



A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

TRANSNET FREIGHT RAIL'S REQUIREMENTS FOR THE INSTALLATION OF ELECTRICAL EQUIPMENT FOR 3kV DC TRACTION SUBSTATIONS

| | | |
|-------------|---|---------------|
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SECTION 1: SUBSTATION DESIGN INFORMATION
1.0 SCOPE

- 1.1 This specification covers Transnet Freight Rail's requirements for the installation of electrical equipment in 3kV DC traction substations.
- 1.2 This specification should be read with the Scope of Work specification for each site/project and the applicable equipment specifications.
- 1.3 This specification also covers the requirements for the supply of security fencing, preparation of the High Voltage (HV) outdoor yard and the erection of all structural steelwork.

2.0 STANDARDS, PUBLICATIONS AND DRAWINGS

Unless otherwise specified this specification must be read in conjunction with the current edition of the relevant SANS, and Transnet Freight Rail's specifications.

2.1 SOUTH AFRICAN NATIONAL STANDARDS (SANS)

| | |
|---------------|---|
| SANS 121: | Hot dip galvanized coatings for fabricated iron or steel articles. Specifications and test methods. |
| SANS 156: | Moulded-case Circuit Breakers. |
| SANS 780: | Distribution Transformers. |
| SANS 1019: | Standard voltages, currents and insulation levels for electricity supply. |
| SANS 1091: | National Colour Standard. |
| SANS 1222: | Enclosures for Electrical Equipment. |
| SANS 1339: | Cross-Linked Polyethylene (XLPE) - Insulated Electric cables for rated voltages (3,8/6,6kV to 19/33kV) |
| SANS 1431: | Weldable structural steels. |
| SANS 1507: | Electric cables with extruded solid dielectric insulation for fixed installations. (300/500V to 1900/3,300V) Part 1 |
| SANS 10142-1: | The wiring of premises. Part 1 |
| SANS 61869-2: | Instrument Transformers Part 2. Current Transformers. |

2.2 TRANSNET FREIGHT RAIL SPECIFICATIONS/ ENGINEERING INSTRUCTIONS

| | |
|-----------|---|
| CEE.0023: | Transnet Freight Rail's requirement for the installation of low and medium voltage cables. |
| CEE.0045: | Painting of steel components of electrical equipment. |
| CEE.0099: | Specification for 3kV DC high speed circuit breakers for traction substations. |
| CEE.0227: | The manufacture of 3kV DC breaker cells and trucks. |
| BBB 0496: | 3kV rectifier for traction substations. |
| BBB 0845: | Requirements for metal oxide surge arresters in accordance with SANS 60099-4. |
| BBB 1267: | Specification for Outdoor High Voltage Alternating Current Circuit Breaker in Accordance with SANS 62271-100. |
| BBB 1616: | 450 Volt gas arrester spark gap for traction power supplies. |
| BBB 2502: | Requirements for battery charger for 3kV DC traction substations. |

| | |
|-----------|--|
| BBB 2721: | AC primary circuit breaker control panel and AC/DC distribution panel for 3kV traction substation. |
| BBB 3005: | 3kV DC under voltage relay manufacturing specification. |
| BBB 3139: | Wave filters capacitors for 3kV DC traction substations. |
| BBB 3162: | Wave filter inductors for 3 kV DC traction substations. |
| BBB 3890: | Requirements for 1.8 milli Henry DC reactor for 3kV DC traction substations. |
| BBB4724: | Requirement for positive isolator for 3kV DC traction substations |
| BBB 5019: | Requirements for traction transformers for 3kV DC traction substations in accordance with SANS 60076 |
| BBB 7842 | Outdoor, High Voltage, Alternating Current Disconnectors combined with earthing switch. |
| BBC 0198: | Requirements for the supply of cables. |
| BBC 0330: | Isolation transformer. |
| BBD5994: | Technical Documentation Management Policy. |

2.3 STATUTORY REQUIREMENTS

Occupational Health and Safety Act and Regulations, Act 85, 1993

3.0 TENDERING PROCEDURES

- 3.1 Tenderers shall indicate clause-by-clause compliance with the specification as well as the relevant equipment specifications. This shall take the form of a separate document listing all the specifications clause numbers indicating the individual statement of compliance or non-compliance.
- 3.2 The tenderer shall motivate a statement of non-compliance.
- 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, and 3.3 could preclude a tender from consideration.

4.0 SERVICE CONDITIONS

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: | 12 ground flashes per square kilometre per annum. |
| Pollution: | Heavily salt laden or polluted with smoke from industrial sources. |

5.0 ELECTRICAL SERVICE CONDITIONS

- 5.1 The incoming AC voltage can vary $\pm 5\%$ of the nominal system r.m.s voltage. Under crippled conditions the supply voltage can drop to as low as minus 15% of the nominal r.m.s voltage.
- 5.2 Frequency of the supply voltage is 50 ± 2.5 Hz.
- 5.3 The AC high voltage system shall be treated as effectively earthed unless otherwise specified.
- 5.4 The traction DC supply voltage is 3,15 kV DC nominal but can vary between 2,4kV and 3,9kV for sustained periods.
- 5.5 The 3kV DC equipment may be subjected to fault currents up to 30kA for 200 milli seconds.

6.0 GENERAL REQUIREMENTS

- 6.1 Equipment/Installations supplied shall be in terms of this specification. Deviations from the specification will not be allowed without the written consent of the Project Manager/Engineer.
- 6.2 Transnet Freight Rail reserves the right to subject material and equipment offered to test or inspection to verify compliance with the clauses of this specification, prior to adjudication or at any stage during manufacture.
- 6.3 The tenderer shall submit the layout drawings of equipment, electrical wiring schematics, and constructional designs to Transnet Freight Rail for design review.
- 6.4 The successful tenderer will be responsible for all costs caused by modifying or replacing equipment accepted by Transnet Freight Rail on the grounds of his statement of compliance and found by Transnet Freight Rail not to comply.
- 6.5 All equipment shall be adequately earthed, insulated, enclosed and interlocked to ensure the safety of staff as well as equipment.
- 6.6 The general design and layout of all equipment shall provide for easy access to all parts.
- 6.7 The equipment shall be installed in such a manner so as to limit fire damage, which may be caused by equipment failure, overheating or flashovers.
- 6.8 The substation control and protection circuits shall be designed and wired according to the fail-safe principle. Control equipment, contactors and relays shall de-energise under fault, power failure or alarm (flag) conditions.
- 6.9 No high voltage cables shall be laid in the same trench or duct as low voltage cables.

7.0 GENERAL DESIGN OF EQUIPMENT

- 7.1 This section covers substation equipment with electrical capacities between 3,0 MW and 6,0 MW.
- 7.2 The overload ratings of the rectifier units shall be:
- 2 times full load for thirty minutes.
 - 3 times full load for one minute.
 - 3 ½ times full load for ten seconds.
- 7.3 The substation can either be a single unit or double unit substation. Each unit comprises of one set of high voltage AC switchgear, one rectifier transformer, and one rectifier assembly, connected for 6 or 12 pulse operation and protected by a AC primary circuit breaker.
- 7.4 For a double unit substation each unit shall have the overload rating as specified in clause 7.2.
- 7.5 Each substation unit shall be capable of operating independently to allow for maintenance, fault finding and servicing of the equipment.

8.0 INSULATION AND CLEARANCES FOR 3kV DC EQUIPMENT

- 8.1 All indoor equipment, which may be energised at a potential of more than 1,0kV shall be protected by, metal barriers, mesh type screens or panels.
- 8.2 The minimum clearance in air between the rectifier unit and any metal barriers, mesh type screens or panels shall not be less than 450mm.
- 8.3 All exposed electrical equipment and busbars connected between the rectifier transformer secondary and the rectifier cubicle(s), or between the rectifier cubicle(s), positive isolators, DC smoothing equipment or track breakers, which is at a potential above 1,0kV, shall be arranged so that there is a minimum clearance of 2,7 m from the lowest "live" high voltage connections and ground or the floor of the access way, unless suitably screened, or otherwise protected.
- 8.4 All nominal 1,5kV and 3kV insulation to earth shall be designed such that the complete rectifier assembly, when installed on site ready for commissioning, will successfully withstand a test voltage of 10,5kV, 50 Hz AC for one minute.
- 8.5 Where the equipment or subassemblies of the rectifier assembly is enclosed and insulated from the outer framework, the insulation between the equipment and outer framework shall withstand the test voltage of 10,5kV 50 Hz for one minute.

