TRANSNET
freight rail

A Division of Transnet Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

3 KV DC TRACTION SUBSTATION EARTHING SYSYTEM FOR HIGH VOLTAGE OUTDOOR YARDS

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1.0 SCOPE

1.1 This specification specifies Transnet freight rail's requirements for the design, supply, installation and testing of the earthing systems for new and existing 3kV DC traction substations.

1.2 This specification must be read in conjunction with Transnet freight rail's drawings BBB 3620 and CEE-TBD-7.

2.0 STANDARDS AND PUBLICATIONS

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

2.2 The following publications (latest editions) are referred to in this specification:

2.2.1 SOUTH AFRICAN NATIONAL STANDARDS

SANS 1063	Earth rods, couplers and connections.
SANS 1507 -1-3	Electric cables with extruded solid dielectric insulation for fixed installations. (300/500V to 1900/3300V).
SANS 2063	Thermal spraying - Metallic and other inorganic coatings - Zinc, aluminium and their alloys.
SANS 10199	The design and installation of earth electrodes.

2.2.2 TRANSNET FREIGHT RAIL

CEE.0177	Code of Practice: Earth systems for electric light and power and traction installations.

TRANSNET FREIGHT RAIL'S DRAWINGS.

BBB 3620	3kV DC earthing arrangement system for high voltage outdoor yards.
CEE-TBD-7	3kV DC earthing arrangement system of traction substation.

3.0 METHOD OF TENDERING

3.1 Tenderers shall indicate clause by clause compliance with the specification. This shall take the form of a separate document listing all the specification's clause numbers indicating the individual statement of compliance or non-compliance.

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

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

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

4.0 DEFINITIONS

Definitions are in accordance with SANS 10199.

4.1 EARTH ELECTRODE

One or more conductive parts embedded in the earth for the purpose of making effective electrical contact with the general mass of the earth, and to act as a path for the discharge of either lightning currents or fault currents.

4.2 EARTHED

So connected to the general mass of earth as to ensure at all times an immediate discharge of electrical energy without danger.

4.3 EARTHING SYSTEM

A system intended to provide at all times, by means of one or more earth electrodes, a low impedance path for the immediate discharge of electrical energy without danger into the general mass of earth.

5.0 EARTHING SYSTEMS OF TRACTION SUBSTATIONS

The earth leakage protection consists of an AC earth leakage and a DC earth leakage system as described below:

5.1 AC EARTH LEAKAGE SYSTEM

The AC earth leakage system is used to detect flashovers on high voltage HV outdoor yard equipment. The equipment in the outdoor yard is insulated from the substation earth mat and connected in parallel through a current transformer to earth mat. (Minimum resistance to earth mat is 10 Ohms). The output of the current transformer feeds to an earth leakage relay, which will trip and lock out the primary circuit breaker when operated.

5.2 DC EARTH LEAKAGE SYSTEM

The DC earth leakage system is used to detect 3kV DC and 380V AC insulation failures. The steelwork and panels inside the traction substation are bonded to a DC earth leakage busbar, which is insulated from earth mat. (Minimum resistance to earth mat is 25 Ohms). The DC earth leakage busbar is connected to the substation negative busbar through a DC earth leakage relay.

Operation of this relay will isolate the complete substation from all sources of supply and lock out the primary circuit breaker and all the 3kV DC high speed circuit breakers.

6.0 SERVICE CONDITIONS

6.1 ATMOSPHERIC CONDITIONS:

Altitude	:	0 to 1800m above sea level.
Ambient temperature	:	-10% to +50 °C.
Relative humidity	:	10% to 90% percent
Lightning Conditions	:	12 ground flashes per square kilometre per annum.
Pollution	:	Heavily salt laden or polluted with smoke from industrial sources.

6.2 SOIL CONDITION:

The soil resistivity can vary from 10 Ohmmeter to more than 5,000 Ohmmeter. Earth value enhancement methods will have to be used, where necessary to obtain the desired value of 5 Ohms or less.

6.3 CORROSION:

Buried conductors will be exposed to both severe galvanic and chemical corrosion. There is a high level of stray current in the vicinity of 3kV DC traction substations which will reduce the life of the earthing system.

