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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Transnet Freight Rail

Transnet and Relevant Third Parties

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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.

END

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TECHNOLOGY MANAGEMENT

SPECIFICATION

3kV RECTIFIER FOR TRACTION SUBSTATIONS

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1.0 SCOPE

1.1 This specification covers Transnet Freight Rail's requirements for the design, manufacture, supply and installation of 3 kV Direct Current (DC) rectifier units for DC traction substations.

2.0 STANDARDS AND PUBLICATIONS

2.1 Unless otherwise specified all materials and equipment supplied shall comply with the current edition of the relevant SANS, IEC or Transnet Freight Rail's publication where applicable.

2.2 The following publications are referred to in this specification:

2.2.1 INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60051:	Direct acting indicating analogue electrical-measuring Instruments and their accessories
IEC 60146-2:	Semiconductor converters - Part 2: Self-commutated semiconductor converters including direct dc converters.

2.2.2 SOUTH AFRICAN NATIONAL STANDARDS

SANS 1019:	Standard voltages, currents and insulating levels for electrical supply

2.2.3 TRANSNET FREIGHT RAIL

CEE.0224.	Drawings, catalogues, instruction book and spares lists for electrical equipment supplied under contract.
BBB 2721	AC Primary Circuit Breaker Control Panel and AC/DC Distribution Panel for 3kV Traction Substations.
BBB 5452	Transnet Freight Rail's Requirements for the Installation of Electrical Equipment for 3kV DC Traction Substations.
Transnet Freight Rail	Electrical Safety Instructions.

2.3 Any items offered in accordance with other standards will be considered at the sole discretion of Transnet Freight Rail. The tenderer shall supply full details stating where the item differs from these specifications as well as supplying a copy (in English) of the recognised standard specification(s) with which it complies.

3.0 TENDERING PROCEDURE

3.1 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. This document can be used by tenderers to elaborate on their response to a clause.

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

3.3 Tenderer shall submit for each type of rectifier a filled in form as per Appendix 1.

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

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

4.0 SERVICE CONDITIONS

4.1 ATMOSPHERIC 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.

4.2 MECHANICAL SERVICE CONDITIONS.

4.2.1 The rectifiers are installed in substations next to or within close proximity of railway tracks and will be subjected to vibration from the trains.

4.3 ELECTRICAL SERVICE CONDITIONS.

4.3.1 INPUT VOLTAGE

4.3.1.1 The rectifier AC input voltages for six-pulse configuration is in the order of 2450V AC per phase. For 12-pulse configuration the AC input voltages can be in the order of 1150V to 1375V phase to phase.

4.3.1.2 The rectifier receives its supply from a 3.3 MVA or 5 MVA rectifier transformers (and 6 MVA where transformers are replaced).

4.3.2 OUTPUT VOLTAGE.

4.3.2.1 The nominal busbar output voltage rating of the system is 3150 Volts but can vary between 2500 V DC and 3900V DC.

5.0 DESIGN OF EQUIPMENT

5.1 The rectifier unit and its associated control equipment should be built up to form an independent unit.

5.2 The rectifier design shall be suitable for operation for existing or new traction substations, the details of which shall accompany this specification.

5.3 For multiple unit substations it shall be possible for each unit to operate completely independently of each other.

5.4 For single transformer, multi-group arrangements, it shall be possible to isolate and switch off one group without affecting the other group.

5.5 Six or twelve pulse operation is used depending on the configuration of the transformers.

5.6 This specification includes all the required control and protection circuits which shall be installed and wired to existing substation control panels by the supplier.

5.7 The control circuitry for tripping and indication purposes shall operate at 110 volt DC.

5.8 RATINGS

5.8.1 The DC output of the equipment shall be rated at 3.3 MW, 4.5 MW, 5 MW or 6 MW full load continuously with overload ratings related to full load 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.

5.8.2 The equipment shall withstand a short circuit for 200 milli-seconds.

5.8.3 The ratings of the rectifier with its configuration shall be displayed on a silkscreen label fixed on the rectifier unit.

5.9 The rectifiers and associated equipment shall be designed to minimise any tendency to resonate or to produce high voltage surges when operating in conjunction with DC smoothing equipment.

5.10 Lightning, transients, surges and tripping are present in the substation environment.

6.0 INSULATION LEVELS

6.1 Insulation levels for high voltage equipment shall be in accordance with the recommendations of SANS 1019.

6.2 The nominal 1.5kV and 3kV insulation to earth shall be so designed that the complete rectifier assembly shall be able to withstand a test voltage of 10.5kV 50Hz AC for one minute.