- 8.6 The clearance between the reactor and any metal frame shall not be less 100mm. The reactor must successfully withstand a test voltage of 10,5kV AC 50 Hz for one minute
- 8.7 The successful tenderer shall advise what precautions must be taken before undertaking the withstand insulation level voltage tests to avoid damage to the equipment.
- 8.8 Creepage distance of insulation and the required air clearances shall be as large as possible. The latter shall not be less than:
- Outdoors: 150mm between the transformer secondary busbars and any steelwork such as wall plates, screening etc.
 - Indoors: 100mm between the equipment at nominal 1,5kV or 3kV DC and negative busbars and panel steelwork, between the high voltage AC supply to the rectifier cubicles and panel steelwork, the equipment at nominal 3kV DC and negative busbars.

9.0 OUTDOOR CLEARANCES AND INSULATION LEVELS

- 9.1 The minimum safety outdoor earth clearances which shall be maintained between any live conductor or metal and earthed metal and the minimum clearances of power lines above ground are in accordance with the statutory requirements of clause 15.1 of the "Electrical Machinery Regulations" of the "Occupational Health and Safety Act and Regulations, Act 85,1993", and are tabled below: -

TABLE 1:

| | | | | | | |
|---|--------|--------|--------|--------|--------|--------|
| Highest phase-to-phase r.m.s voltage for equipment. (U_m) | 24kV | 36kV | 48kV | 72kV | 100kV | 145kV |
| Nominal system r.m.s. voltage. (U_n) | 22kV | 33kV | 44kV | 66kV | 88kV | 132kV |
| Minimum safety outdoor clearance | 320mm | 430mm | 540mm | 770mm | 1000mm | 1450mm |
| Minimum clearance of power lines above ground | | | | | | |
| Outside security fence but within Transnet Freight Rail's reserve | 5200mm | 5300mm | 5400mm | 5700mm | 5900mm | 6300mm |
| Outside Transnet Freight Rail's reserve | 5500mm | 5500mm | 5500mm | 5700mm | 5900mm | 6300mm |

- 9.2 In terms of Transnet Freight Rail's Electrical Safety Instructions the clearances between the nearest exposed electrical equipment and a restricted access way are tabled below: -

TABLE 2:

| | | | | | | |
|---|--------|--------|--------|--------|--------|--------|
| Highest phase-to-phase r.m.s voltage for equipment. (U_m) | 24kV | 36kV | 48kV | 72.5kV | 100kV | 145kV |
| Nominal system r.m.s. voltage. (U_n) | 22kV | 33kV | 44kV | 66kV | 88kV | 132kV |
| Restricted access way (Vertical height) * | 2820mm | 2930mm | 3040mm | 3270mm | 3500mm | 3950mm |

*See clause 903.1.3 of "Transnet Freight Rail's Electrical Safety Instructions"

(The vertical heights in restricted access ways for the various system voltages are calculated by adding 2,5metres to the normal outdoor earth clearance for the different system voltages. Refer to Annexure 9.4 of Transnet Freight Rail's Electrical safety Instructions).

INSULATION LEVELS

- 9.2 For the medium and high voltage nominal r.m.s voltage systems on Transnet Freight Rail the recommended Insulation levels in accordance with SANS 1019 is tabled in table 3.

TABLE 3

| Highest phase-to-phase r.m.s voltage for equipment. (U_m) | Nominal system r.m.s. voltage. (U_n) | Rated lightning impulse withstand voltage peak. | Rated short duration power- frequency withstand r.m.s voltage. |
|---|--|---|--|
| 7,2 kV | 6,6 kV | 75 kV | 22 kV |
| 12 kV | 11 kV | 95 kV | 28 kV |
| 24 kV | 22 kV | 150kV | 50 kV |
| 36 kV | 33 kV | 200 kV | 70 kV |
| 52 kV | 44 kV | 250 kV | 95 kV |
| 72,5 kV | 66 kV | 350 kV | 140 kV |
| 100 kV | 88kV | 380 kV 450 kV | 150 kV 185 kV |
| 145 kV | 132 kV | 550 kV 650 kV | 230 kV 275 kV |
| 245 kV | 220 kV | 850 kV 950 kV | 360 kV 395 kV |

Insulation levels for highest voltage for equipment $U_m < 100$ kV are based on an earth fault factor equal to $\sqrt{3}$ and for $U_m > 100$ kV an earth fault factor equal to $0,8\sqrt{3}$. Where more than one insulation level is given per voltage system, the higher level is appropriate for equipment where the earth fault factor is greater than 1,4.

TABLE 3: Standard Voltages and insulation levels in accordance with SANS 1019:2008 [1]**SECTION 2: TRACTION SUBSTATION EQUIPMENT OUTDOOR YARD EQUIPMENT****10.0 METAL OXIDE SURGE ARRESTERS**

- 10.0 The contractor shall supply and install metal oxide gapless surge arresters in accordance with Transnet Freight Rail's specification BBB 0845.
- 10.1 The surge arresters shall be connected between each phase of the high voltage supply and substation main earth electrode/earth mat
- 10.2 The maximum protected distance from the main transformer bushing terminal to the surge arrester terminal shall be as indicated in table 4.

TABLE 4:

| NOMINAL SYSTEM R.M.S VOLTAGE (kV) | MAXIMUM DISTANCE (Metres) |
|-----------------------------------|---------------------------|
| 44kV | 5 |
| 66kV | 6 |
| 88kV | 6 |
| 132kV | 7 |

- 10.3 The neutrals of high voltage supplies are to be treated as effectively earthed unless otherwise specified.
- 10.4 For the installation of high voltage surge arresters on the main transformer, refer to Transnet Freight Rail's drawing BBB 0938
- 11.0 HIGH VOLTAGE AC DISCONNECTOR**
- The contractor shall supply and install the high voltage AC disconnecting switch in accordance with Transnet Freight Rail's specification BBB 7842.
- 12.0 HIGH VOLTAGE PRIMARY CIRCUIT BREAKER**
- The contractor shall supply and install the high voltage AC primary circuit breaker in accordance with Transnet Freight Rail's specification BBB 1267.
- 13.0 MAIN CURRENT TRANSFORMERS**
- 13.0 The main current transformers shall comply with the requirements of Transnet Freight Rail specification BBB 0937.
- 13.1 The main current transformers shall either be fitted in the high voltage bushings of the main traction transformer or shall be the freestanding post type current transformers install on the line side of the main traction transformer.
- 13.2 In the event of Eskom or Local Utility requiring three current transformers for metering purposes the successful contractor shall supply and install the additional current transformer.
- 13.3 The ratios, accuracy and burdens of the current transformers shall be in accordance with Transnet Freight Rail's Specification BBB 0937.
- 14.0 MAIN TRACTION TRANSFORMER**
- 14.1 The contractor shall be responsible for the delivery, assembling, filling of transformer oil and installation on site of the main traction transformer in accordance with Transnet Freight Rail's Specification BBB 5019.
- 15.0 AUXILIARY TRANSFORMER**
- 15.1 The contractor shall make provision for the supply of an auxiliary transformer which shall comply with the requirements of SANS.780
- 15.1.1 The auxiliary transformer shall be three phase with a minimum rating of 50kVA or higher depending on the substation requirements.
- 15.1.2 The 3 phase auxiliary transformer shall be supplied from the tertiary winding of the main traction transformer
- 15.1.3 The auxiliary transformer shall be the sealed unit type suitable for outdoor installation. Full details of the transformer shall be submitted.
- 15.2 In the case of a double unit substation one auxiliary transformer may be provided unless otherwise specified.
- 15.3 The secondary winding of the auxiliary transformer shall be star-connected.

- 15.4 The auxiliary transformer shall supply the required kVA rating without exceeding the permissible temperature rise laid down in SANS 780.
- 15.5 The nominal no-load secondary voltage of the auxiliary transformer shall be 400V three phase.
- 15.6 Off-load, externally operated tap changing gear shall be provided on the transformer, with tapplings to compensate for any change in the main transformer tapping.
- 15.7 All primary and secondary terminals, including the secondary neutral, shall be brought out through the transformer tank by means of bushing type terminals and shall be arranged for busbar/cable connections.

