TRANSNET
freight rail

A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

REQUIREMENTS FOR TRACTION TRANSFORMERS FOR 3kV DC TRACTION SUBSTATIONS IN ACCORDANCE WITH SANS 60076

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1.0 SCOPE

1.1 This specification covers Transnet freight rail's requirements for the design, manufacture, testing and delivery of traction transformers for 3kV DC traction substations.

2.0 BACKGROUND

2.1 Transnet's traction substations consist of single and double units and in exceptional cases a three unit rectifier configurations.

2.2 Each rectifier unit comprises of a set of high voltage AC disconnects, primary circuit breaker, two current transformers and a traction transformer connected for twelve-pulse rectification with its control and protection circuitry.

3.0 STANDARDS AND PUBLICATIONS

The transformers shall comply with all relevant requirements of the latest editions of the following publications unless otherwise specified.

3.1 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 1019:	Standard voltages, currents and insulation levels for electricity supply.
SANS 1091:	National Colour Standards.
SANS 9001:	Quality Management Systems – Requirements.
SANS 10142-1:	The wiring of premises Part 1- Low voltage installations.
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.
SANS 61869-2:	Instrument Transformers Part 2- Current Transformers.

3.2 TRANSNET FREIGHT RAIL'S PUBLICATIONS

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

4.0 TENDERING PROCEDURE

4.1 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.

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

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

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

4.5 Failure to comply with clauses 4.1, 4.2, 4.3 and 4.4 could preclude a tender from consideration.

5.0 APPENDICES

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

5.1 Appendix 1 -"Schedule of Requirements"

This appendix details the specific requirements for this application.

5.2 Appendix 2 - " Information to be provided by tenderers"

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

6.0 SERVICE CONDITIONS

6.1 ATMOSPHERIC CONDITIONS

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

6.2 ELECTRICAL CONDITIONS

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

6.2.2 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%.

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

Nominal supply voltage	Fault Level
66kV	20kA
88kV	25kA
132kV	40kA

7.0 RECTIFIER 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 specification SANS 60076-1.

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

7.1.3 The design of the transformers shall be such that harmonic disturbances are minimised.

7.1.4 The primary winding of the main traction transformer shall be star connected.

7.1.5 The configuration of the secondary winding shall be two separated delta windings giving 15° phase shift. The total secondary winding shall consist of six phases and the output voltage of each phase shall be approximately 1220V.

7.1.6 The secondary windings shall be designed to be compatible with twelve pulse rectifier units.

7.1.7 The responsible Senior Electrical Engineer at Transnet freight rail shall be consulted before any transformer design is finalised.

7.1.8 Provision shall be made for a three phase tertiary winding on the secondary side of the transformer to supply the auxiliary transformers. The winding may be tapped off the secondary winding or be separately wound. The tertiary winding shall have separate bushings for connection to the auxiliary transformer.

7.1.9 The tertiary winding shall be rated to supply a 50kVA auxiliary transformer unless otherwise specified.

7.2 TEMPERATURE RISE AND RATING.

7.2.1 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.

7.2.2 The maximum temperature rise of the windings subsequent to the application of any of the following rectifier overloads, after the constant continuous rated full load temperature has been attained are as follows:

- 3 x full load for 1 minute the temperature rise of the windings shall not exceed 70°C.
- 3.5 x full load for 10 seconds the temperature rise of the windings shall not exceed 70°C.
- 2 x full load for 30 minutes the temperature rise of the windings shall not exceed 100°C.

7.2.3 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.

7.2.4 The rating of the transformer shall be such that when it is operating in conjunction with the rectifier equipment specified and with an auxiliary transformer connected to the tertiary winding the output of the transformer shall be as follows:

- 2 x full load for 30 minutes
- 3 x full load for 1 minute
- 3.5 X full load for 10 seconds.
- 4.25 x full load instantaneous tripping.

These values shall be proved theoretically.

7.3 VOLTAGE RATIO AND TAPPINGS

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

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

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

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

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

7.3.5 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.

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

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

7.4 BUILT IN CURRENT TRANSFORMERS.

7.4.1 Where build-in current transformers are required, shall be in accordance with SANS 61869-2.

7.5 TRANSFORMER IMPEDANCE

7.5.1 The transformer impedance shall be as high as possible taking into account the voltage regulation as specified in clause 7.3.4 but shall not be less than 8 %.

7.6 MECHANICAL STRENGTH OF TRANSFORMER WINDINGS

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

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

7.6.3 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.

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

7.6.5 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.

7.6.5.1 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.

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

7.6.5.3 Round conductor shall not be used for any windings.

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

7.6.5.5 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.

7.6.5.6 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.

7.6.5.7 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.