6.3 Where PVC trunking is used for the routing of cables it shall be so installed that there can be no danger of a flash over or tracking occurring between the trunking and high voltage circuitry.

7.0 CLEARANCES AND CREEPAGE DISTANCES

7.1 The following minimum safety clearances shall be maintained:

For the nominal DC system voltage, the minimum indoor clearance shall not be less than 150mm from any conductor or metal normally live and ground level.

7.2 Ribbed insulators and standoff bushings shall be used for 3kV DC and shall have a creepage distance of not less than 150mm.

8.0 RECTIFIER UNIT

8.1 RECTIFIER DESIGN REQUIREMENTS.

8.1.1 The silicon rectifier diode assemblies shall comply with SANS 60146-2.

8.1.2 The rectifier unit shall comprise silicon semiconductor-diodes and be of the hockey puk capsule type.

8.1.3 All materials used shall be flame retardant.

8.1.4 To prevent flashovers no insulation material shall be used between rectifier branches. The minimum clearance of 150mm is required between diode modules as well as between diode modules and any earthed metal.

8.1.5 The minimum distance between the incoming supply phases to the rectifier shall not be less than 150mm

8.1.6 It is required that the equipment offered be designed to remain in service in the event of any individual diode in a branch becoming defective.

8.1.7 The rated repetitive peak reverse voltage of a series connected branch of diodes shall be such that should a diode in that branch become defective, the rated repetitive peak reverse voltage of the remaining diodes will be at least twice the value of the applied reverse voltage. The peak inverse voltage shall be not less than 4000V DC or higher for a 24 diode bank.

8.1.8 The creepage distance across the resistor capacitor (RC) circuit components shall be commensurate with the creepage distance across the diode insulation.

8.1.9 Tenderers shall provide a full description of the over voltage and surge protection circuits offered illustrating how this circuit has been designed.

8.1.10 Each rectifier unit shall be provided with a DC voltmeter, range 0-4 000 volts and a DC ammeter range 0-4000 amperes. These shall be mounted on the front of the rectifier unit.

8.1.11 The DC voltmeter shall be connected to the more negative side of the voltage divider.

8.1.12 For the DC ammeter a 4000 ampere 50 mV shunt shall be fitted on the negative busbar of the rectifier.

8.1.13 The DC voltmeter and ammeter shall be class 1.5 or better. The dimensions of the analogue face of the meters fitted on the rectifier unit shall not be less than 144mm x 144mm with a 90 degree display.

8.1.14 A high voltage fuse and potential divider shall be provided for the voltmeter.

8.1.14.1 The potential divider shall of the encapsulated type or consist of not less than ten separate vitreous enamel resistance elements connected in series. These shall be spaced to provide a clearance distance of not less than 150 mm to any earthed metal.

8.1.15 The DC output of the rectifier unit shall be protected from external voltage transients by means of fused resistance capacitance parallel metal oxide varistor circuitry. The fuse shall be fitted with a trip contact, which can be utilised for indication and control.

8.2 DIODES

8.2.1 For 3.3 MW and 4.5 MW rectifiers the Westcode type W2899MC480 and INFINEON (EUPEC) D1809 N40 or N46 diodes (exact equivalent or approved types) shall be used.

8.2.2 For 5 MW and 6 MW rectifiers the Semikron 2P 3000/68 diodes (exact equivalent or approved types) shall be used.

8.2.3 Proof of origin of the diodes and certified test certificates shall be supplied with the diodes.

8.2.4 The forward voltage drop of the diodes shall be within ± 5% variations.

8.2.5 Tenderers shall submit fully detailed data sheets of the type of diode offered.

8.2.6 Each individual diode shall form an integrated module with its heatsink, snubber circuit and parallel voltage- equalising resistor circuit. The module shall contain no connection wires or lugs. All connections shall be made directly through the mounting of the snubber printed circuit board busbar terminations. The design of the module shall enable it to be removed within 10 minutes, without disturbing any other modules.

8.2.7 The pre-load pressure exerted by the fixing clamps or other methods must be easily checked. Fixed indicating torque washers or other methods of obtaining the correct pre-load pressure using torque wrench spanners must be used for assembly of the diode module.

8.2.8 The rectifier design shall be such that only the diode module securing bolts need to be removed for replacement of a module. No busbars or other parts shall obstruct the removal of the diode module.