16.0 AUXILIARY TRANSFORMER PROTECTION

PRIMARY WINDING

- 16.0 The contractor shall make provision for overload protection of the primary winding. Refer to clause 8.8 of specification No BBB 2721.
- 16.1 The protection system shall consist of an approved type of overload relay with its associated current transformers.

16.2 SECONDARY WINDING

- 16.3 The contractor shall supply and install a three phase isolating and earthing switch for the secondary supply of the auxiliary transformer to the substation.
- 16.4 The isolating and earthing switch shall be fitted with mechanical interlocking of the key exchange type, which shall form part of the interlocking procedure for the substation. Refer to clauses 31.0 and 32.0 of this specification.

17.0 AC EARTH LEAKAGE CURRENT TRANSFORMER.

- 17.1 The contractor shall supply and install a bar primary current transformer for the AC earth leakage protection. The current transformer shall be installed on the support steel structure of the primary circuit breaker.
- 17.2 One terminal of the primary winding shall be connected to the primary circuit breaker frame and the other terminal shall be connected to the substation main earth electrode/mat. (Refer to drawing CEE-TBD-7 and BBB 3620).
- 17.3 The current transformer shall be class 10P10, ratio 50/5 or 100/5.
- 17.4 The current transformer shall be designed to withstand a test voltage of 2kV for 1 minute.

INDOOR EQUIPMENT

18.0 3kV DC RECTIFIER EQUIPMENT

- 18.1 The contractor shall supply and install 3kV DC rectifiers in accordance with Transnet Freight Rail's Specification BBB 0496.
- 18.2 Each rectifier unit and its associated control equipment shall be designed to form an independent unit.
- 18.3 The rectifier equipment shall be installed in screened bays fitted with gates.
- 18.4 The gates shall be fitted with mechanical interlocks of the key exchange type in accordance with clauses 31 and 32 of the specification.
- 18.5 The bay screens shall be constructed of approximately 25mm woven wire mesh or expanded metal fixed to tubular or angle iron frames complete with doors, pillars, gates etc.
- 18.6 The height of the screens and gates shall be similar to the height of the control panels but shall be not be less than 1,8 m.
- 18.7 In a double unit substation the rectifier units are referred to as the "A" and "B" units and shall be labelled as such.

- 18.8 It is required that each rectifier unit in a double unit substation can be isolated independently and earthed without shutting down the whole substation.
- 18.9 Individual rectifier units shall be screened from each other and from any other live common equipment. A mechanical key exchange interlocking system type in accordance with clauses 31 and 32 shall be fitted to ensure the safety of personnel working on the isolated rectifier equipment.
- 18.10 The rectifier units and bay screens shall be insulated from the floor.

19.0 3kV DC REACTOR

- 19.1 The contractor shall supply and install a 1.8 milli Henry 3kV DC air core reactor for each rectifier unit. The installation shall include the supply of all the required insulators, foundations, foundation bolts and fasteners.
- 19.2 The 3kV DC reactor shall be in accordance with Transnet Freight Rail's Specification BBB 3890.
- 19.3 The reactor shall be insulated from the substation floor by means of insulators.
- 19.4 Sufficient space shall be allowed for access to the reactor for maintenance and inspection purposes.

20.0 WAVE FILTER

- 20.1 The contractor shall supply and install the wave filter equipment in accordance with Transnet Freight Rail's specification BBB 3139 for wave filter capacitors and BBB 3162 for inductor coils.
- 20.2 A wave filter is connected in parallel with the rectifier output. The filter unit is a capacitive inductive circuit, which is tuned to resonate at specific harmonic frequencies.
- 20.3 The filter equipment shall be so designed that no individual harmonic voltage is greater than 2% of the output voltage.
- 20.4 The inductor coils shall have sufficient adjustment to compensate for change in the capacitance values due to ageing. Refer to Transnet Freight Rail's drawing BBB 3483 for assembly.
- 20.5 A 100 Ampere High Rupturing Capacity (H.R.C) fuse shall be fitted to protect the wave filter equipment.
- 20.6 The fuse holder shall be mounted on insulators.
- 20.7 The insulators shall be so designed that the flashover path is not less than 100mm and shall support the fuse at a distance of not less than 100mm from the bolts securing the base plate. The insulators shall have a minimum dry flashover value of 20kV.
- 20.8 Access to the wave filter equipment shall only be possible once the wave filter capacitors have been connected to rail, discharged and the primary circuit breaker tripped.
A 75 kilo Ohm resistor consisting of two 150 Kilo Ohm, 150 watt vitreous enamel resistors connected in parallel shall be provided for the discharging of the wave filter capacitors when the equipment is isolated and earthed.
- 20.9 The discharge resistors shall be mounted on a suitable insulation panel or bar, which shall be insulated for 3kV DC. A minimum clearance of 75mm must be provided between the terminals, and 100mm between any 3kV live portion of the equipment and earth.
- 20.10 The wave filter capacitors shall be earthed with 95mm² PVC insulated copper cables to the DC earth leakage system.
- 20.11 The wave filter equipment shall be housed in a separate explosion proof room or cubicle.

21.0 3kV DC POSITIVE ISOLATOR

- 21.1 The contractor shall supply and install the 3kV DC positive isolator in accordance with Transnet Freight Rail's specification BBB 4724.
- 21.2 The DC positive isolator metal cubicle/housing shall be insulated from the substation floor.

22.0 CONTROL PANELS

- 22.1 The contractor shall supply and install the AC primary circuit breaker control panel and the AC/DC distribution panel in accordance with Transnet Freight Rail's specification BBB 2721.

22.2 The control panels shall be insulated from the substation floor.

ELECTRONIC EQUIPMENT

22.3 The tenderer must be aware that high voltage surges and transient voltages can be induced in low voltage and control wiring due to switching and lightning. Special care shall be taken in the design and layout of the equipment to limit these voltages.

22.4 Electronic equipment shall suitably be protected against over voltages, surges and transients. Dehn type surge protection units or equivalent shall be used. Liberal use of metal oxide varistors is also encouraged.

23.0 BATTERIES

23.1 The contractor shall supply, install and commission a 53 cell 110 Volt Planté lead acid battery bank. The capacity of the battery can either be 100 Ampere hour rating, 200 Ampere hour rating or capacity dependant on the substation requirements.

The standard for the batteries shall be the 10-hour rate at 20°C. The battery shall be capable of delivering a minimum of 10 Amperes for 10 hours.

23.2 Batteries are installed in traction substations for control and protection purposes. The battery is used for the following functions:

- Tripping and closing of primary circuit breakers.
- Supply to protection relays.
- Closing and holding coil supply to DC high speed circuit breakers.
- 110 Volt supply to control panel.

24.0 BATTERY CHARGER

24.1 The contractor shall supply and install the battery charger in accordance with Transnet Freight Rail's specification BBB 2502.

24.2 The battery charger shall be insulated from the substation floor by means of "Marley" or "Lino" floor covering not less than 2mm thickness.

25.0 TRACK FEEDER HIGH SPEED CIRCUIT BREAKERS

25.1 The successful tenderer shall supply and install the required 3kV DC high speed circuit breakers in accordance with Transnet Freight Rail's specification CEE.0099 as well as with the following additional requirements:

25.2 The high-speed circuit breakers shall be of the conventional truck mounted type as commonly used by Transnet Freight Rail in the 3kV DC traction substations.

25.3 High-speed circuit breakers shall be fitted with an automatic reclosing feature, which provides for 1 (one) reclosure at 20 to 35 seconds interval. Refer to drawings CEE-TBP-35. "Connection diagram for the high speed circuit breaker and electronic control relay". CEE-TBP-39. "Circuit diagram for auto reclosure for the high speed circuit breaker.

25.4 Transnet Freight Rail shall provide the auto reclosure relays. The relays shall be wired by the contractor in accordance with the requirements of clause 25.3.

25.5 The high speed circuit breakers shall be complete in all respects. This shall include housings, rack out trucks, base rails, main and auxiliary contacts and flapper gear and any other fittings or equipment required for the correct operation of the high-speed circuit breakers.

25.6 The high-speed circuit breakers shall be racked into breaker cells, each having two fixed contacts mounted at the rear of the breaker cell. One contact is connected to the substation positive busbar and the other to a wall bushing mounted in the building outer wall.

