour standard
SANS 9001:	Quality Management systems - Requirements

3.4 TRANSNET FREIGHT RAIL

CEE.0224:	Drawings, Catalogues, Instruction Manuals and Spares list for Electrical Equipment supplied under contract.

4.0 APPENDICES

The following appendices form an integral part of this specification:

Appendix 1: Schedule of requirements.

Appendix 2: Information provided by the tenderers.

5.0 TENDERING PROCEDURE

5.1 Tenderers shall indicate clause by clause 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.

5.2 The tenderer shall motivate a statement of non-compliance.

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

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

5.5 Failure to comply with clauses 5.1, 5.2, 5.3 and 5.4 could preclude a tender from consideration.

6.0 SERVICE CONDITIONS.

The transformers shall be designed to operate under the following conditions.

6.1 ATMOSPHERIC CONDITIONS

Altitude:	0 to 1800m above sea level.
Ambient temperature:	-5°C to +45 °C.
Relative humidity:	10% to 90%.
Lightning Conditions:	12 ground flashes per square kilometre per annum.
Pollution:	Heavily salt laden or polluted with smoke from industrial sources.

6.2 ELECTRICAL CONDITIONS

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

Nominal Supply voltage: As specified in Appendix B

No of Phases: Three phase systems.

Fault Levels: A three-phase short circuit on the supply will be limited to the following levels.

Nominal Supply Voltage	Fault level
Up to 66kV	20kA
88kV	25kA
132kV	40Ka

Harmonics: For the supply transformers installed at the traction substations to supply power to the 11 kV and 6,6 kV transmission lines systems, it can be expected that the low voltage winding of such transformers shall be subjected to the total voltage harmonic distortion of up to 27%.

7.0 SUPPLY TRANSFORMERS

7.1 GENERAL

7.1.1 Unless specified the transformers shall be for outdoor use and of the oil natural air natural (ONAN) cooled type and shall comply with all relevant requirements of specifications IEC 60076-1 and BS 171.

7.1.2 All components used in the supply transformer shall be free from polychlorinated biphenyls. (PCB free)

7.2 TRANSFORMER TANK CONSTRUCTURAL REQUIREMENTS.

7.2.1 The transformer tank shall be of welded construction type and shall be designed for the fitting of radiators.

7.2.2 The transformer tank shall be constructed of steel plate not less than 6 mm thick.

7.2.3 The transformer shall be free breathing.

7.2.4 The transformer main tank cover joint shall be welded on all transformers with a ranking below 1MVA

7.2.5 All transformers with a rating of 1MVA and higher shall be fitted with O-Rings on the main tank cover, inspection covers and all flanges.

7.2.6 The welded joint of the main tank cover shall be designed to permit removal of the weld with the minimum damage to the mating flanges so that they will be suitable for rewelding.

7.2.7 The tank cover shall be fitted with lifting lugs for the fitting or removal.

7.2.8 Inspection covers or manholes on the transformer tank shall be bolted and shall be provided with gasket seals. Sturdy handles shall be provided for removal of inspection or manhole covers.

7.2.9 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.

7.2.10 Provision shall be made on the transformer base for the attachment of a tackle for the purpose of hauling the transformer.

7.2.11 Four jacking pads and lifting lugs shall be provided for the jacking and lifting the transformer complete with oil.

7.2.12 Provision shall be made for the fitting of filtration and main drain valves on the transformer tank.

7.2.13 Tenderers shall submit dimensioned drawings showing details of the tank and base construction.

7.2.14 Valves shall be steel fittings and NOT brass.

7.2.15 Drain valves shall be lockable.

7.3 TRANSFORMER FITTINGS REQUIRED

RADIATORS

7.3.1 The transformer shall be fitted with detachable radiators with drain and filling plugs.

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

7.3.3 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.

7.3.4 The radiators shall be provided with lifting lugs for fitting or removal.

7.3.5 The radiators shall be hot dipped galvanized for coastal areas.

CONSERVATOR TANK AND BREATHER

7.3.6 The transformer shall be fitted with a conservator tank with its oil level gauge and drain cock.

7.3.7 The connecting pipe to the conservator shall extend at least 50 mm into it. All pipe connections shall have flange joints.