8.2.9 For identification of the diode polarity, the rectifier symbol shall be clearly marked on the heatsink module and on the diode.

8.2.10 Tenderers shall indicate the recommended intervals between the testing of diodes and their RC snubber components so as to establish their soundness.

8.2.11 Where 3kV DC rectifiers are installed within a distance of 15km from the coast, the profile of the heat sinks shall be tapered by machining, to allow for easy access to remove any salt spray condensation formed on the diode.

8.3 SNUBBER (RC) AND VOLTAGE EQUALISING CIRCUITRY.

8.3.1 The capacitors and resistors employed in the snubber RC circuits shall be of the highest quality and shall be suitably rated for high voltage applications encountered. Vitreous enamel wire wound resistors or similar shall be used and high voltage suitable capacitors shall be used.

8.3.2 If standoff posts are used to support sensing circuits they shall be securely fixed to the main diode module by means of lock washers and nuts to ensure that no sparking occurs due to poor contact.

8.4 DIODE MONITORING EQUIPMENT

8.4.1 DIODE SENSOR TRANSMITTER MONITORING MODULE

8.4.1.1 Sensing circuitry shall be incorporated to monitor each individual diode for open or short circuit conditions.

8.4.1.2 Specific attention shall be given to the protection of the diode monitoring circuit boards in the event of the diode going open circuit and destroying the monitoring modules.

8.4.1.3 Protection circuitry shall be shall be provided for each sensor module.

8.4.1.4 The sensor module shall be powered from the snubber RC circuit of the diode and shall be designed so as not to change the characteristics of the RC circuit across which it is connected.

8.4.1.5 The snubber RC circuitry, and the diode sensing circuitry, shall be removable as a unit with the diode module when the diode module is removed for replacement or repair.

8.4.1.6 The components used to manufacture the diode sensor transmitter module shall be of the highest quality.

8.4.1.7 If resistors are employed they shall be vitreous enamel insulated or similar and shall withstand at least 700 volts across them.

8.4.1.8 The diode sensing circuit board shall be removable from the diode module as an individual circuit board for repair or replacement.

8.4.1.9 The diode sensing circuit board shall be so constructed that it will be protected against reverse polarity on installation after repair or replacement.

8.4.1.9.1 The output signal from the diode sensor transmitter board shall be fibre optic transmitted. Wire conductors are not acceptable.

8.4.1.9.2 Diode monitoring systems utilising Programmable Logic Controllers (PLC) is not acceptable.

8.4.2 RECTIFIER DIODE MONITORING PANEL AND DISPLAY.

8.4.2.1 The rectifier unit shall be fitted with a diode monitoring panel for monitoring the condition of each diode.

8.4.2.2 Each diode shall be clearly numbered on the front display cover of the diode monitoring panel as well as on the diode module. The markings shall be silk screened engraved or similar.

8.4.2.3 The panel shall be fitted with Light Emitting Diodes (LED's) to indicate the condition of the diodes. The LED's shall be green for a healthy diode and red for an open circuit or short circuit diode.

8.4.2.4 A remote reset switch or button to reset the LED's and the diode monitoring panel shall be fitted in the primary circuit breaker control panel.

8.4.3 ELECTRONICS

8.4.3.1 All printed circuit boards shall be constructed from high quality fibreglass material.

8.4.3.2 All printed circuit boards shall slide in high quality edge connectors and shall be easily removed for replacement or repairs.

8.4.3.3 All printed circuit boards with its components shall be coated for protection against moisture, corrosion and dust.

8.4.3.4 Each printed circuit board shall be polarised to prevent the card from being plugged into the wrong socket and to prevent the card from being inserted upside down.

8.4.3.5 The control unit shall be built into a rack mounted unit or similar and shall be able to be removed or installed as a unit.

8.4.3.6 The control unit shall be designed to fail to safe in the event of power supply failure or printed circuit board failure. Contacts shall be provided which can be utilised for lockout signals.

8.4.4 POWER SUPPLY SYSTEM.

8.4.4.1 The power supply shall be of the switch mode design and shall be able to operate within the range of the voltages available in the substation.

8.4.4.2 The power supply as well as the remainder of the unit shall be extensively protected from lightning, transients and surges. Extensive use of gas arresters, inductors and capacitors will be required.