25.7 All other items of material such as cell slabs, main busbars, earthing connections, wall bushing plates or blanking-off plates, control cables etc, shall be included in the tenderer's offer.

25.8 Transnet Freight Rail shall provide details of the wall plate frame and standard cell slabs where applicable.

- 25.9 Where access is possible to the rear of the high-speed circuit breakers (busbar chamber) access barriers shall be installed.
- 25.9.1 The barriers shall be fixed to angle iron frames with fasteners which only be removed with tools. Warning signs shall be fitted to the barriers.

26.0 MODULAR TYPE STEEL HOUSED HIGH SPEED CIRCUIT BREAKERS

- 26.1 Where tenderers offer modular type high-speed circuit breakers they shall submit full information, construction and dimensional drawings with their offer.
- 26.2 Transnet Freight Rail specification CEE.0227 shall be used as a guideline.
- 26.3 The tenderers must be fully aware that the requirements of Transnet Freight Rail's specification CEE.0099 are relevant.
- 26.4 Transnet Freight Rail reserves the right to accept or reject offers for equipment after consultation with tenderers. Transnet Freight Rail's Senior Engineer, Technology Management, shall approve all designs.
- 26.5 The modular type steel housings shall be insulated from the substation floor.

27.0 REGENERATIVE HIGH SPEED CIRCUIT BREAKER

- 27.1 At certain substations Transnet Freight Rail will require 3kV DC regenerative braking energy absorption equipment. If required the successful contractor shall supply the high speed circuit breaker for the protection of the regenerative braking equipment in accordance with Transnet Freight Rail's specification CEE.0099.

28.0 3kV DC UNDERVOLTAGE RELAY

- 28.1 The contractor shall supply and install a 3kV DC under-voltage relay with a high voltage potential divider in accordance with Transnet Freight Rail Specification BBB 3005 and shall provide the following:
- 28.2 Fibre optic technology must be used to provide galvanic isolation between the potential divider and the undervoltage relay.
- 28.3 The potential divider shall be mounted in the 3kV busbar chamber or in the high voltage compartment of the positive isolator cubicle in accordance with Transnet Freight Rail's Specification BBB 4724.
- 28.4 The potential divider shall be protected by an H.R.C fuse connected between the positive side of the 3kV DC supply and the input of the potential divider.
- 28.5 Insulation clearance shall be not less than 100mm. All normally live equipment on the potential divider shall withstand a test voltage of 10,5kV AC RMS 50 Hz for one minute to earth without breakdown.
- 28.6 If the undervoltage relay is wall mounted, an engraved warning label shall be fixed to the front of the undervoltage relay panel with the following warning:

WARNING

THE POSITIVE BUSBAR MUST BE ISOLATED AND EARTHED BEFORE WORK IS UNDERTAKEN ON THE UNDERVOLTAGE RELAY

- 28.7 The following connections shall consist of 95mm² cross-sectional area copper or copper equivalent conductors.
- Potential divider to negative busbar.
 - Resistor base plate to DC earth leakage busbar.
 - Relay metal case to DC earth leakage busbar.

SECTION 3: INSTALLATION

SUBSTATION EARTHING

29.0 INDOOR EARTHING (REFER TO DRAWING CEE-TBD-0007)

The successful contractor shall supply, install and comply with the following:

- 29.1. The supply and installation in the substation building of all earthing conductors for the earthing of all metal work which includes supporting frames, control panels, battery charger, positive isolator panel, track breaker cells, rectifier bay screens, chequer plates and metal bases of insulators mounted directly on the walls or floor etc.
- 29.2. The frames and bases of all items associated with the 3kV DC including the track feeder wall plates, shall be connected through the DC earth leakage relay to the negative busbar in accordance with Transnet Freight Rail's drawing CEE-TBD-0007.
- 29.3. The DC earth leakage relay and the installation thereof shall comply with the requirements specified in clause 8.6 of Transnet Freight Rail's specification BBB2721.
- 29.4. Earthing conductors which could be subjected to 3 kV DC faults caused by insulation breakdown, etc., shall be not less than 70mm² copper strap cross-sectional area or 95mm cross-sectional area PVC insulated stranded copper cable. Other earth conductors must have a minimum of 16mm² copper cross-sectional area.
- 29.5. The earthing system for the 3kV DC positive busbar chamber shall be supplied by the successful tenderer. The design of the system shall be in conjunction with Transnet Freight Rail staff.
- 29.6. The successful tenderer shall supply the portable earthing device and cables according to Transnet Freight Rail's requirements.
- 29.7. All connections to the DC earth leakage relay shall form part of a ring circuit for safety when part of the circuit is disconnected. Refer to drawing CEE-TBD-0007.
- 29.8. The earth conductors shall not be installed in such a manner as to bridge out the earth leakage relay.
- 29.9. The resistance between the DC earth leakage busbar and the substation main earth electrode/mat shall be not less than 25 ohms.
- 29.10. Holding-down bolts grouted in the floor shall not be in direct contact with reinforcing or in with the earth under the concrete floor in the substation.
- 29.11. Where mounting bolts are used for securing electrical equipment to the floor, these bolts must be insulated to prevent electrical contact with any reinforcing or floor.
- 29.11.1 The indoor substation equipment shall be earthed in groups as shown in Transnet Freight Rail's drawing CEE-TBD-0007.

30.0 OUTDOOR EARTHING (DRAWING NO CEE-TBD-7 AND BBB 3620)

The successful tenderer shall supply, install and comply with the following:

- 30.1 Outdoor yard earthing which includes earth spikes, trench earths, earth connections to the support steel structures and fence posts. The material used shall comply with Transnet Freight Rail's specification BBB 3059 and drawing BBB3620.
- 30.2 A rail-earth switch mounted on the gate that provides access to the outdoor yard and where applicable to the 3kV DC overhead feeder security area and provides all connections thereto.
- 30.3 In Transnet Freight Rail switchyards where the supply from the Electrical Utility is terminated on portal structures or where a flying busbar is provided the contractor shall earth these structures.
- 30.3.1 Install two 50mm² galvanised steel earth conductors, one each between the outside portal structure or flying busbar support and the gable of the substation building.

- 30.3.2 The earth conductor shall be suitably terminated and connected to the portal or flying busbar structures. A suitable bracket shall be supplied and mounted on the gable of the substation building. The earth conductors shall directly be terminated on the bracket and connected to the main earth electrode/mat.

Insulating of structures and electrical equipment.

- 30.3.3 The tenderer shall make provision for the insulating of the support steel structures for i.e. the primary circuit breaker, main current transformers and any other structure that is connected to the AC earth leakage system from the concrete foundation.
- 30.3.3.1 The insulating material shall be either the same material used for the insulating of the mast bases for the overhead track equipment or other insulating material that has been approved by Technology Management.
- 30.4. The tenderer shall make provision for the insulating of the base of the main traction transformer from the concrete plinth. Malthoid or any other approved insulation shall be used.

31.0 INTERLOCKING

GENERAL

- 31.1 The equipment for each substation shall include a mechanical interlocking system; preferably the "Castell" or other approved key type. Full details of the type offered instead of the "Castell" type shall be submitted with the tender.
- 31.2 The mechanical interlocking system must be designed to prevent access to the high voltage equipment whilst "live" and ensure that switching and isolating operations are carried out in the correct sequence.
- 31.3 All equipment shall be delivered with the necessary interlocks fitted.
- 31.4 It shall not be possible to operate the locks and release the keys in any but the correct sequence or in any position of the switches or gates, other than the fully "closed" or fully "open" position, as the case may be.
- 31.5 When a unit is switched to local condition and isolated, no remote switching from the control office shall be possible. Tenderers shall furnish full explanatory details of the arrangement whereby the foregoing provisions are met.
- 31.6 The track feeder breakers shall remain closed throughout the isolation procedure.

32.0 ISOLATING PROCEDURE

Sequence to isolate a single unit substation rectifier unit.