7.3.8 A silica gel dehydrating breather shall be provided with the conservator.

7.3.9 Where specified in Appendix 1 the conservator shall be provide with a sealed oil preservation bag.

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

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

7.3.10 Lifting lugs shall be fitted to the conservator.

OIL AND WINDING TEMPERATURE RELAYS

7.3.11 Provision shall be made for thermometer pockets on the transformer tank.

7.3.12 The transformer shall be fitted with a weatherproof dial type thermometer graduated in °C for registering "top oil" temperature. The instrument shall be fitted with a resettable maximum temperature indicator.

7.3.12.1 Adjustable contacts shall be fitted to the thermometer. The contacts shall normally be set to operate at a temperature of 90°C. The trip contacts shall be liberally rated and adequate for closing 110 volt, 6 Ampere DC circuits. If not suitable, auxiliary relays may be provided.

7.3.13 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.

7.3.13.1 The relay shall be provided with trip contacts. The tenderer is to recommend the temperature setting for these contacts which are normally set at 115 °C. The trip contacts shall be liberally rated and adequate for closing 110 volt, 6 Ampere DC circuits. If not suitable, auxiliary relays shall be provided.

GAS AND OIL OPERATED RELAY (BUCHOLZ)

7.3.14 A single—float Buchholz relay fitted with contacts for alarm and trip conditions.

7.3.14.1 The relay shall be fitted with accessible test and sample valves.

PRESSURE RELIEF DEVICE

7.3.15 A suitable pressure relief device shall be fitted on the main tank, the provision of the pressure relief device shall not affect the efficiency of the Bucholz relay in the event of a transformer fault.

MARSHALLING BOX

7.3.16 A marshalling box shall be fitted to the transformer tank. The degree of protection shall be IP55 and shall be corrosion protected.

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

8.0 TERMINALS AND BUSHINGS

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

8.2 These bushings shall conform to the insulation levels as specified in IEC 60137 for the system nominal supply voltage at which the equipment must operate.

8.3 All bushings, stems and terminals shall be of sufficient size to ensure sufficient mechanical strength of attaching and supporting external connections and shall not be smaller than
a) 19 mm diameter for primary and secondary connections
b) 12 mm diameter for auxiliary supply connections.

8.4 Where cable boxes are required, bushings shall be provided for the termination of the cables in the cable box.

8.5 Provision shall be made for earthing terminals fitted on the outside of the transformer tank for the connection of a 95 mm^2 cable.

9.0 TRANSFORMER WINDINGS

9.1 The AC supply system can have a fault capacity specified in clause 6.2.3.

9.2 The transformer windings shall be able to withstand the electromagnetic and mechanical stresses caused by high fault currents.

9.3 Tenderers shall submit details of the construction of the windings and clamping arrangements.

10.0 TEMPERATURE RISE AND RATING.

10.1 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.

10.2 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.

11.0 VOLTAGE RATIO AND TAPPINGS

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

11.2 Tappings shall be provided on the primary windings. (5 tap position).

11.3 The tap range shall be ± 2,5 % and ± 5 % of the nominal voltages.

11.4 The transformers shall supply full load output at all tappings.

11.5 The full load regulation of the transformer shall not be more than 5%. Refer to "Appendix 2". Clause 20.5.

11.6 The tap changing gear must be:

- External
- Manually operated
- Positively locking
- Single off load type and shall operate all 3 phases.
- Rotary type having high-pressure type contacts

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.

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

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

12.0 INSULATION LEVELS.

12.1 Transformer bushings shall comply with IEC 60137.

12.2 Test voltages and minimum creepage distances for normal and polluted atmospheres shall be in accordance with IEC 60137.

13.0 CORROSION PROTECTION AND PAINTING

13.1 PREPARATION OF TRANSFORMER TANK

13.1.1 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.

13.2 PAINTING

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

13.2.2 Internal surfaces of the conservator above oil level shall be cleaned and painted with one coat of oil resistant rust inhibiting etch primer.

13.2.3 The radiators shall be hot dipped galvanized. It is recommended that galvanized radiators used at heavily polluted areas be painted.

14.0 TRANSFORMER OIL

14.1 The tendered prices shall include the first filling of oil. The oil shall comply with SANS 555.

14.2 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.

15.0 RATING PLATES

A non—corrosive metal plate 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 serial No. (Left blank)
- Rated output in MVA
- Frequency
- Secondary voltage and current
- Primary voltage and current
- Primary voltage tappings
- Transformer reactance (%)
- Transformer impedance (%)
- Vector diagram
- 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.