8.4.5 FIBRE OPTIC MONITORING BOARD.

8.4.5.1 The annunciator shall be fitted with fibre optic receivers for signals transmitted from the diode sensor transmitter module.

8.4.6 INTERFACE INPUT-OUTPUT PRINTED CIRCUIT-BOARD

8.4.6.1 The diode monitoring main board shall be able to communicate the condition of the diodes by means of relay contacts.

8.4.6.1.1 Provision shall be made for one diode failure to lockout the substation with a remote flag indication and give a signal to the telecontrol system.

8.4.6.2 The relays shall function in the fail safe mode, i.e. the relays will be energised and will de-energise under faulty conditions.

8.5 COOLING

8.5.1 The rectifier unit shall be fitted cooling fans with temperature sensors for the control of the cooling fan, temperature monitoring and rectifier over-temperature protection.

8.5.2 The direct heat sink temperature sensing method shall be used with multiple sensors connected in series.

8.5.3 Two thermal control switches shall be fitted to the rectifier for the energising of the cooling fans at a temperature of 50°C. Provision shall be made to prevent the fan from cycling at the energising temperature.

8.5.3.1 Suitable fan control circuitry shall be provided by the supplier.

8.5.4 The rectifier unit shall be provided with two over temperature sensing switches which shall be set at 80°C.

8.5.5 The rectifier over temperature protection shall be used for tripping purposes. The circuitry shall be provided by the supplier.

8.5.6 The wiring from the sensors to the fan controller should be of the plastic fibre optic type and the sensors should obtain their supply from the RC circuit.

8.5.7 Fan airflow failure circuitry (vane switches) and relays shall be provided for control and indication purposes. A fan test switch which is spring loaded to the off position shall be provided and installed in the primary circuit breaker control panel.

8.5.8 Adequate measures shall be taken to ensure that the rectifier equipment does not overheat during periods of high loading. Details of the over temperature protective scheme shall be submitted with the tender.

8.5.9 Provision shall be made for adjustable current sensing to control the operation of the cooling fan(s). The fan(s) shall be energised when the main current reaches a value of 700 amps (adjustable.) The current sensing circuitry shall be sufficiently isolated and shall be installed in the primary circuit breaker control panel.

9.0 INSTALLATION.

9.1 The contractor shall be responsible for the transport to site, off-loading, handling, storage and security of all material required for the installation of the rectifier unit.

9.2 The rectifier shall be installed within the substation building and shall be totally insulated from the floor by means of channel insulation or other high voltage insulating material.

10.0 EARTHING

10.1 The metal framework of the rectifier shall be connected to the existing DC earth leakage earthing system in accordance to drawing No. CEE-TBD-7. Should the existing earth strap not be suitable for re-use a new copper earth strap of least cross-section area or a stranded insulated copper conductor with a cross-sectional area of at least 95mm ^{2} shall be used.

11.0 CABLES

11.1 Armoured cables shall be used for the wiring of the cooling fans and any other external power circuitry.

11.2 All cables shall terminate in compression type glands. These glands shall be fitted with neoprene shrouds.

11.3 Screened cables and conductors shall be used for electronic screening and noise reduction techniques where required.

11.4 The fibre optic cables between the rectifier and the annunciator panel shall be protected from damage by means of conduit or trunking or other suitable means. Open fibre optic cables are not acceptable.

11.5 All cabling shall be clearly marked with high quality permanent markers. Sticker marking numbers will not be acceptable.

12.0 INTERCONNECTION OF EQUIPMENT

12.1 Suitably rated copper busbars shall be used for the interconnection of the rectifier to the secondary winding of the traction transformer. The busbars between separately mounted equipment shall incorporate a degree of flexibility to avoid any over stressing of these connections due to movement caused by conductor expansion/contraction and to facilitate alignment of equipment.

12.2 High conductive silicon grease shall be liberally applied to all connections.

12.3 All dissimilar metal connections copper to aluminium (Cu to Al) shall be made using bi-metallic clamps that are specifically designed and manufactured to make that particular connection (adhoc fabricated clamps are not acceptable).

12.4 All copper connections to steel (galvanised) shall be tinned or silver coated.

13.0 INSPECTION, SITE TESTS AND COMMISSIONING.

13.1 Transnet Freight Rail reserves the right to carry out inspection and any tests on the equipment at the works of the supplier/ manufacture.

13.2 Arrangements must be made timeously for such inspections to be carried out before delivery of the equipment to the client.