- 32.1 Trip high voltage AC circuit breaker.
- 32.2 Open high voltage AC disconnecting switch-key "1" released.
- 32.3 Remove key "1"- AC disconnecting switch locked in open and earthed position.
- 32.4 Use key "1" to operate auxiliary supply's three phase isolating and earthing switch - key "1" trapped - key "2" released.
- 32.5 Use key "2" to unlock DC positive isolating and earthing switch.
- 32.6 Open DC positive isolating and earthing - key "2" trapped - key "3" released. Remove key "3". DC positive isolating and earthing switch locked in open position.
- 32.7 Use key "3" to open rectifier unit bay gate (and DC smoothing reactor screen if required).
- 32.8 If a number of keys are required to open the rectifier cubicles, a key exchange system may be used.
- 32.9 Procedure is reversed to switch the rectifier unit back on load.
- 32.10 The number indicated for the keys are for single unit substations only. Where there are two units in one substation the numbers of keys for the two units shall be A1 and B1, A2, and B2, etc. It shall not be possible to exchange keys between any equipment on different units.

- 32.11 The foregoing sequence is given as a guide and may be altered to suit tenderer's equipment. The design shall be approved by Transnet Freight Rail.
- 32.12 Where the wave filter equipment is not located in the rectifier bay, the access to the equipment shall be mechanically interlocked and form part of the interlocking procedure.
- 32.13 Access to the wave filter shall only be possible once the positive isolator is earthed and the primary circuit breaker is tripped. Refer to clause 20.8
- 32.14 Any deviation from the above guideline must be approved by Transnet Freight Rail.
- 33.0 INDOOR CABLING, BUSBARS AND ASSOCIATED EQUIPMENT**
- The contractor shall supply and install the following:
- 33.1 All low voltage PVC insulated supply and control cables.
- 33.2 3kV DC copper cables and copper busbars from the Anode wall plate to the rectifier and from the rectifier equipment to the DC positive isolating switches, DC smoothing reactors, and main DC negative busbar. In the event of aluminium (grade 6063) being used the minimum size shall be 50mm x 25mm busbar.
- 33.3 Where required, the supply and fitting of hot dip galvanised anode wall plates in the wall of the substation building, at the rectifier bays. The wall plate galvanising shall comply with SANS 121.
- 33.3.1 Wall plates shall be fitted with wall bushings, one for each phase and the neutral.
- 33.3.2 Designs and drawings of the wall plate arrangement must be submitted for approval after adjudication of the tender.
- 33.4 The interconnecting busbars from the anode wall plate to the rectifier.
- 33.5 The main 3kV DC positive and negative copper busbars. Minimum dimension of busbars shall be 100mm X 10mm copper or 127mm X 12,5mm aluminium (grade 6063) busbar.
- 33.6 The 3kV DC output positive busbar system, which includes high-speed circuit breaker busbars, and where required the outgoing feeder cables between the high speed circuit breaker busbars and wall bushings.
- 33.7 Barriers in accordance with clause 8.0 where exposed busbars exist between the positive isolator and the DC track breaker positive, busbar.
- 33.8 Cables from the DC smoothing reactor or main positive busbar to the wave-filter equipment.
- 33.9 Control cables from the rectifier cubicles to their respective control panels.
- 33.10 Cables from the auxiliary equipment to the substation control panels.
- 33.11 Connections and cabling between control panels.
- 33.12 Cables between the 110V substation battery and the auxiliary DC panel (2 core, minimum 16mm²).
- 33.13 Cables (95mm² stranded copper) to the wave-filter room(s) for rail (negative) and DC earth leakage connections to wave-filter equipment.
- 33.14 Earthing cables (95mm² stranded copper) between the DC earth leakage busbar and substation negative busbar.
- 33.15 Two core 16mm² and multicore 2,5mm² cables between panel and high-speed 3kV DC circuit breakers.
- 33.16 Two core 6mm² cables between the 25A circuit breakers on the DC panel and the Electrical Supply Utility meter room. Make-off and connect at the DC panel only.
- 33.17 All other busbars and cables required for the interconnection of the substation indoor equipment.
- 33.18 Cable glands for the termination of the cables at the control panels and other equipment. Neoprene shrouds shall be fitted over the cable glands.

- 33.19 The maximum current density per square mm for open conductors shall not exceed 1.55 Ampere for copper and 1.0 Ampere for aluminium.
- 33.20 Low voltage cables for indoor use may be unarmoured.
- 33.21 All high voltage cables shall be armoured XLPE insulated and shall comply with SANS 1339 and Transnet Freight Rail specification BBC 0198. All wiring used on the 3kV DC equipment shall have nominal 3kV insulation unless the clearances comply with those laid down in clause 8.9.
- 33.22 All negative connections and terminals associated with high voltage circuits and which are accessible without first having to isolate and earth such high voltage circuits e.g. the main negative busbar, DC earth leakage relay, etc., shall be of 95mm², copper or copper equivalent cross-section. The terminals shall be painted red.
- 33.23 Notwithstanding the above clauses the contractor shall supply and install any other cables, conductors or busbars required for the successful operation of the substation.

33.24.0 BLOCK JOINTS

- 33.24.1 The contractor shall make block joints in the armouring of all the low voltage supply and control cables, which are connected between the indoor control equipment and the outdoor yard equipment.
- 33.24.2 The block joints shall be clearly visible and shall be not less than 200mm from the cable glands terminating at the outdoor equipment.
- 33.24.3 The block joints shall be sealed with a heat shrink covering to prevent the ingress of moisture.

33.25.0 CHEQUER PLATES

- 33.25.1 The contractor shall be responsible for the supply of all metal chequer plates required for covering of cable trenches inside the substation.
- 33.25.2 Earthing studs suitable for the fitting of 95mm² copper cable shall be welded to each chequer plate.

34.0 CABLES, BUSBARS AND CONNECTIONS (OUTDOOR)

The Contractor shall supply and install the following:

- 34.1 The Inter-connections cables or conductors in the High Voltage yard.
- 34.2 The high voltage AC connections which shall be solderless, concentric grip, or other approved solderless type. The connections must have adequate cross-sectional area to suit both electrical and mechanical requirements.
- 34.3 Copper busbars between separately mounted outdoor equipment. The busbars shall incorporate a degree of flexibility to avoid any overstressing of connections due to foundation movement and expansion or contraction.
- 34.4 All negative connections and terminals associated with high voltage circuits and which are accessible without first having to isolate and earth such high voltage circuits e.g. the main negative busbar shall be of 95mm², copper or copper equivalent cross-section. The terminals shall be painted red.
- 34.5 Copper busbars with removable flexible connections or "all aluminium" stranded conductor may be used interconnection conductors between the main traction transformer secondary bushings and the anode wall bushings which are fixed to the anode wall plate of the substation building.
- 34.5.1 Where "all aluminium" conductors are to be installed the following sizes and number of conductors shall be installed:
- 2 X 800 mm² "all aluminium" stranded conductor per each phase for 6 MW substations, or 50mm X 25mm aluminium (grade 6063) busbar in accordance to Transnet freight rail drawing BBF1615
 - 2 X 800 mm² "all aluminium" stranded conductor per each phase for 4,5 MW substations, or 50mm X 25mm aluminium (grade 6063) busbar in accordance to Transnet freight rail drawing BBF1615.

- 2 X 500 mm² “all aluminium” stranded conductor per each phase for 3 MW substations, or 50mm X 25mm aluminium (grade 6063) busbar in accordance to Transnet freight rail drawing BBF1615.

- 34.5.2 Where two different conductor material joints are used, the Bi-Metallic plates shall be applied.
- 34.6 Conductors from the high voltage AC line aerial conductors and between the surge arresters, AC disconnecting switch, high voltage AC circuit breaker, current transformers, rectifier transformer and rectifier.
- 34.7 Cables or busbars from the rectifier transformer to the auxiliary transformer.
- 34.7.1 The auxiliary transformer shall be connected directly to the tertiary winding of the traction transformer for new installations or existing installations where tertiary windings are employed on the main traction transformer.
- 34.8 Cable from the auxiliary transformer secondary to the short-circuiting switch.
- 34.9 Control cables from the high voltage AC disconnecter, AC circuit breaker and main and auxiliary transformers to the substation control panels.
- 34.10 A multi-core 4mm² cable between the current transformers and the Electrical Supply Utility meter room. Make-off and connect at the current transformer only.
- 34.11 In the case of the Electrical Supply Utility Tee-supplies a multi-core 4mm² cable between the voltage transformers and the Electrical Supply Utility. The Electrical Supply Utility will do the cable connection.
- 34.12 In the case of the Electrical Supply Utility Duplicate Supplies one multi-core 4mm² cable between Transnet Freight Rail’s high voltage AC circuit breaker and the Electrical Supply Utility meter room. (For interlocking Electrical Supply Utility M.O.D’s). The cable shall have 10% spare cores.
- 34.13 A multi-core 2,5mm² cable between the tele-control remote terminals on the control panel and the electrical supply utility meter room. (For tele-control of the Electrical Supply Utility equipment). The cable shall have 10% spare cores.
- 34.14 All other cables as specified. e.g. security lighting and alarms.
- 34.15 All control cables, security and alarm cables shall be armoured cables.
- 34.16 Notwithstanding the clauses above the contractor shall be responsible for all cables, busbars and connections required for the successful operation of the 3kV DC traction substation.