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

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

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

7.6.5.11 The nuts of the bolted connections shall be torqued to the following recommended values to ensure a good stable electrical contact between the mating surfaces:

Bolt Size	Torque value
M10	35.5NM
M12	61.3NM
M16	147 NM

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

7.7 INSULATION LEVELS.

7.7.1 Transformer bushings shall comply with SANS 60137.

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

7.8 INSULATION OF WINDINGS.

7.8.1 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

7.8.2 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.

7.8.3 The primary and secondary windings shall be insulated to withstand the test pressures referred to in SANS 60076-1. The secondary windings must be insulated for a system highest voltage of 7,2 kV.

7.9 TERMINALS AND BUSHINGS

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

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

7.9.3 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.

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

7.9.5 The height of the wall bushings of the substation is 2,8 meters above ground level. Should the design of the transformer offered be such that the total height of the transformer and secondary bushings is less than 2,7 meters, screens must be provided. Tenderers must include the provision of screens in their offer. Details of the screens shall be submitted to Transnet freight rail for approval.

7.9.6 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.

7.10 TANK AND COOLING RADIATORS

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

7.10.2 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.

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

7.10.4 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.

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

7.10.6 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.

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

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

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

7.10.10 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.

7.11 FITTINGS ON THE TRANSFORMERS

The following fittings shall be provided:

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

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

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

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

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

7.11.4 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.

7.11.5 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.

7.11.6 A single—float Buchholz relay fitted with contacts for trip and alarm functions.

7.11.7 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.

7.11.8 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.

7.11.9 A drain cock, two sampling cocks and thermometer pockets on the main tank.

7.11.10 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 7.11.9 by the addition of a suitable fitting having a 50mm gas or metric equivalent female thread.

7.11.11 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.

7.11.12 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.

7.11.13 Where a marshalling box is fitted to the transformer the degree of protection shall be IP55 and corrosion protected.

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

8.0 CORROSION PROTECTION AND PAINTING

8.1 PREPARATION OF TRANSFORMER TANK

8.1.1 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.

8.1 PAINTING

8.1.1 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.

8.1.2 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.

9.0 TRANSFORMER OIL

9.1 Only unused mineral insulating oil shall be used.

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

9.3 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.

10.0 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.

11.0 TESTS AND DATA TO BE SUBMITTED BY SUCCESSFUL TENDERERS

11.1 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 SANS 60076-1.

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

11.3 The rating of the transformer shall be such that when it is operating in conjunction with the rectifier equipment specified and with a auxiliary transformer connected to the tertiary winding the output of the transformer shall be as follows:

- 2 x full load for 30 minutes
- 3 x full load for 1 minute
- 3.5 X full load for 10 seconds.
- 4.25 x full load instantaneous tripping.

These values shall be proved theoretically.

11.4 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.

11.5 The maximum temperature rise of the windings subsequent to the application of any of the following rectifier overloads after the constant continuous rated full load temperature has been attained are as follows:

- 3 x full load for 1 minute the temperature rise of the windings shall not exceed 70°C.
- 3.5 x full load for 10 seconds the temperature rise of the windings shall not exceed 70°C.
- 2 x full load for 30 minutes the temperature rise of the windings shall not exceed 100°C.

11.6 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.

11.7 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.

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

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

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

12.0 DRAWINGS AND MAINTENANCE MANUALS

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

12.2 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.

12.2.1 Dimension drawings showing external arrangements of transformer.

12.2.2 External wiring diagrams for the transformer.

12.2.3 Vector diagram and rating plate.

13.0 GUARANTEE AND DEFECTS

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

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

14.0 QUALITY ASSURANCE

14.1 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 completed by client)

SYSTEM DETAIL

1.0 Transformer required for: _____ substation/location

2.0 Nominal system voltage: _____kV

3.0 Frequency: _____Hz

TRANSFORMER DETAIL

1.0 Number of phases: Primary winding: _____ Secondary winding: _____

2.0 Secondary winding configuration: _____

3.0 Rated power: _____MVA

4.0 Impedance %: _____

5.0 Primary voltage rating: _____kV

6.0 Secondary voltage rating: _____kV

7.0 Vector group: _____

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

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 Other special requirements:

_____

_____

_____

_____

END

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: _____

6.0 Vector group: _____

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

8.0 Oil capacity: _____(Litres)

9.0 Mass of transformer complete with oil: _____kg

10.0 Adjustable axial coils provided: Yes/No

11.0 Type of breather and dehydrating agent _____

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

13.0 Iron loss (Watts): _____

14.0 Copper loss at full load: _____at_____°C

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

16.0 Impedance at full load (%Z): _____

17.0 Reactance (% X): _____;

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

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

20.0 Temperature rise at rated voltage and power of:

Windings: _____°C

Top oil: _____°C

END