13.3 The contractor shall be responsible for carrying out on-site functional tests before the commissioning of the rectifier unit.

13.4 The testing of the rectifier shall include type tests for new design of rectifier units and routine tests which shall be conducted on all units.

13.4.1 The testing shall include the following: -

- Insulation tests.
- Light load tests.
- Functional tests on the associated control equipment and circuitry of the rectifier.
- Temperature rise tests i.e. temperature measurements on diode heatsinks. Maximum temperature rise shall not exceed 75° C.
- Checking of auxiliary and protective devices and control equipment.

- Rated output tests.
- Overcurrent capability test.
- Measurement of output voltage
- Power loss determination

13.4.2 Functional Acceptance by the Maintenance Manager 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.

13.5 Commissioning will only take place after all defects have been rectified to the satisfaction of the Maintenance Manager.

13.6 Commissioning will include the energising of equipment from the primary isolator to the track feeder circuits. The contractor must prove the satisfactory operation of equipment under live conditions.

13.7 On completion of commissioning the contractor will hand the equipment over to the Maintenance Manager in terms of the relevant engineering instructions.

14.0 DRAWINGS, INSTRUCTION MANUALS AND SPARES LISTS

14.1 Drawings, instruction manuals and spare parts catalogues shall be supplied in accordance with Transnet Freight Rail's specification CEE.0224

14.2 All drawings (paper prints) shall be submitted to the technical officer for approval. No Construction or manufacturing activity will be allowed prior to the associated drawings having been approved by the technical officer.

14.3 The tenderer shall supply three copies of an instruction/maintenance manuals, schematic diagrams, diode application notes and protection and filter ratings.

14.4 The contractor shall submit details of spares required in accordance with specification No. CEE.0224.

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

15.0 SPECIAL TOOLS AND/OR SERVICING AIDS

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

15.2 Tenderers shall submit detailed offers for special tools and servicing aids including all specialised equipment required for the servicing and maintenance of the equipment supplied.

16.0 TRAINING

16.1 The tenderer shall submit details with the tender of the training courses, which will be conducted by the contractor for the training of Transnet Freight Rail's 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.

17.0 GUARANTEE AND DEFECTS

17.1 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.

17.2 The guarantee period for all substations shall expire after: -

A period of 12 months commencing on the date of completion of the contract or the date the equipment is handed over to Transnet Freight Rail whichever is the later.

17.3 Any specific type of fault occurring three times within the guarantee period and which cannot be proven to be due to other faulty equipment not forming part of this contract e.g., faulty locomotive or overhead track equipment, etc., shall automatically be deemed an inherent defect. Such inherent defect shall be fully rectified to the satisfaction of the Maintenance manager and at the cost of the Contractor.

17.4 If urgent repairs have to be carried out by Transnet Freight Rail's 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

END

APPENDIX 1

TECHNICAL DATA SHEET

(To be completed by Tenderer)

1.0 Rectifier ratings (MW):_____

2.0 Number of diodes per branch:_____

3.0 Type of Diode:_____

3.0 Full load current rating of diode. I_{FRMS}:_____

4.0 Average current rating of diode. I_{FAVM}:_____

4.0 Repetitive Peak Reverse Voltage of diode:_____

5.0 Surge forward current 10 milli second Sine Wave:_____

6.0 Method of cooling of rectifier:_____

7.0 Method of temperature sensing: _____

8.0 Type of insulation used for frame to floor: _____

9.0 Physical dimensions of rectifier unit:

Height: _____ Breadth: _____ Width: _____

10.0 Name of suppliers where rectifier diodes can be sourced: _____

_____

11.0 Method of correct torque adjustment for heat sinks: _____

_____

12.0 Diode test certificate attached Yes/No:_____

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DRAWINGS, CATALOGUES, INSTRUCTION MANUALS AND SPARES LISTS FOR ELECTRICAL EQUIPMENT SUPPLIED UNDER CONTRACT

Statement of authorisation:
There is no SABS specification available for similar material / equipment and as far as can be ascertained no other specification / standard suitably covers Spoornet requirements. The specification has been compiled in a manner which shall favour / encourage local manufacture of material / equipment to a maximum degree.

Author:	Chief Engineering Technician *Documentation management*	J C van Tonder
Approved:	Senior Engineer Railway Engineering	L O Borchard
Authorised:	Senior Technologist Configuration Management	J H Hancock

Date: January 2002

This page is for control purposes only and shall not be issued with the specification.

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SPECIFICATION

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