35.0 LABELS AND TERMINALS

- 35.1 All labels shall be in English. All lettering shall be white on a black background. Lettering shall be a minimum of 6mm in height.
- 35.2 All labels shall be neatly secured by rivets or screws.
- 35.3 All conductors and cables shall be provided with identification tags at terminals.
- 35.4 All terminals and equipment such as switches and relays shall be suitably numbered according to the substation schematic and wiring diagrams. All terminal blocks and groups of terminal blocks shall be suitably numbered.

36.0 SUBSTATION NEGATIVE RETURN

The substations negative return system which can be in the form of the following:

- Buried XLPE insulated copper cable.
- Rail on sleepers.
- Aerial conductors.

36.1 BURIED XLPE INSULATED COPPER CABLE

- 36.1.1 The contractor shall install 2 x 500mm² single core XLPE copper cables from the substation negative busbar to the negative manhole situated near the railway line.
- 36.1.2 Transnet Freight Rail's staff will undertake the provision of the bare conductors from the negative manhole to track, as well as the rail connections.
- 36.1.3 The negative manhole to drawing CEE-TU-41 is to be supplied and installed by the contractor.
- 36.1.4 The negative return cables shall be laid, in 150mm of soft soil in a trench, at a depth of not less than 1000mm below ground level and spaced not less than 300mm between centres.
- 36.1.5 Where cables are likely to be damaged they shall be protected by concrete slabs. Refer to Transnet Freight Rail specification CEE.0023.
- 36.1.6 The cable route shall be provided with cable warning tape. Refer to Transnet Freight Rail specification CEE.0023.
- 36.1.7 The cable runs shall be marked by cable markers painted signal red. (Stores Item No 9/1503)

36.2 RAIL NEGATIVE RETURN.

- 36.2.1 Where rail is used for the negative return system Transnet Freight Rail shall supply and install the rail from the inside of the substation building to the railway track.
- 36.2.2 The rail shall be insulated from ground by means of concrete sleepers supplied by Transnet Freight Rail.
- 36.2.3 Where the rail enters the substation building it must be insulated from all concrete and brickwork to prevent stray current damage to building reinforcing or other metal. After installation the hole in the wall shall be sealed and made good by Transnet Freight Rail.
- 36.2.4 The rail shall be connected to negative output of the rectifier by means of a suitably rated busbar/cable supplied by the contractor. Transnet Freight Rail will make provision for terminations on the rail.
- 36.2.5 Transnet Freight Rail shall connect the negative return rail to the track by means of PVC insulated steel conductors.

36.3 NEGATIVE FEEDER MONITORING SYSTEM.

- 36.3.1 The contractor shall design supply and install a negative feeder monitoring system in accordance with Transnet Freight Rail specification BBB1843.
- 36.3.2 The negative feeder monitoring system shall be designed to trip the 3 kV DC track breakers in the event of the traction substation negative return circuit becoming open circuited due to cable theft of the negative return cables or other cause of failure of the negative return circuit.

36.4 AERIAL CONDUCTORS

- 36.4.1 Where aluminium conductors are installed; 2 X 800 mm² size for both 4.5 MW and 6 MW shall be used and 2 X 500 mm² for 3 MW substations.
- 36.4.2 Where aerial conductors are used for the negative return, the contractor shall provide the wall plates and wall bushings where required.
- 36.4.3 In the case of aerial conductors used for the negative return, Transnet Freight Rail shall provide the conductors and the installation.

37.0 3kV DC POSITIVE FEEDER CABLES

The positive feeder cables shall be either:

- Buried armoured medium voltage XLPE insulated cable.
- Aerial aluminium conductor

37.1 BURIED XLPE INSULATED CABLE

- 37.1.1 The contractor shall install two single core 6,6kV, 500mm² armoured medium voltage XLPE insulated cables with stranded copper conductors. The cables shall be manufactured with copper tape screen, armour and sheath in accordance with SANS 1339 and Transnet Freight Rail specification BBC 0198. The cables shall run from the high-speed circuit breaker busbar chamber to the associated track switch structure.
- 37.1.2 Tenderers are to allow for making off the cables with suitable terminations. Sufficient length of cable must be left buried at the base of the track switch structure for erection and connection to the track switch. Transnet Freight Rail will do connection to the track switch.
- 37.1.3 The medium voltage cables shall be laid in 150mm of soft soil, in a trench at a depth of not less than 1000mm below ground level and spaced not less than 300mm between centres.
- 37.1.4 Where cables are likely to be damaged they shall be protected by concrete slabs. Refer to Transnet Freight Rail specification CEE.0023.
- 37.1.5 The cable route shall be provided with cable warning tape. Refer to Transnet Freight Rail specification CEE.0023.
- 37.1.6 The cable runs shall be marked by cable markers painted white (Stores Item No 9/1539).
- 37.1.7 Should it be necessary for the cables to pass under the tracks suitable pipes will be installed by Transnet Freight Rail.
- 37.1.8 Where required, the contractor shall supply the necessary wall bushings for positive feeder cables.

37.2 AERIAL CONDUCTOR

- 37.2.1 In the case of aerial conductors used for the positive feeders, Transnet Freight Rail shall make provision for conductors and installation.
- 37.2.2 Where aerial conductors are used for the 3kV DC positive, the contractor shall provide the wall plates and wall bushings.

38.0 TRENCHING FOR OUTDOOR YARD EARTHING CONDUCTORS AND CONTROL CABLES

- 38.1 Before any trenching commences the contractor shall consult with Transnet Freight Rail staff for approval of the routing of the trenches in the outdoor yard.
- 38.2 In existing substation outdoor yards the contractor shall remove the necessary crusher stone in the outdoor yard before any excavation commences. The contractor shall restore the crusher stone after the completion of the work.
- 38.3 Trenching includes all trenches required for the installation of the earthing system and control cables.
- 38.4 The depth of trenches shall not be less than 700 millimetres.
- 38.5 With the installation of new earthing conductors and control cables at existing substations, care must be taken not to damage existing cables in the high voltage outdoor yard during trenching operations.
- 38.6 The Contractor and Transnet Freight Rail staff shall inspect the trenches before and during the installation of the earthing system and control cables.
- 38.7 Before the trenches are closed a representative from Transnet Freight Rail shall inspect the earthing system and other cabling for damage.

39.0 FOUNDATIONS.

- 39.1 The successful tenderer shall be responsible for the design and casting of foundations for the portal and support structures in the traction substation high voltage outdoor yard.
- 39.2 Notwithstanding the supply arrangements (single or double) at any particular substation, tenderers shall clearly understand that all foundations and steelwork to accommodate the supply and to cater for the traction yard are to be provided and erected by the successful tenderer.