7.0 TECHNICAL REQUIREMENTS

7.1 The design and installation of Transnet Freight Rail's earthing system for outdoor yards shall be in accordance with Transnet Freight Rail's drawings BBB 3620 and CEE-TBD-7.

7.2 A 5-second fault current duration shall be used for the rating of the earthing system. The earth down conductors and earth tails shall be able to withstand 6,2 kA for 5 seconds when exothermically welded. The rated AC fault level for 3kV DC traction substations shall be taken to be 16kA.

7.3 Deviation of the design shall be submitted to the project manager for approval.

8.0 EARTHING LAYOUT

8.1 The following electrical equipment in the outdoor yard shall be bonded directly to earth mat.

- The support steel structures for the surge arresters at the Eskom supply side.
- All high voltage surge arresters.
- The high voltage AC disconnects.
- Voltage transformer steel structures where applicable.
- Main Current transformers on Eskom side of primary circuit breaker in high voltage (HV) yard.
- The perimeter fence posts and gates.
- Substation metal roof.

8.2 The following electrical equipment forms part of the AC earth leakage system and shall be connected via a current transformer to earth.

- Main traction transformer.
- Primary circuit breaker.
- Main current transformers between primary circuit breaker and main traction transformer.
- The Auxiliary transformer's barrier screen.

8.3 The following electrical equipment is connected directly to the substation negative busbar.

- The auxiliary transformer tank.
- All spark gaps.

8.4 The following outdoor electrical equipment is connected directly to the DC earth leakage relay busbar.

- The Anode wall plate (Wall Bushings).
- The auxiliary transformer neutral point.
- AC / DC motorised link framework and structure where fitted.
- The auxiliary transformer short circuiting switch fitted on substation wall in the outdoor yard.

9.0 MATERIALS TO BE USED.

EARTHING

9.1 Only copper rods of at least 70 mm^2 shall be used for earth electrodes in accordance to SANS 1063.

The length of the rods will be dependant on the application:

- Earth electrodes (earth spikes). Minimum length of 1.5 meters shall be used.
- Down conductors, earth tails and interconnecting conductors. Rods of varying lengths may be used.

9.2 The minimum size of cable/conductor used for the earthing system shall be 95 mm^2 copper.

9.3 For the installation or replacement of the main earth mat/earth electrode, Copper conductor of at least 16mm diameter shall be used and shall be buried at least 1,5 meters below the ground. The earth mat shall cover an area of at least 1,5 square metre.

9.4 The earth mat shall be provided with a test point connection for test purposes. This test point shall protrude a minimum of 100mm above ground level and shall be protected by means of a metal pipe or metal housing.

9.5 The location of the earth mat/earth spike shall be as close as possible to the main surge arresters support structures.

AC EARTH LEAKAGE SYSTEM

9.6 PVC insulated 95 mm^2 copper cable shall be used where insulated earthing conductors are required for the interconnecting of the high voltage equipment on the AC earth leakage system.

9.7 The resistance between the outdoor yard steelwork connected to AC earth leakage system and main earth electrode shall be a minimum of 10 Ohms.

10.0 INSTALLATION OF EARTHING SYSTEM.

10.1 EARTHING SURVEY

10.1.1 For new installations the contractor shall carry out an earthing survey in accordance with the method as described in specification CEE.0177 or SANS 10199 to determine the type of earthing system required. The contractor shall be required to submit a separate quotation for the survey.

10.1.2 For existing substations the contractor shall carry out earth resistance tests to establish the condition of the existing earth mat/earth spike and shall replace such earth mat/earth spike where required.

10.2 TRENCHING

10.2.1 Before any trenching commences the contractor shall consult with Transnet Freight Rail staff for approval with regard to the routing of the trenches in the outdoor yard.

10.2.2 Trenching shall include all trenches required for the installation of the earthing system.

10.2.3 The perimeter fence trenching shall be as close as possible to the perimeter fence on the inside of the HV yard.

10.2.4 The depth of trenches shall be at least 700 millimetres. Care must be taken not to damage existing cables in the high voltage outdoor yard during trenching operations.