16.0 TESTS AND DATA TO BE SUBMITTED BY SUCCESSFUL TENDERERS

16.1 Manufacturer's type and routine tests as well as impulse voltage withstand including chopped—wave type tests shall be carried out on the transformers in accordance with the current edition of IEC 60076 and BS 171.

16.2 Heat runs shall be carried on the first transformers of a new or different design.

16.3 Transnet freight rail shall be provided with type test certificates and two copies of test sheets, which record the values of the routine tests, or special tests that are carried out on the transformers.

16.4 Transnet freight rail reserves the right to be present/witness all routine including type tests were required.

16.5 Type tests including impulse tests must be quoted for separately.

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

17.0 DRAWINGS AND MAINTENANCE MANUALS

17.1 Drawings, instruction manuals and spares lists shall be supplied in accordance with Transnet freight rail's specification CEE.0224.

17.2 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.

17.2.1 Dimension drawings showing external arrangements of transformer.

17.2.2 External wiring diagrams for the transformer.

17.2.3 Vector diagram and rating plate.

18.0 GUARANTEE AND DEFECTS

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

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

19.0 QUALITY ASSURANCE

19.1 Tenderers must indicate what steps have been taken to implement a Quality Assurance system in terms of the ISO 9000 series of recommendations.

END

APPENDIX 1

SCHEDULE OF REQUIREMENTS

To be filled by client (depot) tick the correct box

SYSTEM DETAIL

1.0 Transformer required for : _____ substation/location

2.0 Nominal system voltage: _____kV

3.0 Number of phases:_____

4.0 Frequency: _____Hz

5.0 Neutral point effectively earthed :

yes		no	

TRANSFORMER DETAIL

1.0 Type of transformer: Outdoor: _____ Indoor: _____

2.0 Number of phases: Single phase: _____Three phase: _____

3.0 Rated power: _____kVA

4.0 Impedance percentage %: _____

5.0 Primary voltage rating: _____kV

6.0 Secondary voltage rating: _____kV

7.0 Vector group: _____

8.0 Off circuit tap switch

8.1 Number of tap positions: _____

10.0 Bushings Required

High voltage side	yes		no	
Low voltage side	yes		no	

11.0 Cable box required

	yes		no	

High voltage side: _____

Low voltage side: _____

12.0 Neutral required

High voltage side	yes		no	
Low voltage side	yes		no	

13.0 Dimensions (if critical)

Length: _____mm. Breadth: _____mm. Height: _____mm

14.0 Special requirements:

1.0 Conservator to be fitted with oil preservation bag.	yes		no	
2.0 Radiators galvanised.	yes		no	

3.0 Other special requirements: _____

_____

_____

_____

APPENDIX 2

INFORMATION TO BE PROVIDED BY TENDERERS

1.0 GENERAL

1.1 Manufacturers name: _____

2.0 TRANSFORMER DETAIL

1.0 Type of transformer: Outdoor: _____ Indoor: _____

2.0 Number of phases: Single phase: _____Three phase: _____

3.0 Rated power: _____kVA

4.0 Impedance (percentage) %: _____

5.0 Primary voltage rating: _____kV

6.0 Secondary voltage rating: _____kV

7.0 Tapping Switch.

No of positions: _____ %Steps: _____

8.0 Vector group: _____

9.0 Free Breathing	yes		no	

10.0 Method of Cooling: _____

11.0 Overall dimensions: Length_____mm. Breadth_____mm. Height_____mm

12.0 Winding material: HV_____ LV_____

13.0 Mass of core and windings: _____kg

14.0 Oil capacity: _____(Litres)

15.0 Mass of transformer complete with oil: _____kg

16.0 HV end turns insulation reinforced	yes		no	

17.0 Type of breather and dehydrating agent: _____

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

18.1 Iron loss (Watts): _____

18.2 Copper loss at full load: _____ at_____°C

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

18.4 Impedance at full load (percentage)_____Z _____X

18.5 Regulation at full load at: 1.0 PF_____Percent, 0.8 PF_____Percent at _____°C

18.6 Efficiency at full load at: 1.0 PF _____Percent, 0.8 PF _____Percent at

18.7 Temperature rise at rated voltage and power of:

Windings: _____° Top oil: _____°C