- 39.3 Wherever there is a combined traction and 11kV/6,6kV distribution yard, a flying busbar is to be provided in Transnet Freight Rail's yard. All foundations and steelworks required to suit this arrangement, including the erection and earthing thereof shall be included in tenderer's offers.
- 39.4 The foundations in the high voltage outdoor yard shall include the following:
- Voltage Transformers if applicable.
 - Surge arresters.
 - AC disconnectors.
 - Current transformers. (If applicable)
 - Primary circuit breakers.
 - Main traction transformer.
 - Auxiliary transformers.
 - Portal lattice structures as required.
 - Any other foundations as specified.
- 39.5 The successful tenderer shall carry out his own survey in regard to soil types and their load bearing capabilities.
- 39.6 Equipment support foundations shall be finished off 200mm above the finished earth level of the yard. The design must be such as to prevent standing water.
- 39.7 All foundation edges shall be bevelled, and the surfaces must be float finished.
- 39.8 All support foundations shall be at the same level.
- 39.9 The design of the concrete plinth for the main traction transformer shall include a concrete gutter around the perimeter of the plinth to contain any spillage of transformer oil.
- 39.10 Provision shall be made on the plinth for skid rails. The spacing of the rails between centres shall be a minimum of 1meter. Details of the design and load bearing parameters of the skid rail system, plinth and rail shall be submitted to Transnet Freight Rail for approval.
- 39.11 The auxiliary transformer if separate shall be provided with its own concrete plinth with a concrete gutter, or may be installed on the same plinth as the main traction transformer.
- 39.12 The 28-day strength of all concrete used shall be a minimum of 20Mpa.
- 39.13 Hand mixed concrete is not acceptable, it must be mechanically mixed.
- 40.0 SUPPORT STRUCTURES**
- 40.1 The design, supply and installation of all steel structures for the support of equipment and tensioning of conductors shall be the responsibility of the successful tenderer.
- 40.2 Special attention shall be taken for the prevention of corrosion of all metallic parts.
- 40.3 The bases of insulators, studs, bolts, support structures and other parts made of ferrous material associated with the electrical connections outdoors, shall be hot-dip galvanised, in accordance with SANS 121.
- 40.4 Steelwork for outdoor installation in coastal areas, i.e., within 50km of the coast, shall first be hot-dip galvanised in accordance with SANS 121, followed immediately at the galvanising plant by the application of the Sterling paint system in accordance with specification CEE.0045.
- 40.5 Steelwork for outdoor installation in inland areas, i.e., at a distance greater than 50km from the coast, shall be hot-dip galvanised to SANS 121.
- 40.6 All high voltage equipment shall be provided with hot-dipped galvanised support structures or pedestals to provide a minimum clearance of 3,6 m (up to 88kV) or 4,1 m (above 88kV) from the lowest "live" high voltage connection to finished ground level.

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- 40.7 Structural steel shall comply with SANS 1431.
- 40.8 All welded joints shall be seal welded with no gaps or blowholes.
- 40.9 All fasteners, nuts and bolts used for the installation of substation steelwork and equipment shall be hot dipped galvanized to prevent corrosion.
- 41.0 FENCING**
- 41.1 The successful tenderer shall supply and install new perimeter fencing as specified.
- 41.2 The successful tenderer shall make provision for the levelling of outdoor yard if required.
- 41.3 The fencing shall be either of the following:
- Concrete palisade fencing in accordance to drawing CEE-TDF- 0016.
 - Hot dipped galvanised steel palisade fencing with the minimum requirements of:
Height 2,4 metres
Size and thickness of pales 40mm x 40mm x 3mm thick.
Corner and intermediate posts 100mm x100mm x 3mm.
Horizontal cross bars 40mmx5mm.
- 41.3.1 The successful tenderer shall make provision for the installation of safety barriers in the high voltage yard in accordance with Transnet Freight Rail's requirements. (Refer to Transnet Freight Rail's Engineering instruction S.016)
- 41.3.2 The successful tenderer shall make provision for a metal barrier screen of 25mm-wire mesh or expanded metal to be constructed around the auxiliary transformer to prevent accidental contact.
- 41.3.3 The successful tenderer shall cast a concrete apron of 150mm wide x 300mm under the perimeter fences of the substation. The top of the apron shall be a minimum of 100 mm above the ground level.
- 42.0 GATES**
- 42.1 The contractor shall supply and install two 4.6 metre wide X 2,4 metres minimum height lockable gates in the perimeter fence to allow for:
- Entrance to substation building and yard.
 - Entrance to the high voltage outdoor yard adjacent to the main transformer (s).
- 42.2 Where access to the HV outdoor yard is gained between the substation building and perimeter fence, a fence the same height as the perimeter fence shall be installed. A 1000mm wide lockable gate shall form part of the fence.
- 42.3 Provision must be made for the fitting of a spark gaps and rail earth switch on the HV yard small gate. Refer to drawings CEE-TBD-7 and BBB3620. The spark gaps shall be provided by Transnet Freight Rail on request.
- 42.4 Where steel palisade fencing is used the gates shall be connected to the fence support post by means of a flexible connection to prevent electrolytic corrosion of gate hinges.
- 42.5 Warning notices and danger signs in accordance with Transnet Freight Rail's Electrical Safety Instructions shall be fitted to the perimeter fencing and gates. This shall be provided by Transnet Freight Rail.
- 43.0 CRUSHER STONE AND WEED KILLER**
- 43.1 After completion of construction, installation of equipment, the laying of all cables and earthing conductors, a suitable weed killer approved by the Technical Officer shall be applied in HV outdoor yard.
- 43.2 Great care shall be exercised to avoid contaminating private property and water supplies.
- 43.3 After treatment with the weed killer, a 100mm layer of 25mm crusher stone shall be laid over the whole area of the Transnet Freight Rail high voltage outdoor yard (within the apron).

44.0 PAINTING

44.1 All indoor and outdoor steelwork, metal screens and barriers shall be painted in accordance with Transnet Freight Rail's Specification CEE.0045.

44.2 The finishing coats for indoor equipment shall be in accordance with SANS 1091.

Metal Bay Screens - Eau-de-Nil (H43).

Support frameworks (indoor) - Eau-de-Nil (H43).

45.0 DISTRIBUTION, LIGHTING OF SUBSTATION BUILDING AND STANDBY 400V AUXILIARY SUPPLIES

45.1 The successful tenderer shall supply and install all light fittings, plugs, conduits, distribution boards, switches, cables and other material in accordance with SANS 10142-1. Galvanised, alternatively PVC conduit and galvanised fittings shall be provided at all substations within 50km of the coast.

45.2 The contractor shall furnish a certificate of compliance for the 400V/220V AC distribution and lighting of the traction substation signed by the accredited person in terms of SANS 10142-1 and who is registered with "Electrical Contracting Board".

45.3 Complete Layout drawing showing the position/type of light fittings, position of plugs, distribution board and switches to be submitted to Transnet Freight Rail for approval.

45.4 220V AC fluorescent light fittings shall be provided. The minimum lighting requirement shall be 100 lux in terms of the "Occupational Health and Safety Act".

11KV / 6,6KV TO 400V AUXILIARY SUPPLY AND CHANGE OVER SYSTEM.

45.5 Where specified a 11kV/6,6kV to 400V distribution transformer will be installed to supply the traction substation in the event of substation failure or when the substation is taken off load.

45.5.1 The 3 phase 400V supply from the above transformer shall be connected to the control circuitry via a automatic change over switching system.

45.5.2 The change over switching system shall be mechanically and electrically interlocked.

45.5.3 Transnet Freight Rail shall supply and install a suitably rated 4core armoured cable from the 11kV/6,6kV to 400V distribution transformer to the change over switching unit.

45.5.4 A 1:1 ratio isolation transformer shall be installed between the 11kV/6.6kV to 400V distribution transformer and change over switching system.

45.5.5 The isolation transformer shall comply with specification BBC 0330.

45.5.6 The successful tenderer shall supply the isolation transformer unless otherwise specified.

EMERGENCY LIGHTING.

45.6 Fluorescent light fittings with its own battery back up supply shall be supplied for emergency lighting.

45.6.1 A minimum of three fittings shall be installed in a single unit substation and four in a double unit substation.

45.6.2 The light fittings shall be installed at the following locations:

- In single unit substations two in the main walkway between the control panels and rectifier unit. One flameproof fitting in the battery room
- In a double unit substation three in the main walkway and one flameproof fitting in the battery room.
- In additional locations where requested by the Project Manager/Engineer.