10.2.5 Before the trenches are closed a representative from Transnet Freight Rail shall inspect the earthing system for correct installation procedure.

10.3 INSTALLATION PROCEDURES

10.3.1 Earth electrodes shall be driven into the ground in the perimeter fence trench at the corners of the outdoor yard and in between the corners.

10.3.2 In the case of double unit substations the number of earth electrodes between the corner electrodes shall be determined in consultation with Transnet Freight Rail.

10.3.3 The depth of the earth electrodes driven into the ground shall be such that the top of the earth electrode shall be a minimum of 700 mm below the surface of the ground.

10.3.4 The earthing of the support steel structures for the surge arresters, AC disconnects, voltage transformers (where installed) and current transformers shall be in accordance with Transnet Freight Rail's drawing BBB 3620.

10.3.5 The surge arresters base shall be connected directly to earth mat/spike.

10.3.6 Where surge arresters are fitted on the main transformer provision shall be made to install an earth electrode in close proximity to the transformer. The earth electrode shall be connected directly to the earth system as shown in drawing BBB3620.

10.3.7 All underground connections which include connections to the earth electrodes, the joints in the copper plated steel rods, connections to the perimeter fence posts, support steel structures and the connection to the new or existing earth mat shall be exothermic welded or crimped by means of tinned lugs or by means of brass clamping system.

10.3.8 Where exothermic welding cannot be carried out, galvanised or stainless steel grade S304 studs, nuts, tinned cable lugs and any other approved means may be used for the termination of the earthing conductors to the fence posts, surge arresters down leads, metal structure and other electrical equipment.

10.3.9 Exothermic welded joints and steel components exposed to corrosion shall be sealed with a durable waterproofing compound i.e. Bitumen, Denso tape or Noxide.

10.3.10 All crimped connections that are above ground level must be filled with an anti corrosive compound.

10.3.11 Where the exothermic welding is carried out on galvanised surfaces of the support steel structures, the galvanising must be removed and the surface cleaned. After completion of the exothermic weld, the surface area on the support steel structure where the galvanising was removed shall be treated in accordance with the requirements of SANS 2063.

10.3.12 Exothermic joints shall be hammer tested on recommendation of the manufacturer to ensure that the mechanical strength of the joints are adequate. The exothermic weld is tapped by a hammer and by sound it is determined whether the joints are solid or that there are voids in the joint.

10.3.13 Where two earthing conductors run parallel to each other, exothermic parallel joints shall be installed every 1,5 metres on all straight sections between these conductors.

10.4 CERTIFICATION OF CONTRACTORS (EXOTHERMIC WELDING)

10.4.1 Only Contractors who are certified and accredited by the exothermic welding industry shall be used for the installation.

10.5 CRUSHER STONE

NEW SUBSTATIONS

10.5.1 After completion of construction, installation of equipment, the laying of all cables and earthing conductors, a suitable weed killer approved by Transnet Freight Rail's Project Manager shall be applied in the outdoor yard unless otherwise specified.

10.5.2 The successful tenderer shall exercise the greatest care to avoid contaminating private property.

10.5.3 After treatment with the weed killer, a 100mm layer of 25mm to 37mm crusher stone shall be laid over the whole area of the Transnet Freight Rail high voltage outdoor yard (within the apron).

EXISTING SUBSTATIONS

10.5.4 The contractor shall remove the necessary crusher stone before any excavation commences.

10.5.5 The contractor shall restore the crusher stone to its original condition once the installation work has been completed.

10.5.6 The contractor shall supply any additional crusher stone required to restore the trenched areas to original condition.

11.0 SPECIAL TOOLS (OPTIONAL)

11.1 Tenderers shall furnish quotations for the special bending equipment, crimping tools and exothermic welding moulds required for the installation of the earthing system.

11.2 The price shall form a separate part of the quotation.

12.0 TESTS AND ACCEPTANCE

12.1 The contractor shall perform resistance measurement tests, which shall be witnessed by a representative of Transnet Freight Rail. The resistance measurements shall be entered into the substation station log book.

12.2 In the event of any dispute, Transnet Freight Rail reserves the right to make the final decision on the acceptance of the earthing system.

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