45.6.3 The light switch shall be clearly labelled "EMERGENCY LIGHTNING".

MOULDED CASE CIRCUIT BREAKERS

- 45.7 All low voltage circuits and equipment shall be protected by moulded case circuit breakers, which comply with specification SANS 156.
- SECURITY LIGHTS**
- 45.8 Where outdoor security lights are specified 400W high-pressure sodium fittings shall be installed at locations specified by the "Scope of Work".
- 46.0 COOLING AND VENTILATION**
- 46.1 Where specified, 3 phase cooling fans shall be supplied and installed in the substation building.
- 46.2 The required filters, louvres and guards shall be provided and installed.
- 47.0 BATTERY ROOM**
- 47.1 A three/single phase non-sparking extraction fan shall be installed for the battery room.
- 47.2 Only Ex non-sparking light fittings shall be installed in the battery room.
- 47.3 Light switches and plug sockets shall not be installed in the battery room.
- 47.4 No-smoking, naked flames and hand protection warning signs shall be fitted to the battery room doors.
- 47.5 A wooden stand treated with acid proof paint shall be provided for the batteries.
- 47.6 A hydrometer and logbook shall be supplied by the contractor for each installation.
- 47.7 The floor of the battery room shall be painted with acid proof paint.
- 48.0 CLEARING OF SITE**
- 48.1 All rubble which is left over as a direct result of work performed by the Contractor shall be removed from the substation building and yard and disposed of by the Contractor. The substation floors and walls shall be left in a clean condition. All cable, wire and conductor cut-offs and surplus material shall be removed from site.
- SECTION 4: SITE TESTING AND COMMISSIONING**
- 49.0 SITE TESTS AND COMMISSIONING**
- The successful tenderer shall be responsible for carrying out on-site tests and commissioning of all equipment supplied and installed in terms of this specification and the contractual agreement.
- 49.1 ON-SITE TESTS**
- 49.1.1 Functional on-site tests shall be conducted on all items of equipment, circuitry and interlocking to prove the proper functioning and installation thereof.
- 49.1.2 The successful tenderer shall submit a detailed list of on-site tests for the approval of the Project Manager/Engineer at least six weeks before tests are due to commence at the first substation.
- 49.1.3 The successful tenderer shall arrange for the Project Manager/Engineer or his representative to be present to witness the on-site tests at each substation.
- 49.1.4 On-site tests and subsequent commissioning shall not commence until all construction work has been completed. Construction staff, material and equipment shall be removed from site prior to the commencement of testing. Testing and commissioning of the substation equipment will not be allowed to take place in a construction site environment.
- 49.1.5 On-site tests shall include the following;
- Polarity tests on all CT's.
 - Ratio tests on all CT's.
 - Magnetising current of all CT's.
 - Secondary injection of all relays.
 - Trip testing, all relays must be checked for correct operation.

- The functionality of all electrical circuitry must be tested.
- The operation of both mechanical and electrical interlocking.
- Tests on primary circuit breakers and other primary equipment in accordance with manufacturer's instructions.

- 49.1.6 At the completion of the on-site tests the Project Manager/Engineer or his representative, shall either sign the test sheets (supplied by the successful tenderer) as having witnessed the satisfactory completion thereof, or hand to the successful tenderer a list of defects requiring rectification.
- 49.1.7 Upon rectification of defects the successful tenderer shall arrange for the Project manager/Engineer or his representative to certify satisfactory completion of on-site tests for that particular substation.
- 49.1.8 Acceptance by the Project Manager/Engineer of satisfactory completion of on-site tests in no way relieves the contractor of his obligation to rectify defects which may have been overlooked or become evident at a later stage.

49.2 COMMISSIONING OF EQUIPMENT

- 49.2.1 Commissioning will include the energising of equipment from the AC disconnects to the OHTE track feeder switches. The successful tenderer must prove the satisfactory operation of all equipment under live conditions.
- 49.2.2 On completion of commissioning the successful tenderer will hand the substation over to the Project Manager/Engineer in terms of the relevant instructions.
- 49.2.3 Tenderers shall allow a period of at least three days per substation between satisfactory completion of on-site tests and commissioning of equipment.
- 49.2.4 During this period the Transnet Freight Rail's Test staff will test the operation of all protective relays and circuits and set the protection relays at each substation.
- 49.2.5 The contractor shall rectify any faults found during the testing and setting of the protection relays.
- 49.2.6 The final testing of the substation must commence at least three days ahead of the contract completion date.
- 49.2.7 The commissioning of the protection equipment by Transnet Freight Rail will in no way absolve the successful tenderer from any of his responsibilities during the guarantee period. It is the successful tenderers responsibility to satisfy himself that the commissioning of the protection equipment has been carried out in a satisfactory manner and in no way compromises the proper operation of the equipment supplied in terms of the contract.
- 49.2.8 The commissioning dates for the substations will be dependent on the availability of power supplies from the supply utility as well as Transnet Freight Rail's electrification program and will be defined by the Project Manager/Engineer.

50.0 SECTION 5: GENERAL QUALITY ASSURANCE

- 50.1 Transnet Freight Rail reserves the right to carry out inspection and tests on the equipment at the works of the supplier/manufacturer.
- 50.2 Arrangements must be made timeously for such inspections and type/routine tests in accordance with the equipment specifications are carried out before delivery of the equipment to the site.

50.3 Type/routine test sheets of the equipment shall be forwarded to the Project Manager.

51.0 GUARANTEE AND DEFECTS

- 51.1 The contractor shall guarantee the satisfactory operation of the complete electrical installation supplied and installed by him and accept liability for maker's defects, which may appear in design, materials and workmanship.
- 51.2 The guarantee period shall commence from the date of successful commissioning of the substation.
- 51.3 The guarantee period for all substations shall expire after a period of 12 months commencing from the date of successful completion of the contract or the date the equipment is handed over to Transnet Freight Rail whichever is the later.

51.4 If urgent repairs have to be carried out by Transnet Freight Rail staff to maintain supply during the guarantee period the contractor shall inspect such repairs to ensure that the guarantee period is not affected and should they be covered by the guarantee, reimburse Transnet Freight Rail the cost of material and labour.

51.5 The cost of training shall be included in the tenderers quotation.

52.0 DRAWINGS, INSTRUCTION MANUALS AND SPARES LISTS

52.1 Drawings, instruction manuals and catalogues shall be supplied in accordance with Transnet Freight Rail specification CEE.0224.

52.2 The tenderer shall supply three copies of an instruction/maintenance manuals, schematic and wiring diagram.

52.3 The contractor shall submit details of spares required in accordance with Transnet Freight Rail's specification no. CEE.0224.

52.4 All spares recommended for normal maintenance purposes that are not available locally (requires importation) must be highlighted.

53.0 SPECIAL TOOLS AND/OR SERVICING AIDS

Special tools or servicing aids necessary for the efficient maintenance, repair or calibration of the equipment shall be quoted for separately.

54.0 TRAINING

54.1 The contractor shall submit details with the tender of the training courses which will be conducted by the contractor for the training of Transnet Freight Rail maintenance staff in the operation and maintenance of the equipment supplied. The courses shall include theoretical as well as practical tuition. The date and venue of this training course shall be arranged with the Maintenance manager.

55.0 PACKAGING AND TRANSPORT.

55.1 The contractor shall ensure that the equipment be packed in such a manner that it will be protected during handling and transport.

55.2 The contractor shall provide transport for the delivery of the equipment to the site where required.

56.0 BIBLIOGRAPHY

[1] SANS 1019: 2008 Edition 2.5 Standard voltages, currents and insulation levels for electricity supply

APPENDIX 1: LIST OF RELEVANT DRAWINGS**DRAWINGS ISSUED WITH THIS SPECIFICATION**

| DRAWING NUMBER | DESCRIPTION. |
|-----------------------|---|
| CEE-TDF-0016 | Concrete fencing |
| CEE-TBD-7 | Earthing Arrangements Traction Substations. |
| CEE-TU-41 | Negative Return Cable Terminating Box. |
| CEE-TCK-1 | Reactor 1,84mH, 1 500 A. (For reference purposes only) |
| CEE-TBP-1 | Wiring diagram for auto reclosure for HSCB. |
| CEE-TBP-39 | Circuit diagram for auto reclosure for HSCB |
| CEE-TBP-35 | Connection diagram for HSCB and electronic control relay |
| CEE-TBP-38 | Schematic Diagram of 3kV HV Protection. |
| CEE-TCL-63 | 3kV Busbar Chamber Arrangement: Cable Feeders. |
| CEE-TCQ-208 | DC High Speed Circuit Breaker Cell Panel (Cell slabs) (sheets 1 to 10) |
| CEE-TBP-33 | DC Track Breaker and Truck Wiring Diagram. |
| BBB 0938 | Surge arresters mounted on traction transformer. |
| BBB 3620 | 3kV Earthing arrangement for traction substation |
| BBF 1615 | Busbar connection assembly |